THE ROLE OF THE EUROPEAN SOVEREIGN DEBT CRISIS ON THE IMPACT OF LEVERAGE ON CORPORATE INVESTMENT EFFICIENCY

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Abstract

A fundamental question in financial research is what determines the capital allocation of corporations. This thesis aims to investigate the effect of corporate leverage on the efficiency of investments in relation to the European sovereign debt crisis of 2011 to 2014. Following the theories of debt overhang and the monitoring role of debt, three hypotheses are constructed concerning the effect of leverage on investment efficiency, the effect of the European sovereign debt crisis on investment efficiency and the role of the European sovereign debt crisis on the debt-investment efficiency relationship.

To test the hypotheses, two measures of investment efficiency are estimated via optimal investment regression models. The residuals of these regression are transformed such that proxies of total investment efficiency, underinvestment and overinvestment could be defined. Using a sample of European listed firms from seven countries from 2011 to 2019, fixed effects regression models on investment efficiency are estimated. This thesis finds that leverage is related to underinvestment via the problem of debt overhang. In addition, the European sovereign debt crisis caused a reduction in overinvestment for firms with an average level of leverage. However, the positive effect of long-term leverage on the amount of investment inefficiency is more pronounced during the European sovereign debt crisis compared to the post-crisis years.

The results of this thesis imply that an increase in leverage results in an increase in underinvestment. In addition, for a multitude of overinvesting firms, an increase in leverage caused these firms to underinvest due to the intensification of the effect of leverage on the capability to invest conform to their respective growth opportunities. This thesis concludes that (long-term) leverage has a positive effect on the amount of underinvestment due to the problem of debt overhang and that during the European sovereign debt crisis this value-damaging effect is stronger for debt with high maturities.

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1. Introduction

A fundamental question in financial research is what determines the capital allocation of corporations (Chen et al., 2017). Firms expect to maintain or improve their business sustainability by maximising profitability and sales revenue via investing in their business processes. Investments are related to managers' expectations and valuations of future business opportunities (Grazzi et al., 2016). According to Modigliani and Miller (1958), a perfect world does not have market friction and the financial structure of a company is irrelevant. In such a world, investment spending would only be determined by investment opportunities, since a firms' objective is to maximise its net present value (Gao & Yu, 2020). Thus, a firm should invest in all value-increasing investment opportunities they encounter. Therefore, ideally, managers should use debt to increase their capacity to invest in all positive net present value investment opportunities when the internal funds are insufficient. In other words, managers should ideally increase the firm's leverage to be able to have sufficient funds to invest in all investment opportunities increase firm value.

However, there are a variety of capital market frictions or imperfections that impede the ability of management to raise cash from external capital markets (Richardson, 2006) and increase the costs of debt beyond the costs of internal finance. Therefore, prior research shows that debt disciplinarily constrains and/or decreases corporate investment (e.g., Ahn et al., 2006; Aivazian et al., 2005a; Firth et al., 2008; Lang et al., 1996; Myers, 1977). This happens because the use of external capital to fund investments causes extra risks and financial obligations compared to the use of internal capital to fund investments. Next to that, highly leveraged firms often have limited ability to borrow additional funds due to the fact that banks recognise the increasing risk of default (Cantor, 1990). Consequently, due to limited capital and extra costs because of high leverage, positive net present value projects could go unfunded or firms are less inclined to invest in negative NPV projects.

The difference between investment affected by market frictions and investment solely being determined by growth opportunities as proposed by Modigliani and Miller (1958), is defined as the investment efficiency of a firm. The magnitude of the investment efficiency is the deviation of the actual investment from the expected and optimal investment given by a firm's investment opportunities (Goodman et al., 2014; McNichols & Stubben, 2008). A firm can

either invest more or less than the optimal investment level, this is defined as respectively overinvestment and underinvestment. Therefore, the constraining effect of external capital on investment levels can either lead to decreased overinvestment or increased underinvestment. This study investigates this effect of debt on investment efficiency during a major shock on the European financial market and economic activity of European firms (Ferrando et al., 2019): the European sovereign debt crisis.

Starting at the end of 2010, countries in the eurozone experienced a severe sovereign debt crisis (Acharya et al., 2018). The sovereign debt crisis was a result of the accumulation of the effects of the global financial crisis, international trade imbalances and failing bailout approaches (Ullah, 2014). A large number of European governments had large imbalances (high sovereign debt) on their balance sheets, which endangered their ability to service their debt (Ferrando et al., 2017). Due to this threat of default, which is also known as sovereign risk, the value of government bonds decreased. In addition, bailouts of heavily indebted countries to improve their financial situation did not make these risks disappear. On the contrary, the bailout policies transferred the sovereign risks across the whole European Union (Kalbaska & Gatkowski, 2012).

The sovereign risks across Europe fed back into the financial sector. This is for the reason that banks hold a large number of government bonds as assets. Since the value of government bonds decreased, the financial position of banks deteriorated. So, the high sovereign debt across Europe increased the threat of insolvency of the banks and exacerbated the financial risks that banks already faced caused by the ongoing global financial crisis of 2008 (Mac an Bhaird et al., 2016). Following the devaluation of the banks' assets, banks no longer possessed the financial strength to lend external capital to firms to sponsor investment projects. Therefore, bank lending to the private sector contracted substantially (Acharya et al., 2018; Dorsman & Gounopoulos, 2013). As a result, the European sovereign debt crisis caused a credit crunch which financially constrained firms that depend on leverage to finance their investment projects.

While the effect of the European sovereign debt crisis on investment levels and the debt-investment relationship has proven to be negative (e.g., Gebauer et al., 2018), it is not widely researched if firms invested corresponding to their potentially changed optimal investment level. Firms could have either invested less because of declining growth opportunities and

declined demand; increased uncertainty of the outcomes of investment projects or insufficient (access to) capital due to the limitations and restrictions caused by the credit crunch. In addition, a declined investment level could either be increased underinvestment or decreased overinvestment depending on the specific growth opportunities of a firm. In other words, the effect of the European sovereign debt crisis on the efficiency of corporate investment has not been studied before and is recommended as a valuable addition to the financial literature (Gebauer et al., 2018; Guler, 2019).

The European sovereign debt crisis offers a unique setting to explore the impact of debt on investment efficiency since it is the first time that markets in the European Union were seriously tested (Kalbaska & Gatkowski, 2012). Opposed to the global financial crisis, the sovereign debt crisis emerged in Europe and is largely confined to Europe (Lee et al., 2013), which makes it a unique case for European firms. While the financial banking crisis of 2008 also caused a credit crunch, the European crisis of 2010 exacerbated these risks by the banks' exposure to large sovereign risks of indebted governments. Consequently, in the years from 2007 till 2009, there still was an increase in total credit supply towards European companies, but after the start of the sovereign debt crisis, credit growth quickly plummeted (De Marco, 2019; Shambaugh 2012). Besides, the financial costs of credit were much larger from 2010 onwards than the period before the crisis (De Marco, 2019), due to largely increased interest spreads for the indebted countries. Furthermore, an increasing level of high corporate indebtedness of European firms before the crisis made firms extra vulnerable to the shift in risk sentiment (Gebauer et al., 2018). All in all, the European sovereign debt crisis of 2012 constrained European firms more than the global financial crisis of 2008 did. Therefore, examining the effects of the European sovereign debt crisis on the leverage-investment efficiency relationship is valuable to analyse the effects of major shocks on a firm's investment performance.

This thesis analyses the relationship between leverage and investment efficiency in times of a financial shock. In particular, this thesis investigates if the limitations and restrictions on corporate lending during the European sovereign debt crisis caused inefficient corporate investment. Next to that, this study aims to examine if firms with high leverage during the European crisis were more constrained to invest following their respective growth opportunities than firms with a relatively lower debt-to-assets ratio. This study aims to

investigate the impact of leverage on the investment efficiency of European companies and the effect of the sovereign debt crisis of 2010 on this relationship. This study analyses these effects by answering the following research question:

What is the impact of the European sovereign debt crisis on the effect of leverage on corporate investment (in)efficiency?

To answer the research question, this study investigates the investment efficiency of a sample of European companies from 2011-2019 via a two-step regression method. Firstly, the investment (in)efficiency is measured by estimating the extent to which a firm's investment deviates from the expected level of investment according to growth opportunities, following a wide variety of prior research (e.g., Biddle et al., 2009; Goodman et al., 2014; McNichols & Stubben, 2008). The residuals of the investment are used as the dependent variable of the second regression to investigate the effect of leverage and the crisis on the investment efficiency of non-financial firms. The residuals are split into negative and positive inefficiencies such that the effect of leverage on both underinvesting firms and overinvesting firms can be explored and analysed.

The contribution of this thesis to the literature is threefold. Firstly, this thesis contributes to the literature on the effect of leverage on investment. Prior research argues in favour of the problem of debt overhang (e.g., Firth et al., 2008; Myers, 1977) where debt decreases investment efficiency and/or a disciplinary role of debt (e.g., Aivazian et al., 2005a; Lang et al., 1996) where debt increases investment efficiency. This study adds to the existing literature by thoroughly examining the direct effect of leverage on investment efficiency by estimating the deviation from the expected level of investment. Furthermore, the effects of leverage on overinvestment and underinvestment is examined separately. In this way, this study contributes to the financial literature by analysing the direct effect of leverage on total investment efficiency and the direction of inefficiency by examining overinvestment and underinvestment.

Secondly, this study adds to the literature regarding the effect of the European sovereign debt crisis on the investment behaviour of European firms. While the effect of the European sovereign debt crisis on investment levels and the debt-investment relationship has proven to be negative, the effect of leverage on the investment efficiency of European firms during the

European sovereign debt crisis has been largely untouched by prior research. Following Gebauer et al. (2018), leverage has a strong negative effect on capital expenditures during the sovereign debt crisis, but they state they did not investigate if the decreased investment is efficient or inefficient. Thus, examining effect of leverage on investment efficiency during the European sovereign debt crisis is a new addition to the literature. In this thesis, it is investigated if firms pass on valuable investment opportunities or decrease overinvesting tendencies. In addition, firms could have either followed decreasing growth opportunities or were unable to invest due to financial limitations and restrictions because of high leverage.

Third, there is a practical contribution to the firm's capital structure and the tendencies firms have while investing. The investment efficiencies of European firms during and after the European sovereign debt crisis are measured, this contributes to the understanding of companies' investment policies and capabilities during crises. A direct relation between relying on debt to invest and investment efficiency during a crisis is analysed. This provides European firms more insight on how to determine the optimal capital structure of the firm. Moreover, the use of multiple countries and definitions of the European sovereign debt crisis in the sample and analysis adds to the understanding of the effects of specific countries on efficient investment and capital structure policies.

The rest of this thesis is structured as follows. Chapter 2 reviews prior research on investment, investment efficiency and leverage. In addition, the literature on the financial crisis and the European sovereign debt crisis regarding investment and leverage are discussed. Afterwards, testable hypotheses are developed and formulated. Chapter 3 outlines the research design used to answer the research question and test the hypotheses. In Chapter 4, the sample used to do the data analysis is presented. Furthermore, sample distributions, descriptive statistics and correlations are reported and discussed. Chapter 5 reports and discusses the regression results. Lastly, the research question is answered and the hypotheses are discussed in the last chapter. In addition, limitations and recommendations for further research are discussed in the conclusion of the thesis.

2. Literature and Hypotheses Development

In this chapter, previous literature is critically reviewed and compared. The goal of this literature review is to investigate prior research on investment efficiency in relation to leverage. Furthermore, the empirical evidence on the effects of leverage on investment policies is reviewed. Afterwards, the causes and effects of the European sovereign debt crisis on the investment efficiency of firms are described and prior research on the effects of leverage on investment during the European sovereign debt crisis is reviewed. Lastly, several testable hypotheses are developed concerning 1) the effect of leverage on investment (in)efficiency and 2) the effect of the European sovereign debt crisis on this relationship.

2.1 Investment efficiency and leverage

In this section, prior research on investment efficiency and leverage and is reviewed. Firstly, Section 2.1.1 details investment (efficiency) theories. In addition, Section 2.1.2 explains the financial frictions that cause investment efficiency. Section 2.1.3 describes theories of leverage in relation to investment efficiency. Lastly, Section 2.1.3 reviews the empirical evidence on the effect of leverage on investment efficiency.

2.1.1 Investment efficiency

Investment is an allocation of resources with the objective to recover the investment costs to make a profit. Since, according to neoclassical theories, the objective of a firm is to maximise its net present value, firms should invest in all positive NPV projects that are available to them (Gao & Yu, 2020). The decision to invest is influenced by the investor's prediction about the costs and gains of an investment opportunity, this decides the net present value of a project. Consequently, an investment project should be undertaken if and only if it increases the value of the shares (Tobin & Brainard, 1976). To be specific, firms should invest in all investment projects with higher predicted gains than the costs to realise the investment. This means that firms invest at the equilibrium point where the marginal benefit of the investment equals the marginal cost after taking into account the adjustment costs (Gao & Yu, 2020; Hu et al., 2019; Tobin & Brainard, 1976).

According to the neoclassical theory (Modigliani & Miller, 1958), capital markets are frictionless. Therefore, investing and financing activities are solely based on a firm's

investment opportunities or expected future profitability of capital (Hubbard, 1998). This proposition implies that firms with the same opportunities can pursue the same amount of investment projects and on average grow at the same rate (Kasahara, 2008). When there is no market friction, the cost of internal capital and external financing is the same. Thus, the availability of internal capital does not matter. If the funds needed to invest in a positive NPV-project exceeds the amount of internally generated funds, firms can raise money as much as they need to close down the gap between needed capital and its cash flow to invest (Richardson, 2006). In this case, firms always invest at their optimum level and adjust their financial structure without any costs involved. This optimum level of investment is known as the optimal operating size (Gao & Yu, 2020).

Under the scenario of no market frictions and imperfections, firms are investing efficiently when they undertake all projects with positive net present value (Biddle et al., 2009). Any deviation from that optimal investment policy is defined as an inefficient capital investment (Chen et al., 2011; Gao & Yu, 2020). Investment efficiency is the sensitivity of capital expenditures to its growth/investment opportunities. According to Hubbard (1998), investment or growth opportunities are measured by the expectations of positive value from additional capital investment. In other words, growth opportunities are a chance to increase the value of your firm. Since firms aim to maximise their value, a higher sensitivity to a firm's growth opportunities and/or a smaller deviation from their optimal investment level is more efficient than a low sensitivity or a large deviation.

According to a wide variety of prior research (e.g., Gao & Yu, 2020; Hubbard, 1998), Tobin's Q can be viewed as a proxy for the investment/growth opportunity. Proxies for investment opportunities can be defined as indicators summarising the incentive to invest (Gao & Yu, 2020). Therefore, in the neo-classical framework, a firm's Q ratio should be the sole driver of capital investment policy (Hayashi, 1982). Tobin's Q is the ratio between two valuations of the same asset(s) (Tobin & Brainard, 1976): the market value and the replacement cost. Therefore, if Tobin's Q is larger than 1, it indicates an increasing opportunity to invest, since the market value of the company is higher than the replacement cost. When the market values the company higher than it costs, a company should invest to increase its value. Whereas investing when the firm's value is valued lower than the replacement cost means that the value of the firm will decrease. Summarizing, Tobin's Q indicates if investment in physical assets is

stimulated and efficient firms should invest until the marginal benefit equals the costs (Tobin & Brainard, 1976).

There are two directions of inefficient investment compared to fully being responsive to growth and/or investment opportunities. Firms can either invest below or above their expected and optimal investment level (Biddle et al., 2009). Underinvesting is passing upon valuable investment opportunities or not investing when there are opportunities to increase the value of the firm. Overinvesting is investing past your optimal level. In other words, overinvesting is investing in negative NPV-projects that decrease the overall value of the firm. Both underinvesting and overinvesting is inefficient investment. Since in both cases, managers are not maximising the value of their firm. Overinvestment effectively destroys value while underinvesting managers are passive while they should increase the value of the firm.

2.1.2 Determinants of investment inefficiency

According to Modigliani & Miller (1985), every firm is able to invest efficiently due to the frictionless market and therefore is able to invest fully in response to their investment opportunities. However, firms do not operate in such a world. There are a variety of capital market frictions or imperfections that cause a firm's investment to become irresponsive to growth opportunities by diverging the costs of outside and internal capital (Chen et al., 2017). Given these imperfections on the financial markets, firms do not invest following the expected optimal investment level which leads to lower future growth, reduced operating performance and decreased firm value (Denis, 2010).

For instance, capital market frictions can impede the ability of a firm's management to raise sufficient funds from external capital markets (Richardson, 2006) and increase the costs of debt beyond the costs of internal finance making firms financially constrained. Accordingly, firms pass upon valuable investment opportunities which cause underinvestment. Other imperfections cause managers to overinvest or take too many risks to maximise their own share or to increase their own profits which damages the performance of a firm. These frictions or imperfections are among others related to asymmetric information among market participants and managerial agency problems (Chen et al., 2006; Jiang et al., 2011; Kadapakkam et al., 1998).

An example of a financial friction that drives investment down is the problem of information asymmetry. Information asymmetry has a negative effect on the firm's ability to invest following their optimal level of investment due to adverse selection (Akerlof, 1970). Adverse selection is a situation where one party has more information than the other party. In relation to investment projects, adverse selection refers to the fact that managers and outside capital providers do not have the same information about growth opportunities (Biddle et al., 2009) since this information is not shared with outside investors (Kadapakkam et al., 1998).

To prevent the risk of lending funds to value-destroying investment projects, external capital providers ask for a risk premium. Thus, asymmetric information between borrowers and lenders leads to a gap between the cost of external and internal financing (Hubbard, 1998), because the bank will increase the cost of external finance if they are not certain of a positive pay-off of the lent funds (Myers & Majluf, 1984). Therefore, adverse selection due to information asymmetry causes underinvestment. This is due to the increased cost of external capital, which makes firms more financially constrained and, consequently, firms may have to pass upon valuable investment opportunities.

Another imperfection concerns agency problems. Models of agency theory are based on the divergence of principal-agent incentives. Managerial agency problems occur when managers control the firm who are not the owners. Managers' objectives could differ from those of shareholders leading in either under- or overinvestment (Richardson, 2006), this is defined as moral hazard. Agency theory implies that managers or shareholders may decide to maximise their own value which leads to distorted investment (Gao & Yu, 2020). An example of moral hazard is that managers might provide upward-biased information about investment projects to get the positive approval of the shareholders. In addition, managers have a natural tendency to increase the size of the firm to further their own interest rather than the interests of shareholders (Jensen & Meckling, 1976). For instance, a divergence between voting rights and cash flow rights gives shareholders incentive and the ability to extract private benefits (Jiang et al., 2011). These examples cause overinvestment. Contrastingly, managers can also be conservative risk-takers to secure compensation and guarantee that they obtain their private benefits (John et al., 2008). This may lead managers to bypass risky projects that would be value-enhancing to shareholders to play it safe (Gao & Yu, 2020).

Thus, moral hazard can lead to either over- or underinvestment based on the availability of capital and the amount of risk-taking, since managers can either reject good projects or invest in bad projects to increase their personal benefits (Gao & Yu, 2020). Consistent with theories of information asymmetry, external investors are likely to recognize agency problems which lead to less access and extra costs to the required financing to invest (Biddle et al., 2009). Besides, shareholders also acknowledge the problem of the natural tendency of managers to overinvest. To prevent this, shareholders are more reluctant to approve investment projects. Depending on the nature of the investment opportunity, this may lead to reduced overinvestment or extra underinvestment.

2.1.3 Leverage

Management base their leverage on its private information about future firm growth. In theory, leverage is used when managers expect high future business opportunities while the internal resources of the company are insufficient (Grazzi et al., 2016). In other words, firms issue debt when they are not able to invest in all investment projects that increase the firms' value. In those cases, firms must rely on an external financial contribution to realise the investment project. If firms do not issue the needed debt, they have to pass upon these positive NPV investment projects which lead to underinvestment.

Following Modigliani & Miller (1958), the capital structure does not affect the value of a firm. Due to frictionless markets, internal and external funds should be perfect substitutes. However, previously mentioned frictions on the financial markets cause extra costs when using external finance. Due to information asymmetry and agency problems, costs of external funds increase through risk premiums and interest rates. This leads to financial hierarchy. According to Shcherbakov (2019), firms rely heavily on internal finance for their investment projects because firms avoid transaction costs by using sources of funds with lower costs first. So, corporate investment expenditures are strongly influenced by a firm's ability to internally generate cash (Hovakimian & Titman, 2003) since using internal capital is cheaper. So opposed to the neoclassical theory, internal and external financing are not perfect substitutes.

Due to the variety of capital market frictions or imperfections that either impedes the ability of management to raise cash from external capital markets (Richardson, 2006) or increase the costs of debt beyond the costs of internal finance, debt disciplinarily constrains and/or

decreases corporate investment (Lang et al., 1996; Myers, 1977; Stulz, 1990). Furthermore, already highly leveraged firms often have an increased limitation to borrow additional funds due to the risk of default (Cantor, 1990). Consequently, high corporate debt levels increase the difficulty for firms to attract extra funds from external finance sources (Myers, 1977) and make highly leveraged firms more dependent on internally generated funds (Cantor, 1990). All in all, because of limited availability to external capital and extra costs as a result of high leverage, investment levels decrease. Hence, firms might rely on equity financing before issuing more debt when growth opportunities are high if the firm does not have enough internal capital (Jung et al., 1996).

In the context of the effect of this reduced investment level on investment efficiency, there are two streams in the capital structure literature. Increased levels of leverage could either improve or damage the investment efficiency of corporations (Ahn et al., 2006). It depends on both the level of investment before using debt financing and the number of growth opportunities that are present to the firm. Consequently, due to the extra costs and limitations regarding debt financing, either positive net present value projects could go unfunded or firms are less inclined to invest in negative NPV projects. The two major streams argue either in favour of the problem of debt overhang (Myers, 1977) or the disciplinary role of debt (Jensen, 1986; Stulz, 1990).

According to Myers (1977), agency costs occur because of conflicts between bondholders and shareholders due to the risk of default. Myers (1977) states that debt overhang reduces the incentives to invest in positive investment opportunities since the returns on investment is partially rewarded to bondholders instead of fully to the shareholders. The shared revenue rewarded to bondholders due to costs increase with debt and thus reduce the marginal returns on investment (Gebauer et al., 2018). In addition, due to higher interest expenses as a result of corporate indebtedness, there is less funds available for investment. Hence, highly leveraged firms are less likely to exploit opportunities as compared to less leveraged companies. In other words, according to the theory of debt overhang, highly leveraged firms are less efficient and will invest less than what is expected in a frictionless market.

Another argument for inefficient investment due to a high leverage ratio is lower financial flexibility (Ferrando et al., 2017). Financial flexibility relates to the ability to undertake investment in the future regardless of the market frictions. Low financial flexibility can

potentially cause liquidity problems in the future. This is for the reason that firms that have used their ability to issue low-risk debt may pass on good investment because financing with risky securities would not be beneficial for the existing stockholders (Myers & Majluf, 1984). Therefore, firms strive to reduce debt levels to increase their borrowing power when investment opportunities increase (Ferrando et al., 2017), which leads firms to have a greater financial flexibility. Accordingly, a higher financial flexibility by having low debt levels leads to more efficient investment. Nevertheless, the desire to repair weak balance sheets by lowering external finance to increase financial flexibility leads to increased savings (Myers, 1977). Consequently, these savings, instead of investing available funds because of high leverage, cause firms to forego profitable investment opportunities.

Alternatively, Jensen (1986) argues that debt reduces the managers' tendency to overinvest and that this can be beneficial for shareholders of low-growth firms because it limits managerial discretion over free cash flows. According to the agency theory, firms with a high level of funds pursue value-destroying investments to stimulate their own interests instead of the interests of the shareholders. However, due to the transaction costs of debt to prevent this from happening, the amount of cash that otherwise could be invested decreases. This is known as the disciplinary role of debt.

Consequently, Stulz (1990) argues that the negative impact on investments prevents over-investment since extra debt payments force managers to pay out cash flow that otherwise could have been invested. Similarly, Opler et al. (1999) state that companies with excess cash after exhausting all positive NPV projects are inclined to over-invest, even when the investment opportunities appear to be poor. Lang et al. (1996) also argue in favour of the disciplinary and monitoring role of debt on investment spending. They state that leverage restricts firms with poor investment opportunities to invest when they should not. So, the theories of the monitoring role of debt argue that leverage has a positive effect on a firm's investment efficiency for naturally overinvesting firms.

2.1.4 Empirical evidence on the effect of leverage on investment efficiency

The potential effect of leverage on investment discussed in the previous section implies that leverage decreases investment levels and can either improve or damage investment efficiency depending on growth opportunities, available funds, financial flexibility/constraints and

financial costs of debt. Either, highly leveraged firms with high growth opportunities spend less on investment compared to firms that can rely on internal funds due to the problem of debt overhang, or highly leveraged firms with low growth opportunities destroy less value due to the disciplinary role of debt. In this section, the empirical evidence on the two theories of these potential effects of leverage on investment efficiency is reviewed.

In their seminal paper about the effects of leverage on investment, Lang et al. (1996) show that there is a negative relation between leverage and future growth, among others through investment, for companies in the United States. This negative effect is only significant for firms that have low growth opportunities. They argue that firms with high growth opportunities can overcome the problems of debt overhang. The increased leverage makes firms with high growth opportunities have more funds to invest in all net present value investment projects. On the other hand, highly leveraged firms with poor growth opportunities are effectively restricted to obtain external funding and therefore their investment levels decrease.

In relation to the investment efficiency theories, Lang et al. (1996) provide support for the disciplinary role of debt for firms that would otherwise have been overinvesting. Thus, Lang et al. (1996) find a positive effect of leverage on firms with substantial opportunities to invest in positive NPV and less overinvestment for firms with low growth opportunities. In addition to the empirical support for the monitoring role of debt, they state that firms with high growth opportunities that are not recognised by the market are effectively constrained to invest and, as a result, underinvest.

Aivazian et al. (2005a) extend the evidence of Lang et al. (1996) for a sample of publicly traded companies located in Canada. In contrast to Lang et al. (1996), this study considers individual firm fixed effects, as well as the use of a panel data methodology as opposed to pooling regressions. They find that the pooling regressions used in previous literature underestimate the negative impact of leverage on investment levels and the use of fixed effects improves the significance and relevance of the results. Consistent with previous literature, Aivazian et al. (2005a) find a significant negative effect of leverage on investment levels using a reduced form investment equation.

Furthermore, to assess the effect of leverage on over- and underinvestment theories, Aivazian et al. (2005a) divide the sample into high growth and low growth firms to test the two different

streams of the effect of leverage on investment efficiency via an interaction effect. The authors find evidence supporting the disciplining role of leverage in preventing overinvestment since the negative effect of leverage on investment levels is stronger for firms with low growth. The results are largely in line with the previous work of Lang et al. (1996). However, they do find that the effect of leverage on firms with high growth opportunities is negative as well. This implies that leverage has both an effect of diminishing overinvestment and increasing underinvestment following both the theory of the monitoring role of debt and the problem of debt overhang.

In a related paper, Aivazian et al. (2005b) investigate the effect of the debt maturity structure on investment behaviour. In contrast to the previous paper, long-term debt has a stronger negative effect on leverage for firms with high growth opportunities after controlling for leverage. Thus, this result provides support for the underinvestment theory of leverage in relation to long-term debt while the effect of leverage was significantly negative for both high growth and low growth firms in the previous paper (Aivazian et al., 2005a). Aivazian et al. (2005b) do not find a significant effect of debt maturity on investment for firms with low investment opportunities. The results imply that high leverage with a high maturity causes firms to pass upon positive NPV-projects.

Other studies find support for the notion that increased debt plays a valuable role in limiting managerial overinvesting tendencies via the disciplinary role of debt (Jensen, 1986; Stulz, 1990). Denis & Denis (1993) investigate the effect of large increases of leverage via leveraged recapitalizations on managerial discretion over investment policies. The results find evidence that the increased amount of debt limits the amount of investment undertaken by firms. Consistent with their expectations, these limitations appear to be valuable to the shareholders. This implies that increases in leverage have a positive effect on reducing overinvestment. The firms in their sample systematically misallocated their funds before the transactions, this indicates that there was a large amount of upwards investment inefficiency beforehand. Margaritis & Psillaki (2010) also find support for the prediction of Jensen and Meckling (1976) that leverage increases the total firm performance for overinvesting firms, due to a reduction of agency problems using the disciplinary role of debt. The results of the studies of Denis & Denis (1993) and Margaritis & Psillaki (2010) imply that there is a positive effect of leverage on investment efficiency for overinvesting firms.

Opposed to previous research, Ahn et al. (2006) find that the effect of leverage on investment is stronger for firms with high growth opportunities. Their study is in relation to diversified firms and how this influences the debt-investment (efficiency) relationship. They state that the disciplinary role of debt is partly offset by operating in different business segments. The findings suggest that higher leverage constraints investment in the segments with the highest growth opportunities. For diversified firms, the positive effect of leverage is significantly reduced and the negative relation between leverage and investment for firms with valuable investment opportunities is increased.

In addition, Ahn et al. (2006) test the effect of leverage on a direct measure of investment efficiency. They do not find a significant relationship between leverage and investment efficiency; however, the study does not provide tables of the regression results. The lack of an effect between leverage and investment efficiency occurred because of the nature of diversified firms. They argue that in cases of low leverage the firm overinvests in their low growth divisions, while in cases of high leverage they underinvest in its high q divisions. Regardless of leverage, the investment efficiency of these firms always seems to be poor. The results do imply a stronger effect of leverage on underinvestment than reducing overinvestment and therefore support the problem of debt overhang proposed by Myers (1977).

Firth et al. (2008) also find different results compared to the evidence until then. For a sample of Chinese firms, they find evidence of the existence of a debt overhang problem and discover that the negative effect of leverage on investment is weaker for firms with low growth opportunities compared to firms with high growth opportunities. This result is in line with the theory of the underinvestment problem of highly leveraged firms. They explain that Chinese banks impose fewer constraints on capital spending of poorly performing firms and therefore the disciplinary role of debt on overinvesting firms does not hold. The lenient lending policies for low growth firms even create more overinvestment. So, the results of Firth et al. (2008) imply a negative effect of leverage on investment efficiency in both directions.

According to Ferrando et al. (2017), having a low leverage level increases a firm's financial flexibility. Financial flexibility is directly related to the ability to pursue new investment projects and is the opposite of being financially constrained. They find that for a large sample of listed and unlisted European firms having a low leverage policy increases financial flexibility.

Firms that maintain a low leverage policy for at least three years, increase their capital expenditure by 22.6%. This means that high leverage constrains the financial flexibility and low leverage levels help to diminish underinvestment problems. Moreover, these results indicate that firms with low levels of leverage are less exposed to capital market imperfections. This means that a low level of leverage increases the firms' ability to invest efficiently since their investment levels are not limited by costs associated with agency and information asymmetry problems.

Lastly, Dang (2011) extends the literature on the debt-investment relationship by examining the underinvestment problem and its effect on the choice of leverage and debt maturity. For a sample of firms from the United Kingdom, they find that firms with valuable growth opportunities decrease their debt levels to control the underinvestment problem. While the firms in the sample adopt low-leverage strategies to diminish underinvestment problems, no evidence is found that this enables the firms to exploit more valuable investment opportunities due to the effects of leverage ex-post. In regards to debt maturity, Dang (2011) find that long-term debt maturity limits high-growth firms from exploiting valuable growth opportunities. Consequently, having a high debt maturity causes inefficient investment. This is in line with previous research on the effect of long-term debt on investment efficiency (Aivazian, 2005b).

All in all, prior research finds support for both potential effects of leverage on investment efficiency. Mostly, the direction of the effect of debt on investment efficiency depends on the number of growth opportunities of a firm. For firms with low growth opportunities, the incentive to overinvest is very large and leverage can effectively diminish these overinvestment problems. On the other hands, firms with high growth opportunities are actively limited by the extra costs and limitations of leverage on their capability to invest. In addition, long-term debt increases the financial constraints of leverage on investment capability and, consequently, increases the negative effect of leverage on investment.

In most of the prior research, the effect of leverage on investment efficiency is not measured directly. Instead, prior research largely focuses on changes in and the effects of leverage on investment levels and how growth opportunities moderate this effect. In the discussed research, investment efficiency is related to the presence of growth opportunities and if the negative effect of leverage on investment is stronger for either low growth firms or high

growth firms. This study extends the prior research by a direct measure of investment efficiency and analysing the effect of leverage on total investment efficiency, underinvestment and overinvestment in relation to a shock on the market. The next section explains this shock, the European sovereign debt crisis, and its potential effects on the debt-investment efficiency relationship.

2.2 The European sovereign debt crisis

In this section, prior research on the European sovereign debt crisis and its effects on leverage and investment efficiency is reviewed and compared. Section 2.2.1 describes the events that caused the European sovereign debt crisis. Following, Section 2.2.2 explores the effects of the European sovereign debt crisis on borrowing conditions for corporations and their ability to invest following their investment opportunities. Lastly, Section 2.2.3 reviews the empirical evidence on the effects of the European sovereign debt crisis on leverage and corporate investment. In addition, the evidence is related to the impact of the European sovereign debt crisis on the relationship between leverage and investment efficiency.

2.2.1 Causes of the European sovereign debt crisis

In 2010, Europe entered a severe sovereign debt crisis. The European sovereign debt crisis significantly disrupted, restricted and put limitations on financial markets and economic activity, both of which were still affected by the impact of the global financial crisis of 2008 (Ferrando et al., 2019). Following these restrictions, borrowing costs for indebted countries reached levels that threatened their ability to service their debt, banks tightened their supply and economic confidence hit a new all-time low. The sovereign debt crisis was a result of the accumulation of the effects of the global financial crisis, international trade imbalances and failing bailout approaches (Ullah, 2014). This section describes the events that caused the sovereign debt crisis, starting from the global financial crisis of 2008 which triggered a lot of financial risks for both governments, banks and corporations.

The financial crisis that led to the Great Recession of 2008 was triggered by an unsustainable housing industry asset bubble and a credit boom in the United States. The spreads on credit instruments and the ratio of house price to rental income were at their all-time extremes (Acharya et al., 2009). The housing prices failed to rise which led to a collapse of trust in the

credit market (Acharya et al., 2009) and untidy financial regulations and supervisions by banks (Kenc & Dibooglu, 2010). Overall, an increase in uncertainty caused a loss of confidence in the solvency and liquidity of financial institutions (Ivashina & Scharfstein, 2010).

The financial crisis began with a dramatic contraction in global growth which also hit Europe (Allegret et al., 2017). When the crisis started, national governments tended to focus on national-level responses. To prevent a larger collapse in economic activity, they quickly realized that international coordination was needed to survive (Quaglia et al., 2009). Consequently, on the 26th of November 2008, the European Commission proposed a European stimulus plan, also known as the European Recovery Plan (European Commission, 2008). It included 200 billion euros to cope with the effects of the global financial crisis, and it aimed among others to stimulate demand and to encourage investments. Incentives to take such actions were that the financial market conditions remained to stay fragile and tighter for longer than expected. Actions were needed to tackle the recession because "the risk is that this situation will worsen still further: that investment and consumer purchases will be put off, sparking a vicious cycle of falling demand, downsized business plans, reduced innovation and job cuts" (European Commission, 2008, p.4).

Throughout 2008 and 2009, there was little concern about European sovereign debt (Lane, 2012). Instead, the focus was on actions that were needed to tackle the recession. Unfortunately, the massive interventions of European governments and central banks to support aggregate demand and the bailouts of insolvent financial institutions caused a notable decrease in public finance (Allegret et al., 2017; Gonçalves et al., 2020). A large number of European governments had large imbalances on their balance sheets, which endangered their ability to service their debt (Ferrando et al., 2017). Due to this threat of default, which is also known as sovereign risk, the value of government bonds decreased.

Due to the intensification of sovereign risk exposure of financial institutions, resulting from the decline of countries' creditworthiness and financial institutions holding a lot of government bonds, a deterioration of bank funding conditions was triggered (Keddad & Schalck, 2019). This was a consequence of declining equity returns for the European banks (Allegret et al., 2017). The large sovereign exposures of financial institutions and declined returns reduced the availability of bank credit for firms during the debt crisis. Consequently,

the absence of bank credit availability affected corporate consumption and investment (Allegret et al., 2017; Acharya et al., 2018).

The lack of growth made indebted countries insolvent. In addition, bailouts of heavily indebted countries bailouts by European governments and central banks to improve the financial situation, prevent further decline of economic activity and support aggregate demand, did not make these risks disappear (Allegret et al., 2017). On the contrary, the bailout policies transferred the sovereign risks across the whole European Union (Kalbaska & Gatkowski, 2012). Furthermore, due to the extensive cross-border lending relations in Europe (Acharya et al., 2018), European firms that were not directly affected by the sovereign debt crisis still had to face indirect consequences. The bailouts and cross-border spillovers amplified the shock transmission across the eurozone (Acharya et al., 2018). This led to the emergence of a new phase for Europe: the European sovereign debt crisis.

2.2.1 Corporate debt and investment during the sovereign debt crisis

The normal role of a bank is to provide liquidity and support investment (European Commission, 2008), however, due to the losses on the balance sheets of financial institutions because of the intensification of sovereign risk by holding sovereign bonds, banks needed to deleverage (Acharya et al., 2018). Financial institutions were unable to diminish the consequences of liquidity shortages on their balance sheets (Kousenidis et al., 2013) and the increase in sovereign risk further exacerbated the financial troubles already encountered by the banking sector following the financial crisis of 2008 and onwards (Keddad, 2019). This caused banks to cut their lending drastically since banks with high liquidity risk exposure tend to hold and build up cash and other liquid assets as opposed to involving in new loan commitments (Cornett et al., 2011; Keddad, 2019). Overall, financial institutions raised the costs of external financing and decreased the availability of credit that could be borrowed for corporate investment (Acharya et al., 2018; De Marco, 2019; Dorsman & Gounopoulos, 2013). In other words, the ability of corporations to issue debt for financing investment decreased due to the effects on the European banks.

The credit crunch caused by the increased sovereign risk of default for banks led to a significant decline in corporate investment due to limited access to external debt capital to fund all positive NPV projects (Mercatanti et al., 2019). The drop in investment was caused by

the increased costs of debt and limited access to increase debt levels, which led to higher external financial constraints for European firms (De Marco, 2019). The extra shock on the banking sector increased the problems of debt overhang for bank-dependent firms since obtaining funds is even more limited for firms that already have a large amount of external financing. This causes firms to be less inclined to invest in attractive investment opportunities. When firms cannot raise the funds needed to pursue positive NPV investment opportunities, the capital expenditure is expected to be below that of less constrained firms with similar investment opportunities. This implies that the sharp decline of access to credit during the European sovereign debt crisis caused underinvestment for firms with substantial growth opportunities.

The leverage levels of many European companies increased rapidly in the years preceding the crises. Easy access to credit and strong increases in investment caused an escalation of corporate debt (Gebauer et al., 2018). When the financial crisis started and evolved into the sovereign debt crisis, the high debt levels made firms vulnerable to the shift in risk sentiment and the fall in asset prices and profits. Because profits decrease, outcomes of investment are uncertain (Campello et al., 2010). Uncertain investment outcomes lead to higher information asymmetries (Kahle & Stulz, 2013). Consequently, higher information asymmetries decrease the capability of firms to obtain external financing due to the increased risk of default and/or the risk of value-destroying investments.

Firms and banks become more cautious and passive in the face of uncertainty, as a result, uncertainty leads to a reduction in firms' responsiveness to investment opportunities which is defined as inefficient investment (Badertscher et al., 2013). Firms want to decrease the risk of investing in high-risk investment projects since the effects of investing in negative NPV projects weigh even more on the profitability of the firm than before a crisis. In case of uncertainty, firms hoard cash to diminish the increase of financial risks (Kahle & Stulz, 2013) and therefore are much more dependent on internal funds (Campello et al., 2010). This leads to inefficient investment since risk-averse managers have a higher tendency to bypass positive net present value projects due to the increased volatility of outcomes.

In contrast to the expectation of underinvestment due to a reduction in credit supply or high uncertainty of investment outcomes, demand shocks could also have an effect on the decline of corporate investment (Balduzzi et al., 2018; De Marco, 2019). Demand shocks due to a crisis

can explain both the decrease in capital expenditure and a decrease in debt issuance. Demand shocks are related to decreasing growth opportunities. A decrease in demand reduces capital expenditures since there are less positive NPV investment opportunities to invest in. When a shock in demand explains the fall in investment, firms require less financing. This causes the debt issuance to decline. If demand shocks explain the decline of investment instead of credit shocks, firms can still invest according to their investment opportunities. In the case of demand shocks, there is no effect of the European sovereign debt crisis on investment efficiency.

2.2.2 Empirical evidence on the effect of the European sovereign debt crisis on the debt-investment efficiency relationship

Corporate indebtedness in European countries during the sovereign debt crisis inhibited investment spending. However, it is not known if the decline of investment caused a misallocation of capital since the decline of investment could be explained by funding shocks, demand shocks or a combination of the two. This study adds to the literature by evaluating the investment efficiency of European firms during the European sovereign debt crisis. Therefore, there is no direct empirical evidence on the effect of this crisis on the debt-investment efficiency relationship (Gebauer et al., 2018; Guler, 2019). In this section, empirical evidence on the effects of the sovereign debt crisis on leverage, investment and the effect of leverage on investment is reviewed. Consequently, previous research is related to potential implications for the effects on corporate investment efficiency following the theories of debt overhang and the monitoring role of debt.

Gebauer et al. (2018) find a significantly negative effect of leverage on investment for a large sample of European companies. The authors find a non-linear relationship by differentiating between high and low debt regimes. Highly leveraged firms invested significantly less than their low leveraged peers. They state that the effects of debt overhang distort investment due to higher default risks and costs of financing for companies with excessively high debt. For lower leverage policies they do not find that leverage constraints investment pre-crisis which implies a lower degree of financial constraints for these firms. However, post-crisis moderate or low debt policies have a negative effect on investment spending as well. Consequently,

during a crisis, even low levels of debt cannot be tolerated due to stronger financial constraints and higher risk aversion.

In their research, Gebauer et al. (2018) state that they do not take a stance on the fact that the reduced investment is caused by demand or supply effects or the effect of the banking shock on the supply of credit. However, they do state that firms with weak balance sheets need to bypass valuable investment opportunities. In addition, they find that for firms with low profitability, the effect of leverage on investment is significantly negative in both high and low debt regimes. Therefore, this study implies that the sovereign debt crisis has a negative effect on investment efficiency and augments the negative effect of leverage on investment spending because of greater constraints.

In a recent paper, Barbiero et al. (2020) study whether market frictions, in the form of firm and bank related agency problems, and its effect on leverage might have affected the relationship between growth opportunities and investment. As a part of the study, they assess the influence of a banking crisis on the relationship between debt, growth opportunities and investment for a sample of 8.5 million firms from 22 European countries between 2004 and 2013. Barbiero et al. (2020) define the crisis as the period from 2008 onwards, this period spans the financial crisis and the beginning of the sovereign debt crisis. Firstly, they find that while leverage reduces firm investment and that this effect is less pronounced for firms operating in sectors facing good global growth opportunities. This result is in line with the theory of the monitoring role of debt on investment.

Furthermore, Barbiero et al. (2020) find that during a banking crisis leveraged firms invest less than during normal financial circumstances. In addition, for the same level of debt, the negative effect of a banking crisis on investment is larger for firms in sectors facing good growth opportunities. This is in contrast with the results during non-crisis periods. The results of Barbiero et al. (2020) imply that due to a banking crisis firms with high growth opportunities invest less when they are highly leveraged. If the reduced investment implies underinvestment depends on the level these firms were investing before the crisis. However, since the effect of debt on investment during a crisis is higher for firms with high growth opportunities, the results seem to be in line with the theory of debt overhang when firms enter a crisis.

Acharya et al. (2018) investigate the effects of the sovereign debt crisis on corporate policies of European firms. Firstly, due to large sovereign bond holdings, banks from GIIPS countries (Greece, Italy, Ireland, Portugal and Spain) lost on average 10.8% of their equity while banks from other European countries lost on average 6% of their equity. Due to these losses on the balance sheets of financial institutions banks needed to deleverage, which caused a reduced loan supply. The authors argue that this reduced loan supply or credit crunch following the European debt crisis was an important contributor to the severity of the crisis. Firms with a lending relationship with banks that suffered heavily from the sovereign debt crisis became financially constrained. Acharya et al. (2018) find evidence that leveraged firms had on average lower levels of investment. In relation to investment efficiency, the results imply that firms were significantly hit by the reduction of credit supply. The banks' pressure to deleverage seemed to be the most important determinant for the low investment levels of European firms. This indicates that firms could not invest following their growth opportunities. Consequently, this study implies that firms invested inefficiently during the European sovereign debt crisis and that the drop in investment was not explained by decreasing growth opportunities.

Bucă & Vermeulen (2017) analyse the effect of bank credit tightening on firm investment during the financial crises from 2008 until 2014. They examine a panel dataset of aggregated balance sheet data for different manufacturing industries in six countries out of the euro area (Germany, France, Italy, Spain, Belgium & Portugal). Consistent with Acharya et al. (2018) they hypothesize that corporations dependent on bank financing to invest in their investment opportunities should reduce investment more than firms that are less dependent on bank financing. They find that investment by borrowers more dependent on banks drops significantly more relative to firms that are independent of banks. Bucă & Vermeulen (2017) also find that the negative effect of the shock of credit supply on investment holds after controlling for demand shocks. All in all, the combination of large bank dependence of the euro area combined with a significant credit crunch caused the large decline in aggregate capital expenditure and indicates a negative effect of leverage and the crisis on investment efficiency. The results strongly suggest that investment in the crisis period would not have been as weak if firms were less dependent on bank finance. This implies that investment was

not purely decided by their respective growth opportunities and therefore implies that the European sovereign debt crisis caused underinvestment.

The general effects of a high European bank dependence are also shown by Cingano et al. (2016). The sample involves Italian firms and banks during the financial crisis between 2007 and 2010. Their analysis shows that a firm's investment decisions are highly sensitive to the availability of bank credit and that firms with high debt significantly invest less than less leveraged firms. Based on a range of alternative estimations, they suggest that the investment expenditure of an average firm would have increased 25 to 35 cents per additional euro of available credit during the Great Recession of 2007-2010. Without the negative supply shock or the credit crunch, total investment from 2007 to 2010 would have been 24 per cent higher than the capital expenditure that was observed. While the results are for the period before the sovereign debt crisis, the implications are expected to be roughly the same for the period afterwards. This study implies that Italian firms were roughly constrained to invest due to the lack of credit supply. These results indicate that leveraged firms underinvested during the financial crisis of 2008 and this is probably worse during the sovereign debt crisis due to the increased frictions on the capital markets.

Comparably to Cingano et al. (2016), Balduzzi et al. (2018) test the effect of changes in the credit supply conditions of banks on the investment decisions of firms for a sample of Italian firms from 2006 to 2013. Therefore, this sample covers both the financial crisis and the sovereign debt crisis. The authors find robust evidence that higher banks' cost of funding results in less investment. This effect is most significant for young and small firms. In addition, they do take demand shock effects into consideration. Controlling for demand shocks, Balduzzi et al. (2018) still find a negative effect of the credit supply shock on corporate investment it indicates that firms were pressured to invest less than they would have if the credit crunch was not present. Furthermore, the effects of the European sovereign debt crisis on investment were larger than the effects of the financial crisis. Consequently, firms had to bypass substantive profitable investment opportunities during the sovereign debt crisis.

Opposed to previously reviewed literature which indicates that even low levels of leverage impede investment during the European sovereign debt crisis (Bucă & Vermeulen, 2017; Gebauer et al., 2018), Ferrando et al. (2017) find that moderate levels of leverage can be beneficial for firms during a crisis. In particular, Ferrando et al. (2017) find for a large sample

of European private and public firms that accumulated spare debt capacity through a conservative leverage policy allows firms to raise external financing and undertake investments when there is an opportunity to grow during financial shocks. They state that financial flexibility can be attained through a conservative leverage policy. Accordingly, a higher degree of financial flexibility allows firms to reduce the negative impact of liquidity shocks on investment and leverage levels increase significantly more for these firms during a crisis period. Extrapolating to the sovereign debt crisis, financial flexible firms with low leverage levels face limited restrictions and could have enough borrowing power to increase their leverage to invest in more positive net present value projects. In contrast, highly leveraged firms are effectively constrained to increase their external finance using debt. Consequently, the amount of investment of highly leveraged firms decreases more compared to firms with less debt on their balance sheets.

Summarising, most prior research on the effects of the financial crisis or European sovereign debt crisis on the debt-investment efficiency relationship indicate that high corporate leverage was the main determinant of the investment drop due to the credit crunch. In particular, high leverage imposes firms to decrease their investment below the optimal level following the increased financial costs and constraints of debt financing. As opposed to previously mentioned research, Mercatanti et al. (2019) find that debt was not a significant determinant of the decreased investments during the crisis over a period between 2006-2012 for a sample of listed European firms. Instead, they find evidence that corporate investment has been primarily driven, albeit weak, by changes in firm-level fundamentals and investment opportunities, measured as Tobin's Q during the sovereign debt crisis. In other words, according to this study, investment declined because of a decline in investment demand following decreasing investment opportunities. Thus, investment followed the declining growth opportunities and, consequently, firms invested efficiently.

Mercatanti et al. (2019) do find that costly external finance has influenced the investment decisions of public European firms during the most acute phase of the crisis period between 2008 and 2012. During the financial crisis between 2008 and 2009, they find a significant negative effect of short-term debt on investment. However, when they divide the sample into the financial crisis and the sovereign crisis, this negative effect of debt is not significant during the sovereign debt crisis. Mercatanti et al. (2019) argue that large listed firms have enough

internal capital to be able to overcome the financial risks and follow their growth opportunities. Therefore, this study implies that there is no effect between the sovereign debt crisis and investment inefficiency. However, the sample period ends before the peak of the sovereign debt crisis ends.

Similar results are found for U.S. firms during the financial crisis. For example, Kahle & Stulz (2013) do not find evidence in support of a direct link between a bank lending supply shock and financial and investment policies during the financial crisis. Neither net debt issuance nor capital expenditures decrease more for bank-dependent firms compared to bank independent firms. They note that the impact of the bank lending supply shock is limited when firms can access substitute sources of funds, like cash public debt, issue equity and the sale of assets. Put differently, according to Kahle & Stulz (2013) firms had enough alternative ways of obtaining funds to pursue all positive NPV-projects. The results of Mercatanti et al. (2019) and Kahle & Stulz (2013) imply that, during a credit crunch following a crisis, firms might still be able to pursue their growth opportunities independent of their debt levels due to alternative ways of funding.

2.3 Hypotheses

In this section, testable hypotheses are developed based on the review of theories and empirical evidence concerning 1) the effect of leverage on investment (in)efficiency and 2) the effect of the European sovereign debt crisis on the debt-investment efficiency relationship. Section 2.3.1 develops hypotheses based on the over- and underinvestment theories of external debt financing and the effects of leverage on the (in)efficiency of corporate investment. Section 2.3.2. develops hypotheses based on the empirical evidence on the role of the European sovereign debt crisis on a firm's investment behaviour and investment decisions and the role of the European sovereign debt crisis on the impact of corporate leverage on investment efficiency.

2.3.1 Effect of leverage on investment efficiency

According to Modigliani and Miller (1958), a perfect world does not have market friction and the financial structure of a company is irrelevant. In such a world, investment spending would only be determined by investment opportunities. However, there are a variety of capital market frictions or imperfections that cause managers to become irresponsive to growth

opportunities. Given these imperfections on the financial markets, firms do not invest to the expected optimal investment level. These frictions or imperfections are among others related to asymmetric information among market participants (Chen et al., 2006) and managerial agency problems (Jiang et al., 2011). Frictions on the financial market limit the ability of firms to raise credit from external capital markets and increase the costs of debt beyond the costs of internal finance. This makes the financial structure of a company relevant since it has an impact on the value of the firm.

Ideally, leverage is solely based on a firm's expectation of future investment opportunities. Firms should raise their leverage if the amount of internal funds is insufficient to pursue all positive net present value investment projects. However, external finance is costly and having a high debt level reduces the access to extra external debt due to the risk of default. Thus, for highly leveraged firms raising external funds is difficult. Therefore, leverage has a negative effect on investment levels since leverage reduces a firms' ability to pursue investment opportunities.

In relation to the efficiency of the decreased investment levels due to leverage, there are two streams of literature regarding the effect of leverage. Increased levels of leverage could either improve or damage investment efficiency (Ahn et al., 2006). It depends on both the level of investment before using debt financing and the amount of growth opportunities that are present to the firm. Consequently, due to the extra costs and limitations regarding debt financing, either positive net present value projects could go unfunded or firms are less inclined to invest in negative NPV projects.

The two major streams argue either in favour of the problem of debt overhang (Myers, 1977) or the disciplinary role of debt (Jensen, 1986; Stulz, 1990). In cases of debt overhang, debt causes underinvestment due to the extra costs of debt. Since profits are partially rewarded to bondholder instead of fully to the shareholders, marginal returns on investment decrease. In addition, when corporate leverage is high, firms might be unable to increase their debt levels when growth opportunities are higher than the available funds to spend on investment projects. Consequently, highly leveraged firms are less likely to exploit all profitable opportunities as compared to less leveraged companies. Alternatively, according to agency theory (Jensen, 1986), firms with a high level of funds pursue value-destroying investments to stimulate their own interests instead of the interests of the shareholders. Based on the same

assumptions of the problem of debt overhang, leverage restricts firms with poor investment opportunities to invest when they should not. Due to the fact that firms have higher costs related to debt financing, not all funds can be invested in poor investment opportunities. This is defined as the disciplinary role of debt which causes a reduction in overinvestment.

Prior research found empirical evidence that leverage disciplinarily decreases the amount of investment following the increased financial costs of debt funding (e.g., Ahn et al., 2006; Aivazian et al., 2005a; Firth et al., 2008; Lang et al., 1996; Myers, 1977). However, these studies find support for both potential effects of leverage on investment efficiency. When referring to the two streams of theories, prior research often refers to the growth opportunities of a corporation. For firms with low growth opportunities, the incentive to overinvest is very large and leverage can effectively diminish this tendency. On the other hands, firms with high growth opportunities are actively limited by the extra costs and limitations of leverage on their capability to invest which leads to underinvestment. In addition, Aivazian et al. (2005b) and Dang (2011) find that the effect of leverage is stronger for long-term debt compared to debt with a shorter maturity.

The difference between investment affected by market frictions and investment solely determined by growth opportunities is the investment efficiency of a firm. When investment is not solely based on growth/investment opportunities of the firm, investment is inefficient. The chance of investing below the optimal level of investment increases with leverage because increased leverage creates more financial constraints to obtain and spend funds to invest in all positive NPV-projects compared to using internal funds. Consequently, high leverage levels increase the interest costs paid to bondholders which decreases the marginal returns of investment projects. While for overinvesting firms the effect of increased leverage helps to diminish the upwards inefficient investment, for extreme levels of leverage, overinvestment can turn into underinvestment.

When looking at investment efficiency in total, there is an increased chance that even for firms with low growth opportunities the problems of debt overhang caused by increasing levels of debt impede firms to invest in all profitable investment opportunities. Thus, it is expected that firms with extremely high leverage underinvest below their expected investment regardless of their respective growth opportunities. Following the theories of leverage on investment and the empirical evidence, the three hypotheses are developed. H1 tests the effect of

leverage on investment efficiency as a whole where it is expected that the theory of debt overhang is stronger than the monitoring role of debt. H1a and H1b decompose the leverage - investment efficiency relationship into the predicted effect of leverage on the amount of under- and overinvestment following the theories of debt overhang and the monitoring role of debt. This results in the following hypotheses:

H1: Leverage has a negative impact on investment efficiency.

H1a: Leverage increases the amount of underinvestment.

H1b: Leverage decreases the amount of overinvestment.

2.3.2 Effects of the European sovereign debt crisis

In late 2010, Europe entered a severe sovereign debt crisis. The European sovereign debt crisis significantly disrupted, restricted and put limitations on financial markets and economic activity, both of which were still affected by the impact of the global financial crisis of 2008 (Ferrando et al., 2019). Following these restrictions, borrowing costs for indebted countries reached levels that threatened their ability to service their debt, banks tightened their supply and economic confidence hit a new all-time low. The sovereign debt crisis was a result of the accumulation of the effects of the global financial crisis, international trade imbalances and failing bailout approaches (Ullah, 2014). Due to these restrictions and limitations, corporate investment declined significantly all over Europe. The reduced investment could either be caused by a shock on credit supply or a shock in demand for external funds due to decreasing growth opportunities. These explanations have different implications on the effect of the crisis on investment efficiency.

Firstly, due to an intensification of sovereign risk exposure of financial institutions, resulting from the decline of countries' creditworthiness, a deterioration of bank funding conditions was triggered. The large sovereign exposures of financial institutions reduced the availability of bank credit for firms which in turn affected corporate consumption and investment. Overall, financial institutions raised the costs of external financing and the availability of credit that could be borrowed for corporate investment decreased. Therefore, following the credit supply shock investment fell rapidly below the optimal level, which indicates underinvestment.

Secondly, demand shocks can potentially explain both the decrease in investment and the decrease in debt issuance that was found in previous literature (Mercatanti et al., 2019). A

decrease in demand reduces capital expenditures as some growth and investment opportunities are no longer adding positive net present value. When a shock in demand explains the fall in investment, firms require less financing. This causes the debt issuance to decline. According to demand shocks, firms are investing according to their respective growth opportunities, and therefore, are investing efficiently.

The empirical evidence on investment during the European sovereign debt crisis is largely in favour of the negative effects of a credit supply shock (e.g., Acharya et al., 2018; Bucă & Vermeulen, 2017). For example, Barbiero et al. (2018) find that for firms with the same level of debt the negative effect of a banking crisis on investment is larger for firms in sectors facing good growth opportunities. This indicates that the European sovereign debt crisis caused underinvestment. Prior research in favour of the demand shock effect on investment (e.g., Kahle & Stulz, 2013; Mercatanti et al., 2019) did not include the peak of the sovereign debt crisis or investigated U.S. firms during the financial crisis. In addition, Bucă & Vermeulen (2017), Balduzzi et al. (2018) and Barbiero et al. (2020) find that the negative effect of the shock of credit supply on investment levels hold even after controlling for demand shocks.

Therefore, this study assumes that the credit supply shock, because of the heavy credit dependence of European firms, restricted investment below the optimal level even when growth opportunities declined. Because of limited access to external debt capital and other constraints on the financial markets imposed by the European sovereign debt crisis, firms could not fund all positive NPV projects by raising their constrained capital to the optimal level. Therefore, during the European sovereign debt crisis, firms are expected to invest below their respective growth opportunities. Consequently, the following hypothesis is developed:

H2: The European sovereign debt crisis has a negative impact on investment efficiency.

When a credit supply shock explains the effect of the crisis on the decreased investment, the effect of the credit supply shock increases the problems of debt overhang. Problems of debt overhang closely relate to access to external capital in the form of debt and the financial costs of debt. During the credit crunch, the access was lower and the financial costs were higher. Consequently, Gebauer et al. (2018) suggest a stronger negative effect of leverage on investment during the sovereign debt crisis. The authors state that for companies with excessively high debt, the effects of debt overhang distort investment below optimal due to

higher default risks and costs of financing. In addition, when they divide the sample into low- and high-debt regimes, during the crisis even moderate and low debt policies have a negative effect on investment spending as well. Consequently, during a crisis, even low levels of debt cannot be tolerated due to stronger financial constraints and higher risk aversion. Barbiero et al. (2020) also find that leverage has an increased negative effect on leverage during the crisis periods. Moreover, they find that this effect is more pronounced for firms that have high growth opportunities which is in line with the debt overhang theory.

Thus, prior research on the effects of the European sovereign debt crisis on the debt-investment efficiency relationship indicates that high corporate leverage was the main determinant of the investment drop due to the credit crunch. In particular, high leverage imposes firms to decrease their investment below the optimal level following the increased financial costs and constraints of debt financing. Other empirical evidence (e.g., Acharya et al., 2018; Bucă & Vermeulen, 2017) show that firms with a lending relationship with banks suffered heavily from the sovereign debt crisis and became financially constrained. These firms had on average lower levels of investment compared with firms independently of bank credit. In addition, while Mercatanti et al. (2019) argue in favour of a demand shock. They do find a negative effect of leverage on investment during the most restricted period of the crisis period.

Opposed to these ideas, Ferrando et al. (2017) find that firms with low leverage are able to overcome the extra financial risks that occurred due to the sovereign debt crisis. Low leverage policies increase the borrowing power of these firms which makes them capable to increase their leverage even in difficult conditions. Therefore, this study implies that firms with low leverage are able to invest better in response to their investment opportunities when a crisis starts. In contrast, firms with high leverage do not have to the power to obtain more external funds and face high financial costs due to the risk of default. As a result, it is possible that firms with high leverage were able to increase their leverage despite the financial restrictions to invest following their growth opportunities

When the assumption is that the credit supply shock explains the decline in corporate investment, highly leveraged firms are even more restricted to obtain sufficient external capital to fund all positive investment opportunities. Next to that, the negative effect of leverage on investment efficiency should be larger, because highly leveraged firms do not

have a significant continuous stream of internal funds to finance attractive investment opportunities and financial costs of debt increased due to the shock on banks. Therefore, it is expected that during the European sovereign debt crisis leverage had a stronger negative effect on investment efficiency compared to the years after the crisis when conditions loosened. Consequently, the following hypothesis is developed:

H3: The European sovereign debt crisis strengthens the negative effect of leverage on investment efficiency.

3. Methodology

In this chapter, the methodology used to answer the research question and test the hypotheses is explained. In short, to test the effect of (the European sovereign debt crisis on the impact of) leverage on investment efficiency, multiple regressions are done. Firstly, the investment (in)efficiency of every firm in the sample is measured by estimating the extent to which a firm's investment deviates from the expected/optimal level of investment. The optimal level of investment is measured following a regression on a selection of variables measuring growth opportunities, following a wide variety of prior research (e.g., Biddle et al., 2009; Goodman et al., 2014; McNichols & Stubben, 2008). The residuals of the optimal investment equation are used as the dependent variable (total investment inefficiency, underinvestment & overinvestment) of the main regressions which investigate the effect of leverage and the crisis on the investment efficiency of a sample of European firms during and after the European sovereign debt crisis.

First, Section 3.1 explains the regressions used to estimate total investment efficiency, underinvestment and overinvestment. In Section 3.2, the research methodology to test the hypotheses is described and discussed. Section 3.3 explains the measurement of the variables. Lastly, in Section 3.4, robustness and additional tests are stated to further extend the research.

3.1 Estimation of investment efficiency

The aim of this study is to test the effect of leverage on investment efficiency. Before formulating and developing the regressions which test the hypotheses to answer the research questions, investment efficiency has to be estimated. Since the direct effect of leverage on a measure of investment efficiency has not been studied before, this study is not able to directly follow a specific research methodology of prior research of leverage on investment efficiency. Prior research on leverage and investment (e.g., Ahn et al., 2006; Aivazian et al., 2005a; Firth et al., 2008; Gebauer et al., 2018; Lang et al., 1996), do regressions using investment levels as the dependent variable instead of measures of investment efficiency. When these papers include and refer to theories about the debt-investment efficiency relationship, they relate to the effect of leverage for firms with respectively high and low growth opportunities. When the negative effect is higher for firms with high growth opportunities, this implies that they

had to invest less than their optimal level. In contrast, for firms with low growth opportunities, a negative effect of leverage on the investment level means that firms are hindered in spending above their optimal level. While dividing firms into high and low growth opportunities gives an indication about the direction of reduced investment, it is not definitive. This approach does not take into account the level of investment of a firm in relation to the optimal level and, subsequently, it is possible that a firm with good growth opportunities was investing above their optimal level. Nevertheless, these papers are interested in the effect of leverage on investment and what investment efficiency theory is applicable to the reduced investment because of high leverage. The amount of (in)efficiency is mostly not of interest and, therefore, using growth opportunities as an indicator for over- or underinvestment is sufficient.

The most common approaches to estimate the amount of investment efficiency in previous literature are either investment sensitivities to Tobin's Q and/or cash flows, or the residual from an optimal investment level regression based on growth opportunities (Gao & Yu, 2020). Both approaches conceptualise investment efficiency to the fact that firms have to undertake all and only projects with positive net present value (Chen et al., 2011). Models of investment-q and investment-cash flow sensitivities assume that a higher sensitivity to Q or a lower sensitivity to cash flow equals a better investment efficiency. The assumption is that if the investment is related to internal cash flow, it is not completely following growth opportunities measured by Tobin's Q (Biddle & Hillary, 2006). To indicate the effect of a certain variable on investment efficiency, the variable of interest is interacted with the q- or cash flow sensitivity. The direction of this interaction indicates the effect of the variable on investment inefficiency. However, solely using the interaction of leverage with a proxy of investment opportunities on investment may cause serious measurement errors. In addition, there is no direction of inefficiency. A low sensitivity to growth opportunities does not directly imply over- or underinvestment.

To avoid the problems of using a single interaction term that does not explain either under- or overinvestment, a range of studies (e.g., Aivazian et al., 2005a; Bae et al., 2017; Biddle et al, 2009; Chen, 2011; Gomariz et al., 2014; Goodman et al., 2014; McNichols & Stubben, 2008) assume that investment is a function of the investment opportunities measured by multiple proxies. The fitted value of this function can be defined as the optimal investment for a firm

in a certain year and the difference between the optimal investment and the realised investment is the amount of suboptimal investment or investment inefficiency. Gao & Yu (2020) explain that this method is most appropriate when the suboptimal investment is the focus of the study. In addition, as opposed to investment efficiency measures using sensitivities, investment efficiency based on the expected value of investment can be split into underinvestment and overinvestment based on the value of the residual which can give extra insight into the effect of leverage on investment efficiency.

Therefore, this study follows a commonly used estimation approach which investigates a two-step regression procedure in which a first-step regression divides a variable in its expected or predicted component based on investment opportunities and its unexpected/abnormal component which signals inefficiency. This thesis follows prior studies (Biddle et al., 2009; Chen, 2011; Goodman et al., 2014; McNichols & Stubben, 2008) by measuring investment (in)efficiency by estimating the extent to which a firm's investment deviates from the expected level of investment given by its investment opportunities. Specifically, the amount of unexpected investment or investment inefficiency is calculated as the absolute value of the residuals from an investment equation based on investment opportunities. The advantages of this measure are that investment efficiency is directly quantified and it can be measured on a corporate level instead of industries or countries. In addition, this measure creates a divide between overinvesting (positive deviations from the optimal level) and underinvesting (negative deviations from the optimal level).

To estimate the abnormal component of investment, investment has to be defined first. Most prior research on investment focus on capital expenditure as the measurement of corporate investment (e,g., Aivazian et al., 2005a; Badertscher et al., 2013; Firth et al., 2018; Gebauer et al., 2018; Goodman et al., 2014; McNichols & Stubben, 2008; Mercatanti et al., 2019). Capital expenditure is the acquirement of fixed assets. There are two ways to measure investment: net investment or gross investment. Net investment excludes depreciation while gross investment includes depreciation. Gebauer et al. (2018) use both net and gross investment since the different measures have different implications. Net investment is more relevant from a policy point of view given its close link to an economy's level of productivity, while gross investment has a stronger theoretical motivation since financial constraints should affect both investment that replaces depreciated assets and new investment. However, their

measurement of gross investment is allowed to be a negative value while this is not possible. Gross investment is always positive since the potential negative net investment, is negative because of depreciation expenses.

Therefore, following previous research of leverage on investment (e.g., Ahn et al., 2006; Aivazian et al., 2005a, 2005b; Barbiero et al., 2020; Gebauer et al., 2018; Firth et al., 2018; Lang et al., 1996) this study uses the net capital expenditure of fixed assets as the measure of investment that is decomposed into optimal and suboptimal investment. Net investment is defined as the change in net total fixed assets scaled to the lagged book value of total fixed assets. A negative amount of net investment means that the total fixed assets decreased and, consequently, depreciation was larger than the funds spend on the increase of property, plants & equipment.

The following, widely used (e.g., Bae et al., 2019; Goodman et al., 2014; Shroff, 2017), two models of McNichols & Stubben (2008) are used to measure the investment efficiency, overinvestment and underinvestment. Following McNichols & Stubben (2008), the optimal investment equation includes lagged Tobin's Q, which is a proxy of investment opportunities, and current period cash flow, which is included to control for differences in internal financing capability (Fazzari, 1988). The residual term obtained by OLS (Ordinary Least Squared) regression is used as the index of investment efficiency. To estimate the optimal level of investment, the following investment model is used and is referred to as the basic model:

$$Net\_Inv_{i,t} = a + \beta_1 TobinQ_{i,t-1} + \beta_2 CF_{it} + \varepsilon_{i,t} \quad (1)$$

where $Net\_Inv_{i,t}$ is firm i's net capital investment at time t scaled by the lagged book value of fixed assets. $TobinQ_{i,t-1}$ is lagged Tobin's Q, measured as the market value of assets (market capitalization + total assets – book value of equity) divided by the book value of assets. CF_{it} is defined as the cash flow from operations scaled by the lagged book value of fixed assets. a is a constant and $\varepsilon_{i,t}$ is the error term.

Consistent with McNichols & Stubben (2008), and numerous other studies based on this method, an additional estimation of investment efficiency is calculated. They do this because of potential measurement errors, estimating both equations diminishes and/or avoid the risk of errors and increase the robustness of the analysis. The second investment efficiency is an extended modification of Equation (1). Asset growth and past investment are added to the

regression. According to McNichols & Stubben (2008), adding lagged asset growth addresses potential measurement error in Tobin's Q, while the investment level of the prior year captures a firm-specific component not captured by the other variables in the model. This leads to the following OLS extended regression model which estimates investment efficiency, and is referred to as the extended model:

$$Net\_Inv_{i,t} = a + \beta_1 TobinQ_{i,t-1} + \beta_2 CF_{it} + \beta_3 Growth_{i,t-1} + \beta_4 Net\_Inv_{i,t-1} + \varepsilon_{i,t} \quad (2)$$

where $Net\_Inv_{i,t}$ is firm i's net investment at time t scaled by the lagged book value of fixed assets. $TobinQ_{i,t-1}$ is lagged Tobin's Q, measured as the market value of assets (market capitalization + total assets – book value of equity) divided by the book value of assets. CF_{it} is defined as the cash flow from operations scaled by the lagged book value of fixed assets. In addition, $Growth_{i,t-1}$ is the natural log of total assets at the end of year $t-1$ divided by total assets at the end of year $t-2$. a is a constant and $\varepsilon_{i,t}$ is the error term. All variable definitions are following the study of McNichols & Stubben (2008) such that the investment efficiency estimation method is similar to prior research.

$InvEff_{i,t}$ is the measurement of investment efficiency for sample firm i in year t using the residuals or prediction error from the basic and extended models: equation (1) and (2), negative residuals indicate underinvestment and positive residuals indicate overinvestment. To obtain the residuals for each firm, the models are estimated cross-sectionally each year, to capture year differences in the estimations. McNichols & Stubben (2008) estimate for each industry-year for each two-digit SIC industry with more than 30 observations. Since the sample is split up into numerous countries and industries, a lot of information would be disregarded due to this high threshold. Therefore, this study allows firms within different industries and within different countries to experience correlated booms and busts over time, following Bae et al. (2019) and Samet et al., (2017). Furthermore, Bae et al. (2019) do not find any empirical differences using pooled samples per year compared to estimating per industry per year. Therefore, estimating the optimal investment model per year for the pooled sample should not produce any measurement problems. As an additional solution, the second step regressions include firm-fixed effects which take any time-invariant variation into account. Consequently, the effects of countries and industries, as well as other firm-specific variation, are taken into consideration in the investment efficiency regressions.

The residuals ($InvEff_{i,t}$) after estimating Equations (1) and (2) are either a positive or a negative deviation from the expected optimal investment level. Firm-year observations with positive residuals are defined as overinvesting firms, while negative residuals indicate underinvestment. The main measure of investment efficiency, $AIE_{i,t}$, is the absolute value of the residuals ($InvEff_{i,t}$). This means that the residuals of underinvesting firms are multiplied by negative one. In this way, a higher value of $AIE_{i,t}$ indicates a lower (higher) degree of efficiency (inefficiency) and a higher deviation from the optimal amount of investment.

In addition, the residuals are split into the amount of underinvestment ($UI_{i,t}$) and the amount of overinvestment ($OI_{i,t}$). Using these variables, investment efficiency is decomposed into underinvestment and overinvestment. Both measures increase in inefficiency. In particular, $UI_{i,t}$ is the amount of underinvestment and is measured as the absolute value of the negative residuals of $InvEff_{i,t}$. $OI_{i,t}$ is the amount of overinvestment and is measured as the absolute value of the positive residuals of $InvEff_{i,t}$. Using these variables, the effect of leverage on investment efficiency ($AIE_{i,t}$), underinvestment ($UI_{i,t}$) and overinvestment ($OI_{i,t}$) can be tested. The next chapter describes the regression method to test the hypotheses.

3.2 Regression Method

The aim of this thesis is to investigate the effect of leverage on investment efficiency. Additionally, the effect of the European sovereign debt crisis on this relationship is of interest. To investigate this, the developed hypotheses are tested using fixed effect regressions with a measure of investment efficiency as the dependent variable and leverage as the independent variable of interest. Following the first step of measuring investment efficiency, Section 3.2.1 presents the second step which involves a regression that estimates the effect of leverage on investment efficiency. Afterwards, Section 3.2.2 proceeds with presenting the theoretical framework to test the effect of the European sovereign debt crisis on the debt-investment efficiency relationship.

3.2.1 The effect of leverage on investment efficiency

As explained in the previous section, prior research on investment and leverage use direct investment equations with growth opportunities to assess potential inefficiency (Ahn et al., 2006; Aivazian et al., 2005a; Barbiero et al., 2020; Firth et al., 2008; Gebauer et al., 2018; Lang et al., 1996). However, the variables used in the measurement of investment efficiency are

also mostly used in their investment equations. Therefore, this study combines these investment equations by choosing a select number of control variables to include in the following leverage-investment efficiency equations that also have an effect on the efficiency of the investment spending of a firm. The measurement of all variables is reported and discussed in Section 3.3 (Table 1).

This study uses a fixed-effect regression model following the analysis of Aivazian et al. (2005a) and Firth et al. (2008). The fixed-effect model is most appropriate when estimating an investment model since there is large heterogeneity across firms within the same industry and country. Fixed effects account for all time invariant factors and, consequently, control for industry and country at the firm level. Aivazian et al. (2005a), find that using a pooling regression (e.g., Lang et al., 1996; Ahn et al., 2006) underestimates the effect of leverage on investment and leads to biased coefficients. Following the research on leverage and investment, right hand sided variables are lagged by one period to mitigate endogeneity and reverse causality issues. In addition, this is reasonable since investment decisions are based on prior knowledge of growth opportunities and capital structure. Therefore, the following fixed-effect regression is developed to test the effect of leverage on investment efficiency:

$$AIE_{i,t}/UI_{i,t}/OI_{i,t} = a + \beta_1 Lev_{i,t-1} + \beta_2 Size_{i,t-1} + \beta_3 ROA_{i,t-1} + \beta_4 Tang_{i,t-1} + \beta_5 Age_{i,t-1} + YEAR + \mu_i + \varepsilon_{i,t} \quad (3)$$

where the dependent variable is the measurement of investment (in)efficiency explained in Section 3.1, which is either total investment efficiency ($AIE_{i,t}$), the amount of underinvestment ($UI_{i,t}$) or the amount of overinvestment ($OI_{i,t}$). $Lev_{i,t-1}$ ($LtLev_{i,t-1}$) is the measure of (long-term) debt to assets and is the independent variable of interest. Following prior research on the effect of leverage on investment (e.g., Aivazian et al., 2005a; Barbiero et al., 2020; Firth et al., 2008; Gebauer et al., 2018) and other research on investment efficiency (e.g., Benlemlih, 2018; Biddle et al., 2009; Chen et al., 2011; Chen et al., 2017; Goodman et al., 2014), the regressions control for the following selected variables: The size of the firm ($Size_{i,t-1}$), return on assets ($ROA_{i,t-1}$), asset tangibility ($Tang_{i,t-1}$) and the age of the firm ($Age_{i,t-1}$). $YEAR$ is a set of dummies per year to take the year fixed effects into account. Hence, the regression controls for changing economic conditions. Lastly, μ_i is the firm fixed effect and $\varepsilon_{i,t}$ is the error term. To account for heteroskedasticity and autocorrelation, the

regressions include robust standard errors clustered at the firm level. Section 3.3 and Table 1 outline the definitions and measurements of all variables in the regression model.

The effect of leverage on investment efficiency (Hypothesis 1) can be tested via Equation (3). Firstly, regressions are done for the absolute value of $InvEff_{i,t}$, $AIE_{i,t}$, for both the basic and the extended model to estimate investment efficiency. In this way, the effect of leverage on the total investment efficiency can be estimated. Besides, all regression are done separately for $UI_{i,t}$ and $OI_{i,t}$. This gives a clear indication of the effect of leverage on the two directions of inefficiency. In addition, the two sub effects of leverage can explain the main effect of leverage on total investment inefficiency. $AIE_{i,t}$, $UI_{i,t}$ and $OI_{i,t}$ increase in investment inefficiency. This means that a positive effect of an independent variable means that it increases the deviation between the optimal level of investment and the realised investment level.

The effect of leverage on investment efficiency is captured in β_1. β_1 captures the effect of a change in leverage on investment efficiency while keeping all other variables constant. Following H1, a significant positive effect is expected. This means that the absolute investment inefficiency increases with leverage. Furthermore, following H1a and the theory of debt overhang, high leverage increases underinvestment. Therefore, when $UI_{i,t}$ is the dependent variable, a significant positive effect of leverage on underinvestment is expected. Correspondingly, H1b states that leverage decreases the amount of overinvestment following the theory of the monitoring role of debt. Thus, when $OI_{i,t}$ is the dependent variable, a significant negative effect of leverage on overinvestment is expected.

3.2.1 The role of the European sovereign debt crisis

After establishing the effect of leverage on investment efficiency, the role of the European sovereign debt crisis on this effect is investigated and tested. This section presents the theoretical framework for testing the monitoring effect of the European sovereign debt crisis on the debt-investment efficiency relationship. To test and investigate the role of the crisis, the regression strategy is altered in two ways. In previous research, researchers either split the sample into two periods (e.g., Gebauer et al., 2018) or added a crisis variable and interacted this dummy that interacts the period of a crisis with the variable(s) of interest (e.g., Barbiero et al., 2020; Mercatanti et al., 2019) or combine both strategies to get a complete

view of the effect of a crisis (Benlemlih et al., 2018). To indicate the effect of the Sovereign debt crisis on investment efficiency and the debt-investment efficiency relationship, both methods are done.

First, the sample is split into two time periods to identify differences between the crisis period and after the peak of the crisis has ended. Following Benlemlih et al. (2018) and Gebauer et al. (2018), the base model, Equation (4), is estimated for the crisis period and the post-crisis period. This method allows all variables in the model to change. Therefore, this method gives an indication about the effect of leverage during and after the crisis period. For instance, you can directly compare a coefficient of the variable of interest between two samples. Despite the comparison of results, H2 and H3 cannot be directly tested using this method. Furthermore, splitting the sample in half reduces the number of observations in the model and a decreased sample size yield less precise coefficient estimates (Mercatanti et al., 2019).

Secondly, to increase the sample size and allow the model to test the moderating effect of the crisis, a dummy variable is included in the model that allows the dependence of leverage and the measure of investment efficiency to change between normal and crisis times via an interaction term. Following Mercatanti et al. (2019) and Barbiero et al. (2020), to investigate the effect of the crisis, a dummy variable is included that is 1 during the time of the European sovereign debt crisis and 0 after the crisis has ended. Using the interaction term between the crisis dummy and leverage, the hypotheses including the role of the debt crisis can be tested since the model allows the effect of leverage to change. In addition, the main effect of the European sovereign debt crisis is also included to ensure that the effect of leverage and the intercept can change when entering the crisis period (Mercatanti et al., 2019). Including this main effect means that year effects are excluded. This is the case since multicollinearity occurs when including both.

The following model involves all proposed alterations to test the effect of the European sovereign debt crisis and the moderating role of the crisis on the debt-investment efficiency link:

$$AIE_{i,t}/UI_{i,t}/OI_{i,t} = a + \beta_1 Lev_{i,t-1} + \beta_2 Crisis_{i,t} + \beta_3 Crisis_{i,t} \times Lev_{i,t-1} + \beta_4 Size_{i,t-1} + \beta_5 ROA_{i,t-1} + \beta_6 Tang_{i,t-1} + \beta_7 Age_{i,t-1} + \mu_i + \varepsilon_{i,t} \quad (4)$$

where the dependent variable is the measurement of investment efficiency explained in Section 3.1, which is either total investment efficiency ($AIE_{i,t}$), the amount of underinvestment ($UI_{i,t}$) or the amount of overinvestment ($OI_{i,t}$). $Lev_{i,t-1}$ ($LtLev_{i,t-1}$) is a measure of (long-term) debt to assets. $Crisis_{i,t}$ is a dummy variable which takes the value of 1 during the sovereign debt crisis. The regressions control for the following lagged variables: The size of the firm ($Size_{i,t-1}$), return on assets ($ROA_{i,t-1}$), asset tangibility ($Tang_{i,t-1}$) and the age of the firm ($Age_{i,t-1}$). Lastly, μ_i is the firm fixed effect and $\varepsilon_{i,t}$ is the error term. To account for heteroskedasticity and autocorrelation, the regressions include robust standard errors clustered at the firm- level. Section 3.3 and Table 1 outline the definitions and measurements of all variables in the various regressions.

Instead of using the normal measure of (long-term) leverage, the crisis interaction model uses the mean-centered (long-term) leverage. This implies that, for all firms, the population's mean of leverage for the whole dataset is subtracted from the debt level of the firm. This causes the zero value of leverage to be the average level of leverage for the whole sample. Mean centering variables is done to clarify the regression coefficients (Iacobucci et al., 2015). The reference of the main effect of the dummy variable changes from the effect when the continuous variable is zero to the effect when the interacted continuous variable is at its average. In other words, when measurements include arbitrary zeros, then it can be worthwhile to center a variable such that results are interpretable with respect to the variable's mean than to an arbitrary point of zero (Iacobucci et al., 2015).

Mean centering of a continuous variable in an interaction term with a dummy variable has no direct effects on the coefficients and the interpretation of the continuous variable and the interaction term, only the interpretation of the main effect of the dummy variable changes to a more valuable and practical situation (Dalal et al., 2012). If leverage was not centered around a meaningful level, the main effect of the European sovereign debt crisis was interpreted as the effect when a firm does not have any liabilities on their balance sheet. Since this is a rare and/or non-existent case, the mean centering of this variable in the interaction, increases the usefulness and interpretability of the empirical model.

Hypothesis 2 and 3 are tested via Equation (4). The effect of the European sovereign debt crisis on investment efficiency is captured in β_2. A significant positive effect is expected. A positive effect has the implication that investment efficiency during the European sovereign debt crisis

was worse compared to the post-crisis period when limitation potentially loosened. Since investment plummeted during the European sovereign debt crisis due to financial constraints on the market, the coefficient of the crisis on underinvestment is expected to be positive and the coefficient is expected to be negative for the effect of the crisis on overinvestment.

The effect of the European sovereign debt crisis on the leverage-investment efficiency relationship is captured in β_3. The interaction term $Crisis_{i,t} \times Lev_{i,t-1}$ captures the differential impact of leverage on investment efficiency during the crisis compared to the post-crisis period. An expected positive effect implies that during the crisis the effect of leverage on investment inefficiency is worse compared to the post-crisis years. Compared to the subsample analysis, the marginal effect of leverage after the crisis is β_1 and the marginal effect of leverage during the crisis is the sum of the coefficients $\beta_1 + \beta_3$. Therefore, the effect of leverage on investment efficiency is allowed to change during different periods. In addition, it is expected that the sovereign debt crisis strengthens the effects of leverage on both underinvestment and overinvestment in their respective direction.

3.3 Measurement of variables

In this section, the independent and control variables of Equation (3) and (4) are conceptualized. All definitions and measurements of the variables used in the first and second step are stated in Table 1. The estimation of the dependent variable investment efficiency is defined in Section 3.1. Furthermore, all variables in the two optimal investment equations are defined in that section. The conceptualization of the variables is following McNichols & Stubben (2008). As a result of the two equations and three measures of investment (in)efficiency, there are 6 main measures of investment efficiency which are tested to investigate the debt-investment efficiency link. In particular, these total measures of investment efficiency can be split into absolute investment efficiency (AIE), underinvestment (UI) and overinvestment (OI). All measures of investment efficiency increase in inefficiency. Thus, a higher value indicates a higher deviation from the optimal level of investment which is detrimental to the investment performance of a firm.

The aim of this study is to investigate the effect of leverage on investment efficiency. Following Aivazian et al. (2005a, 2005b), leverage is measured in two ways: total debt to assets and long-term debt to assets. Aivazian et al. (2005a) recommend using both measures of leverage to

Table 1
Variable definitions. This table presents all definitions and measurements of each variable used in the analyses. Panel A reports the dependent variables for both the first and second step regressions and Panel B reports the independent variables of interest to answer the hypotheses. Lastly, Panel C shows the definitions of the firm-level control variables. All data to calculate the variables is obtained from the Orbis database.

Variable	Definition	Measurement
Panel A: Dependent Variables		
$Net\ Inv_t$	Net investment (%)	Change in net total fixed assets scaled to lagged book value of total fixed assets
$InvEff_t$	Investment efficiency (signed)	Residuals of cross-sectional regressions based on optimal investment equations (1) or (2)
AIE_t	Investment efficiency	Absolute value of $InvEff_t$
UI_t	Underinvestment	Absolute value of the negative values of $InvEff_t$
OI_t	Overinvestment	Positive values of $InvEff_t$
Panel B: Independent variables of interest		
Lev_{t-1}	Leverage	Ratio of total liabilities to total assets
$LtLev_{t-1}$	Long-term leverage	Ratio of long-term debt to total assets
$Crisis_t$	European sovereign debt crisis	Dummy variable indicating the crisis which is 1 from 2011 to 2014 and 0 from 2015 to 2019
Panel C: Control variables		
$TobinQ_{t-1}$	Tobin's Q	Market value of assets (market capitalization + total assets – book value of equity) divided by total assets
CF_t	Cash flow	Cash flow from operations divided by lagged total assets
$Growth_{t-1}$	Asset growth	Natural log of total assets divided by lagged total assets
$Size_{t-1}$	Firm's size	Natural log of total assets
ROA_{t-1}	Return on assets	Ratio of EBIT to total assets
$Tang_{t-1}$	Asset tangibility	Tangible fixed assets divided by total assets
Age_{t-1}	Firm's age	Natural log of years since a firm went public

capture the dominant role of long-term debt as a determinant of investment. In addition, in a follow-up research, Aivazian et al. (2005b) show that the maturity structure of a firm's debt has a significant impact on its investment decisions. Aivazian et al. (2005b) explain that long-term debt might mature after the expiration of the investment opportunity. This reduces the incentive to invest in positive NPV investment projects since the benefits partially go to the lenders rather than to the shareholders. For shorter debt maturities, this effect of reducing the incentive to invest is less strong. Therefore, the following leverage measures are defined: firstly, leverage (Lev) is defined as the lagged book value of total liabilities divided by the book value of total assets. Secondly, long-term leverage ($LtLev$) is defined as the book value of long-term debt divided by total assets.

Next to the effect of leverage, this study also investigates the effect of the sovereign debt crisis on the relationship between leverage and investment efficiency. Therefore, in Equation (4), the effect of the European sovereign debt crisis is included via an interaction composed of the measure of debt to assets and a crisis indicator. Here, the indicator of the crisis ($Crisis$) is a dummy variable that equals 1 in 2011-2014 and 0 in 2015-2019 (Gebauer et al., 2018; Gonçalves et al., 2020; Mercatanti et al., 2019). The sovereign debt crisis started in late 2010

for European countries. However, since investment spending and the efficiency of the investment is based on the previous year, the crisis affects the investment from 2011 onwards. The crisis dummy variable splits the sample period in half and covers the start, peak and end of the European sovereign debt crisis. Using this variable, the effect of the crisis on investment efficiency and the debt-investment efficiency can be tested.

Following prior research on the effect of leverage on investment (e.g., Aivazian et al., 2005a; Barbiero et al., 2020; Firth et al., 2008; Gebauer et al., 2018) and other research on investment efficiency (e.g., Benlemlih, 2018; Biddle et al., 2009; Chen et al., 2011; Chen et al., 2017; Goodman et al., 2014), the regressions control for the following selected variables: firm size, return on assets, age & asset tangibility. These variables account for the firm-level determinants of investment efficiency. The size of a firm ($Size$) is defined as the natural logarithm of total assets. As a proxy for profitability, return on assets (ROA) is defined as the ratio of earnings before interest and taxes to total assets. The firm's age (Age) is measured as the natural logarithm of the difference between the current year and the first year a firm went public. Lastly, asset tangibility ($Tang$) is the ratio of property, plant and equipment (fixed assets) to total assets.

To summarise, this thesis follows the following research methodology. Firstly, residuals of Equation (1) and Equation (2) are estimated for each country-year. This results in a basic estimate and an extended estimate of absolute investment efficiency, underinvestment and overinvestment. Next, fixed-effects regressions are done using Equation (3) and (4) for two measures of leverage (total liabilities to total assets and total long-term debt to total assets) in regards to total investment efficiency, underinvestment and overinvestment. Results are used to test H1 (H1a & H1b), H2 and H3 and subsequently, the research question can be answered based on the hypotheses that were tested.

3.4 Robustness tests

To check the robustness of the results, this study already uses different variables for and measurements of investment efficiency and leverage. In addition, the effect of the crisis is tested using an interaction term as well as via a subsampling approach. To increase the robustness of the regression results further robustness include: the addition of the variables used in the estimations of investment efficiency in Equation (3) and (4); excluding the lowest

deciles in the measures of underinvestment and overinvestment to reduce potential estimation errors and another estimation of investment efficiency based on the growth of sales opposed to cash flow and asset growth following the model of Biddle et al. (2009). Lastly, multiple other definitions of the European sovereign debt crisis dummy and subsample analysis are proposed to account for the effect of different and potentially dominating countries in the sample.

First of all, according to Chen et al. (2018), using residuals as dependent variables can result in biased coefficients and standard errors that can lead to incorrect inferences. Chen et al. (2018) indicate certain problems for this widely used two-step regression method used in many different areas in accounting and finance research. They focus on unchanged residuals as a dependent variable but also indicate that transformed residuals (like in the investment efficiency model used in this thesis) can potentially cause problems. Among other models, they test if the investment efficiency model yields different inferences when the two-step regression is modified in a single regression. Chen et al. (2018) do not find significant different inferences for the investment model used in this study; other uses of residual analysis do yield different inferences. Therefore, they still discourage the use of unchanged residuals as the dependent variable because of potentially biased coefficients.

Chen et al. (2018) do not find any direct problems for the investment efficiency model used in this thesis. Furthermore, the residuals used in this investment efficiency are transformed (absolute value and split into under- and overinvestment) which is less likely to produce measurement errors. However, to increase the reliability of the results and reduce potential estimations errors, Chen et al. (2018) propose that the residuals from the first-step regressions should be regressed on the combination of all variables used in the first-step and second-step regressions. Therefore, following the concerns about biased coefficients when using residuals as the dependent variable of a two-step regression plan, the first-step variables to determine investment efficiency are added to the investment efficiency regressions as an adequate solution to these concerns.

Next, to increase the robustness of the results, two different estimation methods of investment efficiency are defined. Firstly, the lowest deviations (the lowest value of residuals) of the optimal investment level could be defined as efficient investment. In addition, it is highly possible that due to measurement error they are wrongly categorised as under- or

overinvestment. Following Biddle et al. (2009) and Chen et al. (2011), the positive and negative residuals of the two methods to estimate optimal investment are sorted in deciles. For positive residuals (OI), the observations from the bottom decile are excluded. Similarly, for negative residuals (UI), the observations from the upper decile are excluded. In this way, investment efficiency measures close to zero (the estimated optimal level of investment for a firm) are excluded from the estimations. This potentially benefits the model since those observations are most likely to be misclassified. After multiplying the negative residuals by -1, such that they increase in inefficiency, the tests regarding the effect of leverage on investment efficiency and the role of the European sovereign debt crisis are repeated using the remaining observations.

Secondly, to further improve the robustness of the results, the model of Biddle et al. (2009) is followed to estimate the firm-specific model of investment as a function of growth opportunities measured by Tobin's Q and sales growth. Similar to the models of McNichols & Stubben (2008), the residuals proxy as the deviation from expected investment. The model of Biddle et al. (2009) is widely used by prior research regarding the effects of firm-specific variables on investment efficiency (e.g., Benlemlih et al., 2018; Chen et al., 2011; Chen et al., 2013; Gomariz et al., 2014). Optimal investment and investment efficiency are estimated via the following regression:

$$Net\_Inv_{i,t} = a + \beta_1 TobinQ_{i,t-1} + \beta_2 SalGrowth_{i,t-1} + \varepsilon_{i,t} \quad (5)$$

where $Net\_Inv_{i,t}$ is firm i's net capital investment at time t scaled by the lagged book value of fixed assets. $TobinQ_{i,t-1}$ is lagged Tobin's Q, measured as the market value of assets (market capitalization + total assets – book value of equity) divided by the book value of assets. The new variable, $SalGrowth_{i,t-1}$, is defined as the percentage change in sales from year $t-2$ to $t-1$. a is a constant and $\varepsilon_{i,t}$ is the error term. Consistent with the previous investment models, this equation is estimated cross-sectionally per year to estimate the residuals. The definition for absolute investment efficiency, underinvestment and overinvestment are exactly the same as for the basic and extended model of investment efficiency based on the models of McNichols & Stubben (2008). Using this new estimation method of efficiency, all hypothesis tests are repeated. It is expected that using a different estimation method does not change the inferences of the research methodology proposed in the main model.

Lastly, multiple other definitions of the European sovereign debt crisis dummy and subsample analysis are proposed to account for the effect of different and potentially dominating countries in the sample. First of all, the regressions are done without the dominating country in the sample. A dominating country could be a country with more observations than other countries or a country with different inferences on the leverage-investment efficiency relationship. Next, the dummy indicating the crisis in Equation (4) is altered since firms in certain countries can potentially be less or more affected by the European sovereign debt crisis. First of all, following Peia et al. (2020), a new crisis variable is 0 for firms in the United Kingdom. Secondly, following Acharya et al. (2020), an alternative crisis variable is defined as 1 for firms who are defined as GIIPS countries (Greece, Italy, Ireland, Portugal & Spain) and 0 for all other countries in the sample.

Using these two variations of the measurement of the sovereign debt crisis, the role of certain countries in the sample can be tested. In the United Kingdom, a different monetary system is used compared to countries in the European Union and, therefore, firms operating in the UK were potentially less affected by the European sovereign debt crisis since their currency system is not directly linked to the monetary system of the most affected countries (Peia et al., 2020). In addition, GIIPS countries experienced a severe recession, while non-GIIPS European countries were potentially less affected by the economic downturns felt the most by the widely researched GIIPS countries (Acharya et al., 2018). The alternative crisis dummies are tested for the whole sample, such that the effect of the crisis in potentially more affected countries can be compared to 'normal' times. In the final analysis, the crisis denoting the debt crisis period for GIIPS countries is compared to the other countries excluding the United Kingdom to account for the difference between severely constrained firms and more stable Eurozone countries (Acharya et al., 2018).

4. Data

This chapter presents and describes the sample used to investigate the research question. The sample involves a selection of listed firms out of multiple selected European countries. In Section 4.1, the selection of the firms and countries in the sample is outlined. In addition, the data cleaning method is stated. Section 4.2 presents and discusses the year and country distributions, descriptive statistics of the variables used in the analysis and the correlation matrix of the variables used in the various regressions.

4.1 Sample

To investigate and answer the research question, data of European listed companies is sampled using the Orbis Database from 2010 to 2019. The Orbis database from Bureau van Dijk is the largest cross-country firm-level database encompassing firms' financial statements and production activity (Kalemli-Ozcan et al., 2015). It includes balance sheets and income statements of a large amount of European public firms. Therefore, the Orbis database allows cross-country comparability and analysis. All information to compute the variables in all regressions and robustness tests are sampled from this database.

Most prior research that investigates the effects of the European sovereign debt crisis for a multitude of European countries includes either a sample of GIIPS countries (Greece, Ireland, Italy, Portugal & Spain) (Kousenidis et al., 2013; Ferrando et al., 2019) or GIIPS countries, Germany & France and a selection of other countries (Acharya et al., 2018; De Marco, 2019; Kalbaska & Gatkowski, 2012). A selection of GIIPS countries is always included since these countries were most adversely affected after the outbreak of the sovereign debt crisis (Acharya et al., 2018). In addition, Germany, France and the United Kingdom are often chosen because they are the biggest economies in the Eurozone and/or Europa and it is important to investigate the effects of the crisis on the most important components of Europe. Furthermore, the United Kingdom is characterized by a highly developed financial sector and close links with Eurozone countries (Allegret, 2017). Next to that, analysing the United Kingdom gives insight into the effects of a different currency system.

Therefore, this study includes the following countries in the sample: Ireland, Italy, Portugal & Spain; Germany, France & the United Kingdom following Acharya et al. (2018) and Kalbaska &

Gatkowski (2012). These countries are chosen because they represent big economies in Europe or are part of GIIPS and have a high data availability in the Orbis Database. Following Barbiero et al. (2020), Greece is excluded from the selection of GIIPS countries due to the limited availability of data in the Orbis Database. Thus, this thesis investigates the effect of leverage on investment efficiency and the role of the European sovereign debt crisis for a sample of firms out of seven countries that represent either GIIPS or the biggest economies of Europe. Using this sample, results can be generalized for other countries in Europe.

The data that is sampled spans the years of 2009 to 2019, which covers the beginning, peak and end of the European sovereign debt crisis (2010-2014) and a post-crisis period (2015-2019) (Gebauer et al., 2018; Gonçalves et al., 2020; Mercatanti et al., 2019). The effects of investments are caused by lagged variables, thus the effects of the European sovereign debt crisis on investment efficiency start in 2011. Data is collected for the years before the actual effect of the crisis, this allows the regressions to be based on lagged variables and lagged growth variables.

In line with other studies regarding leverage and investment (e.g., Ahn et al., 2006; Aivazian et al., 2005a; Firth et al., 2008; Gebauer et al., 2018), companies in the financial industry (SIC 6000-6999) and utility sectors (SIC 4900-4999) are excluded using Standard Industrial Classification (SIC) Codes. Firm-year observations with missing data in the required variables for the second step regressions are excluded. If a firm has enough information to estimate investment efficiency for one of the models, it is included. In this way, no valuable information gets lost. Following McNichols & Stubben (2008), firms without fixed assets are excluded as well.

Lastly, all continuous financial variables are winsorized at the 1st and 99th percentile. This is widely done to account for outliers in prior research regarding leverage and investment (e.g., Ahn et al., 2006; Aivazian et al., 2005a, 2005b) and in the literature regarding investment efficiency based on residuals (e.g., Biddle et al., 2009; Chen et al., 2011; McNichols & Stubben, 2008). The act of winsorizing is replacing all observations in the 1st and 99th percentile with the value at the 1st and 99th percentile such that the range of the variable decreases and the effect of outliers on the regressions decreases. The final panel dataset consists of 4451 European publicly listed firms and 13759 firm-year observations from 2011-2019.

4.2 Data summary

4.2.1 Sample composition

Table 2 presents the sample composition by year and by country. Panel A of Table 2 shows the sample distributions per year. The number of observations per year are increasing. Table 2 shows that there are more observations for 2019 (1881 observations) compared to 2011 (1001 observations). Moreover, the firm-year observations are getting larger each year from 2011 onwards. The larger share of recent observations is because of the survivor bias in the Orbis database (Kalemli-Ozcan et al., 2015). This means that the database is more likely to store recent and active firms as opposed to firms that are no longer active. Each year the sample size increases, which means that 37.23% of the firm-year observations are during the 4 years of the European sovereign debt crisis (2011-2014) and 62.77% of the firm-year observations are during the post-crisis period, which is defined as the last 5 years in the sample (2015-2019).

In addition, the Orbis database stores a maximum of 10 firm-year observations for each firm. Due to the need for lagged variables in relation to the survivorship bias of the Orbis database, the number of firm-year observations at the beginning of the sample is lower. Consequently, there is not enough data for lagged growth variables in 2011 for firms that reported from 2010-2019. Similarly, for observations regarding lagged growth for 2012, firm-year observations from 2010 to 2012 are needed for the calculation of the variable. Therefore, for the extended model of investment efficiency (Equation (2)), the amount of observations per year is lower. The basic investment efficiency estimation method (Equation (1)) does not involve lagged growth variables. Thus, the maximum of 10 years storage of financial statements for a firm is not a problem for the basic investment efficiency measure based on Tobin's Q and cash flow. All in all, there are sufficient firm-year observations during and after the crisis. Consequently, the differential impact of the European sovereign debt crisis on the debt-investment efficiency can be tested.

Table 2, Panel B presents the firm-year observations per country in the sample. Logically, the countries with the largest economies (UK, Germany & France) contribute the most observations to the sample of European listed firms from 2011 to 2019. In particular, the publicly listed firms of the United Kingdom contribute a large share to the total selection of

Table 2
Sample composition. This table shows the distribution of the sample. Panel A present the number of firm observations by year and Panel B presents the number of firm observations by country. The whole sample consists of 13759 firm-year observations for a total of 4451 firms in 7 countries from 2011 to 2019.

Panel A: Distribution by year

Year	Observations	Percent	Cumulative
2011	1001	7.28	7.28
2012	1285	9.34	16.61
2013	1390	10.10	26.72
2014	1446	10.51	37.23
2015	1519	11.04	48.27
2016	1627	11.82	60.09
2017	1759	12.78	72.88
2018	1851	13.45	86.33
2019	1881	13.67	100
Total	13759	100	

Panel B: Distribution by country

Country	Observations	Percent	Cumulative
DE	2800	20.35	20.35
ES	299	2.17	22.52
FR	3409	24.78	47.30
GB	5858	42.58	89.88
IE	321	2.33	92.21
IT	856	6.22	98.42
PT	216	1.57	100
Total	13759	100	

firms (42.5%). In addition, the most affected countries during the European sovereign debt crisis (GIIPS-countries) have a low share (12.29%) compared to the UK, Germany and France. This thesis uses the same countries in the sample to investigate the research question as Acharya et al. (2018). The distribution of firms in these countries is comparable. In the sample of Barbiero et al. (2020), the big economies out of Europe are also dominating the total firm-year observations. Therefore, the distribution of firm-year observations by country is as expected in relation to prior research.

As proposed in Section 3.4, as a robustness test and additional test, dominating countries are excluded in the sample or accounted for by changing the measurement of the crisis. Therefore, as a robustness test, all regression tests are done without the United Kingdom to investigate the role of firms in the United Kingdom on the results. In addition, the crisis is investigated for all countries except the UK as well as an alternative crisis variable for all GIIPS countries in the sample. Using these robustness tests, potential problems of the sample are mitigated. However, the effect on European firms as a whole is investigated since cross-border spillovers and contagion is expected to amplify the shock transmission across the eurozone (Acharya et al., 2018; Allegret et al., 2017). Therefore, the effect of leverage on investment efficiency is expected to be similar in direction among the European countries.

4.2.2 Descriptive statistics

Table 3 presents the descriptive statistics of all variables used in the regression models, including the control variables and variables needed to estimate investment efficiency. The table summarises the unchanged residuals from the optimal investment equations ($InvEff$)

Table 3
Summary statistics. This table presents the descriptive statistics of all continuous dependent and independent variables used in the first and second step regressions. For each variable, the number of observations for each variable (N), average and standard deviation (Mean & St. Dev.), range (Min & Max) and quartiles (p25, Median & p75), are reported. All variables are defined in Table 1. The reported measures of investment efficiency (InvEff, AIE, UI & OI) are based on Equation (1) and are referred to as the basic model of investment efficiency. All financial variables, except the investment efficiency measures, are winsorized at 1% and 99%.

Variables	N	Mean	Std. Dev.	Min	p25	Median	p75	Max
Net Inv_t	13759	.237	1.082	-.782	-.082	.023	.168	8.357
$InvEff_t$ (signed)	13191	0	1.052	-4.306	-.308	-.148	-.012	8.665
AIE_t	13191	.453	.950	0	.109	.214	.424	8.665
UI_t	10069	.297	.303	0	.115	.208	.383	4.306
OI_t	3122	.958	1.784	0	.078	.250	.818	8.665
Lev_{t-1}	13759	.525	.258	.026	.349	.521	.683	1.465
$LtLev_{t-1}$	13083	.131	.146	0	.004	.088	.206	.676
$TobinQ_{t-1}$	13759	1.806	1.527	.424	1	1.322	1.988	10.492
CF_t	13191	-4.127	30.242	-234.271	0	.323	1.121	36.941
$Growth_{t-1}$	12603	.062	.260	-.695	-.044	.038	.131	1.261
$Size_{t-1}$	13759	12.009	2.336	7.306	10.285	11.809	13.553	17.987
ROA_{t-1}	13759	-.007	.218	-1.157	-.021	.048	.092	.327
$Tang_{t-1}$	13759	.185	.200	0	.030	.110	.271	.858
Age_{t-1} (in years)	13759	14.625	12.649	1	7	12	18	95

from the basic model based on Tobin's Q and cash flow (Equation (1)). The residuals are transformed to obtain the dependent variables used to analyse the effect of leverage on investment efficiency. The dependent variable in the regressions is either the absolute value of the residuals to measure the investment efficiency for all firms (AIE), the absolute value of the negative residuals which measures the amount of underinvestment (UI) or the value of the positive residuals which measures the amount of overinvestment (OI). In addition, the descriptive statistics of both the first-step and the second-step regressions are reported. In the appendix, Table A.1 and Table A.2 report the descriptive statistics for either underinvesting firms or overinvesting firms to distinguish between the direction of inefficiency and the role of certain variables on the subsamples used in the under- and overinvestment regressions.

By design, the mean of investment efficiency is zero. However, the median of the residuals is -0.148. This indicates that most firms are underinvesting since negative values relate to underinvesting firms. In effect, following the basic model of investment efficiency, 10069 firms are underinvesting and 3122 firms are overinvesting. Nevertheless, the mean of overinvestment (0.958) is higher than the mean of underinvestment (0.297). This inflates the mean of absolute investment efficiency (0.453) which consists of both the values of overinvestment and underinvestment. In addition, the standard deviation of overinvestment (1.784) is much higher than the standard deviation of underinvestment (0.303). However, the

medians of absolute investment efficiency (0.214), underinvestment (0.208) and overinvestment (0.250) are roughly similar.

This means that for overinvestment the upwards deviation from the optimal level is on average higher compared to the downwards deviation from underinvesting firms. Thus, if a firm is overinvesting, on average, the overinvestment is less efficient compared to an averagely underinvesting firm in terms of the absolute deviation from the expected optimal level estimated by growth opportunities. In addition, the maximum value of overinvestment (8.665) is higher than the maximum value of absolute underinvestment (4.306). The outcomes of the estimation of investment efficiency are comparable to the main prior research based on similar estimation methods using the optimal level of investment being determined by a selection of growth opportunities. For example, Bae et al. (2017), Benlemlih et al. (2018), Biddle et al. (2009), Chen (2012) and Cheng (2013) also report a larger share of firms who are underinvesting as well as a higher magnitude and range of the value for the upwards residuals of overinvesting firms.

Subsequently, since the measure of absolute investment efficiency consist of the both the values of underinvestment and overinvestment, the highest values of AIE are involved with the amount of deviation from overinvesting firms. This means that a positive effect on absolute investment efficiency might be involved with overinvestment rather than underinvestment. Similarly, if a financial variable induces underinvestment, it is possible that this variable has a negative effect on absolute investment efficiency since it is related to the lower values of absolute deviation which are associated with underinvestment. To account for the potential effect of the different ranges of underinvestment and overinvestment on the absolute value of investment efficiency, all tests are also done for underinvestment and overinvestment as dependent variables to decompose the effects of leverage on absolute investment efficiency.

Next, the variable of interest is leverage. This variable is measured either as leverage based on all liabilities (Lev) or leverage based on long-term debt ($LtLev$). The average value of liabilities to assets is 0.53. This means that firms on average rely more on debt financing than on internal or equity financing. The data on leverage is comparable to samples of European firms during the European sovereign debt crisis of Gebauer et al. (2018) and Barbiero et al. (2020). The mean of long-term leverage is 0.13 which is a small part of the total liabilities to

assets ratio. Following Aivazian (2005a), this means that, on average, European listed firms have a strong reliance on short-term debt opposed to debt financing with longer maturities. In addition, a multitude of firms relies solely on short-term debt, since a lot of firms report zero or very low long-term debt. Lastly, there are more firm-year observations that report a value for total liabilities compared to the total firm-year observations with a value for long-term leverage. Therefore, there are more firm-year observations for the regressions on leverage compared to the estimation models based on long-term leverage. This might affect the statistical significance of these models due to a reduced sample size.

Following Table A.1 and Table A.2, the average values of leverage and long-term leverage are higher for underinvesting firms compared to overinvesting firms. For example, the mean of leverage is 0.533 for underinvesting firms and 0.487 for overinvesting firms. This indicates that, on average, firms with higher leverage are investing below their optimal level of investment measured by growth opportunities. Thus, this suggest that leverage diminishes the ability of corporations to invest conform their investment opportunities.

Lastly, the descriptive statistics of the variables used to estimate the optimal level of investment using Equation (1) and (2) are comparable to the descriptive statistics of the same variables in the research of McNichols & Stubben (2008). This is of relevance since the method of McNichols & Stubben (2008) to estimate investment efficiency is followed in this thesis. For example, the standard deviation and range of cash flow are similar. In addition, the statistics of Tobin's Q are highly similar as well. In addition, the investment values are also similar to prior research of European firms during the European sovereign debt crisis (Barbiero et al., 2020; Gebauer et al., 2018) and are similar in size compared to McNichols & Stubben (2008). Therefore, the method to estimate the optimal level of investment can be used since the input variables are comparable in terms of mean, standard deviation and the values in quartiles.

Finally, the figures of the firm-level independent control variables are comparable to prior research on investment during the European sovereign debt crisis for European firms (Barbiero et al., 2020; Gebauer et al., 2018). In addition, the separation of underinvesting and overinvesting firms in Table A.1 and A.2 also is as expected where underinvesting firms have less growth, higher size and a higher age as expected in prior research on investment efficiency (e.g., Biddle et al, 2009). Concluding, the descriptive statistics of the variables used in this study are generally in line with other studies with samples of European firms during the

European sovereign debt crisis, which suggests that the sample is representative and the results can be compared to other studies.

4.2.3 Correlation matrix

Table 4 presents the pairwise correlations between the dependent and independent variables used in the models to investigate the effect of leverage on total investment efficiency. Both the variables from the investment efficiency estimation models and the regression models used to test the hypotheses are included in the correlation matrix. The correlation matrix can be used to spot initial effects and correlations between variables of interest. In addition, correlation matrices are used to ascertain the level of multicollinearity between variables. Too high correlation between control variables might affect the reliability of the regression results, too high correlation may cause multicollinearity issues.

Opposed to what was expected based on prior research and defined in Hypothesis 1, leverage has a significant negative correlation at the 1% level with the absolute value of investment efficiency. However, as explained, this is possible due to the fact that the mean of overinvestment is higher and that the highest values of the absolute value of the investment efficiency are the inefficiencies of overinvesting firms. In addition, as discussed, the mean of leverage is higher for underinvesting firms compared to overinvesting firms. To decompose the effect of leverage on investment efficiency, investment efficiency is split into underinvestment and overinvestment. In addition, as correlation results do not control for differences in firm and time characteristics, multivariate analyses and tests improve and clarify the inferences that can be drawn out of potential effects between variables and relationships between variables.

As expected, the two measures of leverage are highly correlated. This is for the reason that total leverage increases with every increase of long-term debt to assets. Therefore, a higher long-term debt to assets ratio is logically related to a higher value of total leverage. Aivazian et al. (2005a) also show a high correlation between the two measures of debt to assets. The effects of the two measures of leverage are assessed in different regressions. This means that the highly correlated variables are not included at the same time. Therefore, there is no multicollinearity problem because of the high correlation between the two variables which measure the capital structure of a firm.

Table 4

Correlation matrix. This table presents the Pearson pairwise correlation coefficients for all first and second step regressors. The proxy of investment efficiency included in this table is the absolute value of the residuals based on Equation (1) and is referred to as the investment efficiency based on the basic optimal investment model. All variables are defined in Table 1. All financial variables, except the investment efficiency measures, are winsorized at 1% and 99%. The symbol * denotes two-sided statistical significance at the 1% level.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) AIE_t	1.000										
(2) Lev_{t-1}	-0.084*	1.000									
(3) $LtLev_{t-1}$	-0.060*	0.512*	1.000								
(4) $Size_{t-1}$	-0.200*	0.181*	0.277*	1.000							
(5) ROA_{t-1}	-0.197*	-0.020	-0.024*	0.392*	1.000						
(6) $Tang_{t-1}$	-0.190*	0.079*	0.313*	0.257*	0.149*	1.000					
(7) Age_{t-1}	-0.103*	0.067*	-0.027*	0.227*	0.204*	0.059*	1.000				
(8) $TobinQ_{t-1}$	0.137*	-0.001	-0.029*	-0.204*	-0.275*	-0.139*	-0.152*	1.000			
(9) CF_t	-0.274*	0.130*	0.016	0.199*	0.387*	0.131*	0.094*	-0.183*	1.000		
(10) Net Inv_{t-1}	0.038*	-0.080*	-0.024*	-0.075*	-0.030*	0.007	-0.120*	0.076*	-0.007	1.000	
(11) $Growth_{t-1}$	0.034*	-0.091*	-0.001	0.039*	0.226*	-0.029*	-0.086*	0.068*	-0.008	0.338*	1.000

Lastly, potential multicollinearity issues are assessed. First of all, following Aivazian et al. (2005a, 2005b) and Firth et al. (2008), there might be a potential problem with estimations when there is a high negative correlation between growth opportunities measured as Tobin's Q and leverage or long-term leverage. They explain that firms with high growth opportunities reduce their leverage level and adjust the capital structure in favour of short-term debt. This may lead to multicollinearity issues between those variables in the regression models. As shown in Table 4, the negative correlations between Tobin's Q and leverage and/or between Tobin's Q and long-term leverage are not high. Thus, multicollinearity is not a serious problem.

Finally, problems might occur in an estimation process when there is a significantly high correlation between the various right-sided explanatory regressors. Therefore, it is important to look at the correlation matrix in Table 4 to assess potential multicollinearity problems between the control variables. All correlations among the independent variables used as controls are reasonable and do not indicate great multicollinearity problems. The largest significant correlation between two control variables is the correlation between cash flow and the size of a firm (0.392). As can be seen in Table 4, all the correlation coefficients are less than absolute 0.40, which suggests that multicollinearity is not a serious problem in the sample (e.g., Aivazian et al., 2005a; Firth et al., 2008).

5. Results

In this chapter regression analyses are done to identify the effect of leverage on investment efficiency as well as the role of the European sovereign debt crisis on the debt-investment efficiency relationship. This chapter presents the results of the proposed research design to answer the research question and test the hypotheses. The research design is based on previous literature and tested via a sample of public European firms between 2011 and 2019. Following this sample period, the sample can be split into a period during the European sovereign debt crisis and a period after this crisis such that the effect of the European sovereign debt crisis can be identified.

Firstly, Section 5.1 reports the base estimation which provides insight on the effect of leverage on investment efficiency. In addition, the effect of leverage on respectively under- and overinvestment is tested to further identify the direction of the relationship. Afterwards, in Section 5.2 the role of the European sovereign debt crisis is added to the regression models. In particular, the sample gets split into a crisis period and a period after the crisis. Furthermore, analysis with an interaction term between a European sovereign debt crisis dummy with the measure of leverage is done to identify the interaction effect of the crisis on the debt-efficiency relationship. Lastly, Section 5.3 reports results of additional tests that lend robustness and extend the reported results. For instance, three alterations to the measure and specification of the investment efficiency model are tested. In addition, adjustments to explore the effect of dominating countries on the regression results is explored.

5.1 Base estimation

To start off the results, this section reports and discusses the results of the regressions based on the effect of (long-term) leverage on investment efficiency. Before adding and exploring the effect of the European sovereign debt crisis in the regression models, the effect of debt on investment decisions should be investigated. In this section, the specification described in Equation (3) is applied to examine the sensitivity of investment efficiency to the capital structure of a firm. Firstly, Section 5.1.1 presents the analysis and results focused on the effect of leverage on total investment efficiency, at the same time controlling for firm-level fundamentals and time fixed effects.

Afterwards, Section 5.1.2 elaborates and extends these results by investigating the direction of the effect of leverage on investment efficiency. To do this, Equation (3) is tested separately for upwards and downwards absolute deviations from the optimal level of investment measured by the investment efficiency estimation methods, to identify the effect of leverage on the amount of underinvestment for underinvesting firms and overinvestment for overinvesting firms. When the effect of the ratio of (long-term) leverage on investment efficiency and the direction of inefficiency (theory of debt overhang or the theory of the monitoring role of debt) is identified, it can be tested if the European sovereign debt crisis mitigates or exacerbates these positive or negative effects.

5.1.1 The effect of leverage on investment efficiency

Table 5 reports the regression results of the models examining the influence of (long-term) leverage on investment efficiency. These results relate to investment efficiency in the value of the positive and the absolute value of the negative deviations from the expected level of investment measured via the two models of McNichols & Stubben (2008). Since the measure of investment efficiency in this study is defined as the absolute value of the deviation from the expected investment estimated, an increase in the dependent variable means a larger deviation from the expected investment. Thus, positive effects indicate that an increase in the independent variable of interest results in an increase in inefficient investment. Table 5 presents both results for the basic model of investment efficiency (Equation (1): columns (1) and (2)) and the extended model of investment efficiency (Equation (2): columns (3) and (4)) for both the ratio of total liabilities to total assets and the ratio of long-term debt to assets to identify the effects of capital structure decisions on the investment performance of a firm.

Following prior research on investment and the effect of leverage on investment, the regression models include fixed effects. Fixed effects are used in panel data to account for the seriality of firm observations for multiple years. To ensure and identify that the fixed effects estimation is most suitable in the regressions compared to pooling or random effects, two statistical tests are performed for the base model of the effect of leverage on investment efficiency. Following Aivazian et al. (2005a), to identify if using a panel data approach with fixed effects opposed to a pooling approach or a panel data approach with random effects is needed, the Lagrangian Multiplier (LM) test (Breusch & Pagan, 1980) and the Hausman specification test are conducted (Hausman, 1978) for all models in Table 5.

Table 5
Effect of leverage on investment efficiency. This table presents regression results of the effect of leverage on the absolute value of the residuals from the optimal investment equations. The measure of investment efficiency (AIE) is increasing in inefficiency. The variables of interest are the two measures of leverage. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects as specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Basic Model		Extended model	
	(1) AIE	(2) AIE	(3) AIE	(4) AIE
Lev_{t-1}	-.213*		-.224*	
	(.109)		(.123)	
$LtLev_{t-1}$		-.080		-.017
		(.129)		(.129)
$Size_{t-1}$	-.264***	-.238***	-.206***	-.191***
	(.043)	(.043)	(.046)	(.046)
ROA_{t-1}	-.076	-.005	.087	.152
	(.110)	(.109)	(.117)	(.115)
$Tang_{t-1}$	-2.773***	-2.643***	-2.776***	-2.654***
	(.247)	(.266)	(.286)	(.301)
Age_{t-1}	-.001	-.024	.006	-.008
	(.048)	(.048)	(.050)	(.049)
Constant	4.267***	3.881***	3.867***	3.685***
	(.556)	(.550)	(.602)	(.605)
Obs.	13191	12532	11986	11403
R-squared	.083	.085	.081	.087
Time FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

For all models in Table 5, the null hypotheses of both tests are rejected at the 1% significance level. The null hypothesis of the LM test is that there are no individual effects in the data and the null hypothesis of the Hausman test is that the random effect model is preferred as opposed to a fixed-effect model. Therefore, the results suggest that the individual effect is not zero and that the individual effects in the panel data are uncorrelated with the independent variables (Aivazian et al., 2005a). Estimation with fixed effects for testing the effect of leverage on investment decisions for a set of multiple firm-year observations is consistent with prior research (e.g., Ahn et al., 2006; Aivazian et al., 2005a, 2005b; Barbiero et al., 2020; Firth et al., 2008). In addition, other research on the absolute value of the residuals of an optimal investment function use fixed effects as well (e.g., Bae et al., 2017; Benlemlih et al., 2018; Chen et al., 2011). The LM test (Breusch & Pagan, 1980) and the Hausman test (Hausman, 1978) confirm that a fixed effects approach is the most suitable estimation method.

Table 5 reports the estimates of the effect of (long-term) leverage on the absolute value of investment efficiency. The robust standard errors of the estimated regression coefficients are reported in parentheses. Opposed to what was expected and defined in H1, leverage (Lev) has a marginally significant negative effect on the absolute value of investment inefficiency

(AIE) at the 10% level, other variables held constant. In addition, for the models with long-term leverage ($LtLev$), the coefficients are negative as well. Nevertheless, the coefficients in column (2) and (4) are statistically insignificant. These results do not directly find empirical evidence for Hypothesis 1. H1 stated that an increase in leverage results in an increase in investment inefficiency because of the extra financial constraints a firm is facing and financial costs related to debt financing. In addition, due to the large problems of debt overhang when leverage reaches excessive levels (Myers, 1977), even firms that were overinvesting can turn into underinvesting firms. Therefore, H1 predicted that leverage should have a positive effect on the absolute value of the deviation from the expected model of investment based on growth opportunities.

The coefficients of the effect of total leverage for the basic model (Column 1) and the extended model (Column 3) are respectively: -0.213 and -0.224. These coefficients indicate that an increase in leverage increases the investment efficiency of a firm and, consequently, reduces the amount of inefficiency compared to the expected level of investment measured by Equation (1) and (2). An increase in efficiency of investments following an increase in leverage relates to the theory of the monitoring role of debt (Jensen, 1986; Stulz, 1990). However, as explained in Section 4.2.2, high values of the total investment efficiency measure are related to overinvesting firms and low/medium values of investment efficiency are related to underinvestment. In addition, as discussed, the average level of leverage for underinvesting firms is higher than the average level of overinvesting firms.

Therefore, the negative effect of leverage on the absolute value of investment efficiency potentially means that instead of only a reduction in overinvestment, a negative effect could potentially imply that an increase in leverage causes overinvesting firms to switch into underinvesting firms due to the increased financial frictions. This could potentially imply that the absolute value of the inefficiency has decreased while it changed direction from an upwards to a downwards deviation from the expected level of investment. Furthermore, following the higher average value of leverage for underinvesting firms, a higher value of leverage is related to an underinvesting firm which has a lower deviation from the optimal level. Following these reasons, it is important to decompose investment efficiency into under- and overinvestment to indicate what this significant negative effect means for the

interpretation of H1 by exploring H1a (increase of underinvestment) and H1b (decrease of overinvestment).

The significantly negative effect is also economically significant. For example, the coefficient of leverage on investment efficiency for the basic model in Column (1) is -0.213. This indicates that a one standard deviation increase in leverage results in a 12% decrease in investment efficiency (economic/substantive significance is calculated as the standard deviation of the independent variable (0.258) multiplied by the regression coefficient (-0.213) divided by the average investment efficiency (0.453) following prior research on investment and investment efficiency (e.g., Aivazian et al., 2005a; 2005b; Biddle et al., 2009; Chen et al., 2011; Chen et al., 2017; Cheng et al., 2013)). Similarly, for the extended model in Column (3), for a one standard deviation increase in leverage, investment efficiency decreases by 13% ((0.258*-0.224)/0.435=-0.133).

Thus, according to the regression results in Table 5, a one deviation change in total leverage results in a decrease of 12-13% in investment inefficiency. The percentual changes in investment inefficiency are in absolute values. Due to the measurement of investment efficiency, it is also likely that the decreased investment efficiency is related to a firm that switched from overinvestment into an underinvesting firm. In this case, the total decrease is larger since the deviation switched direction from positive to negative while the absolute investment efficiency measures the changes in the absolute value of the residuals from the expected investment model. To confirm the direction of the negative effect, Section 5.1.2 explores the effects of (long-term) leverage on under- and overinvestment to further test H1, H1a and H1b.

Turning to noteworthy control variables, the effects of the significant control variables are as expected. Firstly, the effect of firm's size ($Size$) on the absolute value of investment efficiency is significantly negative at the 1% level for all estimated regression models in Table 5. This is in line with prior research (e.g., Biddle et al., 2009; Chen et al., 2012; Goodman et al., 2014), and is due to the fact that larger firms invest less than smaller firms due to economies of scale and decreased growth opportunities. Therefore, larger firms have less overinvestment and invest more efficiently. Asset tangibility ($Tang$) has a negative effect on the absolute value of investment (in)efficiency as well in all models. A higher ratio of tangible assets to total assets decreases contractibility issues and supports a firms' borrowing ability. This might help to

resolve issues of debt financing such that firms can follow their respective investment opportunities (Almeida & Campello, 2007).

5.1.2 The effect of leverage on under- and overinvestment

In the previous table on investment efficiency and leverage, there is evidence that leverage increases investment efficiency and the effect of long-term leverage is not significant. Only examining the absolute value of investment efficiency does not give an indication about the reduction of absolute inefficiency caused by an increase in leverage. Due to the measure of investment efficiency, a negative effect of leverage on the absolute value of investment efficiency can be related to an underinvestment problem as well as a reduction in overinvestment. Before concluding on the effect of leverage on investment efficiency, as an extension to research on the direct effect of (long-term) leverage on investment efficiency of a firm, in this section the sample is divided into an underinvestment scenario (negative deviation with regard to expected investment) and an overinvestment scenario (positive deviation with regard to expected investment). In firms that underinvest, it is tested whether leverage may exacerbate underinvestment problems through the problem of debt overhang (Myers, 1977) following Hypothesis 1a. For overinvesting firms, it is tested whether leverage may mitigate overinvestment problems through reducing free cash flow problems by the monitoring or disciplinary role of debt (Jensen, 1986; Stulz, 1990) following Hypothesis 1b. Afterwards, conclusions are formulated based on the first three hypotheses relating to the debt-investment efficiency relationship.

Table 6 presents the result of the analysis regarding the effect of (long-term) debt on the amount of underinvestment. Since underinvestment is measured as the absolute value of the negative deviations from the expected investment, a positive effect means a larger deviation. Thus, positive effects indicate that an increase in the variable results in more underinvestment. All firm-year observations in this sample are underinvesting firms, so these regressions test the effect of leverage on the amount of deviation below the expected level of investment. Table 6 is constructed similarly to Table 5, the dependent variable in Columns (1) and (2) is the amount of underinvestment estimated by the basic model and for Columns (3) and (4), the dependent variable is estimated by the extended model. For both models, the two measures of leverage are included separately in the regression equations. All models include year fixed effects and firm fixed effects.

Table 6
Effect of leverage on underinvestment. This table presents regression results of the effect of leverage on underinvestment which is measured as the absolute value of the negative residuals from the optimal investment equations. The measure of investment efficiency (UI) is increasing in inefficiency. The variables of interest are the two measures of leverage. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects as specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Basic Model		Extended model	
	(1)	(2)	(3)	(4)
	UI	UI	UI	UI
Lev_{t-1}	.083***		.084**	
	(.032)		(.036)	
$LtLev_{t-1}$		.024		-.002
		(.038)		(.042)
$Size_{t-1}$	.014	.025**	.087***	.094***
	(.012)	(.011)	(.012)	(.012)
ROA_{t-1}	-.226***	-.210***	-.053	-.043
	(.036)	(.032)	(.036)	(.031)
$Tang_{t-1}$	.059	.099	.104	.136*
	(.060)	(.068)	(.073)	(.078)
Age_{t-1}	.021	.034***	-.009	.001
	(.014)	(.012)	(.015)	(.015)
Constant	.057	-.096	-.520***	-.636***
	(.153)	(.134)	(.159)	(.156)
Obs.	10069	9600	9035	8619
R-squared	.228	.258	.255	.287
Time FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

Following Table 6, leverage (Lev) has a significant positive effect on the amount of underinvestment, all else equal. This means that an increase in leverage results in an increase in the amount of deviation from the optimal level of investment, which is in line with the theory of debt overhang (Myers, 1977). The positive effect of leverage based on total liabilities (Column (1): 0.083) is significant at the 1% level for the basic model and the positive effect (Column (3): 0.084) is significant at the 5% level for the extended model. This means that for underinvesting firms, the extra financial costs and constraints of debt financing pressure these underinvesting firms even more to cut investments below their optimal level of investment decided by growth opportunities. Similar to the models of total investment efficiency in Table 5, there is no significant effect found of long-term leverage ($LtLev$) on the amount of underinvestment while it was expected that the long-term debt financing would increase the financial constraints.

The statistically significant positive effects of leverage on underinvestment in Column (1) and (3) are also economically and substantially significant. For a one standard deviation increase in leverage, underinvestment increases on average by approximately 7%. As an example, for

Column (1), a standard deviation increase of leverage (0.258) multiplied by the significant regression coefficient (0.083) results in an increase in the amount of underinvestment of 0.02. This increase is 7.2% of the average underinvestment (0.297) of all underinvesting firms in the sample. This is a substantive increase in the deviation below the optimal level and hurts the investment performance of a leveraged firm. Therefore, following Table 6, there is empirical evidence for H1a. This hypothesis states that leverage has a positive effect on underinvestment due to the problem of extra debt overhang following Myers (1997).

The controls on underinvestment in Table 6 are in line with prior research. For instance, the positive effect of firm's size ($Size$) for Column (2), (3) and (4) on underinvestment is also found by Benlemlih et al. (2018). They state that larger firms have fewer growth opportunities and tend to reduce investment activities, this explains the higher amount of underinvestment. In addition, the measure of profitability (ROA) has a significant negative effect on underinvestment for the estimation of the basic measure of underinvestment in Column (1) and (2). This is expected since more profitable firms should have more funds to invest conform to their growth opportunities. The negative effect of the return on assets is also consistent in the extended model in Column (3) and (4), however, the effect is not statistically significant.

Table 7 presents the result of the analysis regarding the effect of the ratio of (long-term) debt to total assets on the amount of overinvestment. Overinvestment is measured as the positive residuals of the estimation of investment efficiency, a positive effect means a larger upwards deviation in relation to the expected investment based on the growth opportunities. Thus, positive effects indicate that an increase in the independent variable results in a greater amount of investment in value-destroying investment projects. All firm-year observations in this sample are overinvesting firms, so the regression models in Table 7 test the effect of (long-term) leverage on the amount of deviation above the expected level of investment. Table 7 is constructed similarly to the previous regression tables based on investment efficiency and underinvestment. Following Hypothesis 1b, it is expected that an increase in leverage has a negative effect on the amount of overinvestment due to the disciplinary or monitoring role of debt on the amount of corporate investment (Jensen, 1986; Stulz, 1990).

Table 7 shows that leverage has no significant effect on the amount of overinvestment. Neither for total leverage (Lev) or long-term leverage ($LtLev$), there is a significant effect on the amount of overinvestment given that the firms in the sample are still overinvesting after

Table 7
Effect of leverage on overinvestment. This table presents regression results of the effect of leverage on overinvestment which is measured as the absolute value of the positive residuals from the optimal investment equations. The measure of investment efficiency (OI) is increasing in inefficiency. The variables of interest are the two measures of leverage. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects as specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Basic Model		Extended model	
	(1)	(2)	(3)	(4)
	OI	OI	OI	OI
Lev_{t-1}	-.544		-.506	
	(.406)		(.391)	
$LtLev_{t-1}$		-.249		-.183
		(.517)		(.500)
$Size_{t-1}$	-.537***	-.483***	-.592***	-.528***
	(.147)	(.155)	(.142)	(.147)
ROA_{t-1}	-.372	.236	.739*	.593
	(.404)	(.420)	(.427)	(.445)
$Tang_{t-1}$	-7.335***	-6.761***	-7.335***	-7.200***
	(.686)	(.735)	(.653)	(.729)
Age_{t-1}	.144	.027	.324*	.237
	(.178)	(.177)	(.186)	(.182)
Constant	8.042***	7.288***	8.108***	8.122***
	(1.675)	(1.724)	(1.683)	(1.694)
Obs.	3122	2932	2951	2784
R-squared	.170	.158	.176	.173
Time FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

the change in leverage. Even though the coefficients are insignificant, across the basic and the extended model, the coefficients of, respectively, total leverage (-0.544 & -0.506) and long-term leverage (-0.249 & -0.183) are negative and roughly similar in size. However, since the coefficients are insignificant this could be random. The consistent negative values do indicate that it is possible that a higher leverage level is related to lower overinvestment, but the negative effect is not significant based on this sample. These (insignificant) negative effects are consistent with the theory of the monitoring role of debt (Myers, 1977). Despite the consistency of the negative coefficients of the measures of leverage on overinvestment, there is no empirical evidence for H1b due to the effect of both leverage measures on the amount of overinvestment being insignificant.

Turning to noteworthy control variables, consistent with the investment efficiency and underinvestment models, the size of a firm is negatively related to investment inefficiency proxies. This means that larger firms invest relatively less due to economies of scale, which causes lower overinvestment or more underinvestment. Therefore, larger firms are less inclined to invest above their optimal level of investment based on their respective growth

opportunities (Benlemlih et al., 2018). Asset tangibility has a large significant negative effect on overinvestment. Following Gebauer et al. (2018), this is expected and this effect of tangibility is also found in other studies. They explain that there is a possibility that the effect of tangibility is high since the variable is relatively persistent across time and partly captured by the fixed effects in the model. The decreased overinvestment caused by increased tangibility is also found in the investment efficiency models of Gomariz et al. (2014).

To conclude, Table 5 showed empirical evidence for a reduction of investment inefficiency when leverage increased. This finding was opposed to the expectation in Hypothesis 1. H1 stated that leverage causes inefficient investment due to the pressure on investment levels by costs of debt, decreased capability to borrow extra external funds and other financial restrictions. However, to conclude on the inference of this negative effect of leverage, the sample was split into under- and overinvestment. As explained before, due to the lower range, lower mean and higher share of underinvestment compared to overinvestment caused by the estimation method of the measures, lower values of the absolute value of the residuals are related to underinvestment. While Table 5 showed a negative effect of leverage on the inefficiency of investments, Table 6 showed that leverage increases the amount of underinvestment and the effect of leverage on overinvestment in Table 7 was insignificant.

Because there is a significant effect of leverage on the increase of underinvestment and an insignificantly negative effect of leverage on the amount of overinvestment, Table 6 and Table 7 show that leverage is related to an increase in underinvestment. Overinvesting firms potentially turn into underinvesting firms when these firms increase their leverage ratio which explains the significant negative effect in Table 5. On the contrary, when only investigating overinvesting firms in Table 7, the effect of leverage is insignificant. Due to the estimation method, for the measures of absolute investment efficiency, leverage has a negative effect on the absolute value of the residual. Following the subsampling approach of under- and overinvestment related to the total investment efficiency, it can be concluded that leverage causes inefficient investment below the optimal level. While the absolute value of the inefficient investment is less, the results are largely in line with the problem of debt overhang (Myers, 1977) and the monitoring role of debt is weighing too much on the investment spending such that overinvesting turns into underinvesting.

5.2 The role of the European sovereign debt crisis

In this section, the role of the European sovereign debt crisis on the debt-investment efficiency relationship is added to the regression models. By dividing the sample into two periods (2011-2014 & 2015-2019), the impact of debt financing on investment efficiency can be further explored and tested. It is expected that the European sovereign debt crisis intensifies the effects of leverage on under- and overinvestment in their expected directions following the theories of debt overhang and the disciplinary or monitoring role of debt by decreasing the availability to debt financing for leveraged firms and increased interest costs.

As proposed in the research design section, the role of the crisis is investigated in two ways. Firstly, the European sovereign debt crisis is accounted for via a subsampling approach based on a crisis period and post-crisis period. This subsampling approach is used to indicate if there is a difference in the effects of leverage on investment efficiency during the two periods. In addition, the moderating effect of the crisis is directly tested via an interaction term between the measure of leverage and a dummy indicating if a firm-year observation is affected by the European sovereign crisis. This section is divided into two subsections, Section 5.2.1 elaborates on the role of the European sovereign debt crisis on the debt-investment efficiency relationship. Afterwards, in Section 5.2.2 the measure of investment efficiency is split into underinvestment and overinvestment to identify if the crisis increases or decreases the effects found in Section 5.1. In addition, after doing all the analyses regarding the effect of leverage and the role of the crisis, the results are discussed.

5.2.1 The effect of the European sovereign debt crisis on investment efficiency

Starting off with the role of the European sovereign debt crisis on investment efficiency, Table 8 reports the regression results of the models examining the role of the European sovereign debt crisis on the effect of (long-term) leverage on total investment efficiency in both directions. The dependent variables in the regression models are the absolute value of the residuals from the estimation of the basic model (Equation (1)) in columns (1) to (6), and the extended model (Equation (2)) from columns (7) to (12). For both models, the two methods to investigate the role of the European sovereign debt crisis are employed. Firstly, Columns (1), (2), (7) and (8) show regression results of the base model of leverage on investment efficiency for the subsample of firms during the crisis period (2011-2014). Similarly, Columns

(3), (4), (9) and (10) presents the regression results during the post-crisis period (2015-2019). As explained, dividing the sample in a crisis and post-crisis period enables all the coefficients of the variables to change over time. This can give an indication of the impact of a time period on the effect of a variable on investment efficiency.

To test hypotheses 2 and 3, in Columns (5), (6), (11) and (12) a dummy variable indicating if a firm-year observation is during the European sovereign debt crisis is added to the estimation model as well as an interaction term between the crisis variable and the measure of leverage as defined in Equation (4). The addition of the crisis variable in an interaction term enables hypotheses 2 and 3 to be tested. Hypothesis 2 states that the European sovereign debt crisis has a negative effect on investment efficiency. Therefore, the coefficient of the crisis dummy is expected to be positive. Likewise, Hypothesis 3 states that the European sovereign debt increases the negative effect of leverage on investment efficiency via an increase in the problem of debt overhang. Consequently, a positive effect is expected for the interactions terms of the crisis dummy and (long-term) leverage. The models that include the crisis variable do not account for time fixed effects because of multicollinearity with the dummy variable; all models include firm fixed effects.

Firstly, Table 8 shows that dividing the sample in a crisis and post-crisis period has a substantial effect on the significance of the coefficient of leverage (Lev) on the absolute amount of investment inefficiency. During the crisis period, the effect of leverage on investment efficiency is insignificant (Column (1) & Column (7)). In fact, the insignificant coefficient is positive for the basic model (Column (1): 0.029). As opposed to the insignificance during the crisis, the effect of leverage is significantly negative during the post-crisis for the basic model in Column (3). This finding is in line with the models in Section 5.1 where leverage decreased the absolute value of investment inefficiency. Moreover, this effect is also substantially significant. During the post-crisis period, a one standard deviation increase in leverage results in an average decrease in investment inefficiency of 21%. Compared to the decrease of 12-13% when the whole sample was pooled in Table 5, removing the firm-year observations during the European sovereign debt crisis results in a bigger effect of leverage on reducing investment inefficiencies.

Therefore, during the post-crisis period, the beneficial effect of the monitoring role of debt on the investment behaviour is more pronounced compared to the firm-year observations during

the European sovereign debt crisis for the basic model comparing Column (1) and (3). Following the insignificance of the leverage variable in the crisis models and the substantially increased negative coefficient in the post-crisis period compared to the full sample, the results indicate that the positive effect of leverage on investment efficiency via the monitoring role of debt is less pronounced in the crisis period. While the effect of leverage is not significant, the coefficient of leverage for the basic model during the crisis period is positive. This indicates that an increase in leverage results in an increase in inefficiency following the theory of debt overhang via added financial constraints. To test this potential effect of the European sovereign debt crisis, a crisis variable ($Crisis$) is added in the model in Column (5), (6), (11) and (12).

While there seems to be a difference in the effect of leverage between the crisis period and the post-crisis period as discussed, the interaction term of the crisis dummy and leverage ($Crisis * Lev$) is insignificant in both the basic model (Column (5)) and the extended model (Column (11)). In addition, the interaction term is negative (-0.030) for the basic model, while the interaction term (0.031) in the extended model is positive. The negative effect in the basic model is unexpected since the coefficients of leverage on investment efficiency differ substantially between the crisis and post-crisis period in the opposite direction. The main effects of leverage (Lev) in the interaction term models in are highly similar in size compared to the coefficients of leverage on investment efficiency without the dummy variable added to the estimations in Table 5. This is expected since the interaction term is insignificant and does not significantly affect the debt-efficiency relationship for total leverage.

The main effect of the crisis dummy ($Crisis$) is marginally significantly negative for two specifications (Column (6) and Column (11)) at the 10% level. Following these results, Table 8 suggests that there is some evidence opposed to Hypothesis 2. The models suggest that there is some empirical evidence for the fact that firms invest more efficiently during the crisis. Furthermore, the effect is also substantive significant. There is a decrease of 7.7% of investment inefficiency during the European sovereign debt crisis compared to the post-crisis period. However, the statistical significance is low and this effect is also not robust across specifications. There is no empirical evidence to state that firms invested more or less efficient during the European sovereign debt crisis compared to the period after this crisis when both underinvestment and overinvestment are considered.

Turning to the measure of long-term leverage ($LtLev$), there are consistent changes in the effect of long-term leverage on investment efficiency in the crisis (Column (2): 0.305 & Column (8): 0.362) and the post-crisis samples (Column (4): -0.296 & Column (10): -0.135). During the crisis, long-term leverage has an insignificant positive effect on investment inefficiency. While the effect is not significant, the results suggest that an increase in long-term leverage increase the deviation between the realised investment level and the estimated optimal investment level during the European sovereign debt crisis. For the post-crisis samples, the effects of long-term leverage are insignificantly negative, this finding is consistent with Table 5 and the coefficients of the total leverage variable.

While the main effects of long-term leverage during the crisis, post-crisis and the full sample are not significant, the interaction term between the crisis variable and mean-centered long-term leverage ($Crisis * LtLev$) is statistically significant and positive. This means that there is a significant positive difference in the effect of leverage during the European sovereign debt crisis compared to the effect of leverage after the crisis has ended. The main effects of long-term leverage are insignificantly negative. The coefficients are -0.164 for the basic model (Column (6)) and -0.121 for the extended model (Column (12)). The interaction terms are significantly positive at the 10% and the 5% level. Due to the size of coefficients (0.248 & 0.298) compared to the main effect of long-term leverage, it is expected that the insignificant negative main effect flips into a positive effect of long-term leverage on the absolute value of investment efficiency. This could also be seen in the subsampling between the crisis period and the post-crisis period where the coefficients turned from positive into negative insignificant coefficients.

In addition to the statistical significance of the interaction term between the crisis indicator and long-term leverage, the moderating role of the European sovereign debt crisis on the effect of leverage on investment efficiency is also economically significant. Compared to the post-crisis period, a one standard deviation increase in long-term leverage results in an additional average change in deviation from the optimal level of investment of 8% for the basic model in Column (6). As an example, assuming the main effect of long-term leverage is moderately significantly negative during the post-crisis period, a one standard deviation increase in long-term leverage results in a decrease in the deviation of the expected level of investment of 5.3% (Calculation: 0.146 (standard deviation) x -0.164 (coefficient)/ 0.452

(average of the absolute value of investment efficiency of the basic model) = -5.3%). While during the crisis period the effect of long-term leverage on investment efficiency is the sum of the main effect (-0.164) and the interaction term (0.248). In this case, during the crisis period a one standard deviation increase in long term leverage would result in an increase in the average investment inefficiency of a firm of 2.7% (0.146 * (-0.164 + 0.248) / 0.452 = 2.7%). Thus, the effect is non-trivial.

Concluding, for the total measure of leverage there is not a significant change in direction and/or effect on investment efficiency. However, the coefficients during the crisis period are smaller in absolute size compared to the coefficients during the post-crisis period for the extended model and there is a change in direction from negative to a positive effect of leverage on investment inefficiency during the European sovereign crisis for the basic model. Following the significant interaction terms of the ratio of long-term debt to assets in addition to the difference in coefficients of leverage in the subsampling approach, the models do find some evidence for Hypothesis 3. An increase in (long-term) leverage results quicker into inefficient investment during the European sovereign debt crisis following the theory of debt overhang. While during the post-crisis period, the theory of the monitoring role of debt on investment decisions is leading.

Table 8

Role of the European sovereign debt crisis on investment efficiency. This table presents regression results on the role of the European sovereign debt crisis on the debt-investment efficiency relationship. The measure of investment efficiency (AIE) is increasing in inefficiency. The variables of interest are the two measures of leverage and the crisis indicator. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. The crisis dummy variable (Crisis) is a binary variable that is 1 during the crisis and 0 in the years after the crisis. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects when specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Basic Model						Extended Model					
	Crisis Period (2011-2014)		Post Crisis (2015-2019)		Interaction Effect		Crisis Period (2011-2014)		Post Crisis (2015-2019)		Interaction Effect	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	AIE	AIE	AIE	AIE	AIE	AIE	AIE	AIE	AIE	AIE	AIE	AIE
Lev_{t-1}	.029		-.368**		-.226**		-.168		-.271		-.271**	
	(.213)		(.167)		(.115)		(.226)		(.173)		(.126)	
$LtLev_{t-1}$		.305		-.296		-.164		.362		-.135		-.121
		(.288)		(.188)		(.133)		(.312)		(.18)		(.134)
$Crisis_t$					-.036	-.035*					-.036*	-.030
					(.023)	(.021)					(.022)	(.021)
$Crisis_t * Lev_{t-1}$					-.030						.031	
					(.082)						(.084)	
$Crisis_t * LtLev_{t-1}$						.248*						.298**
						(.129)						(.132)
$Size_{t-1}$	-.516***	-.457***	-.466***	-.486***	-.233***	-.204***	-.512***	-.478***	-.374***	-.394***	-.162***	-.142***
	(.123)	(.140)	(.077)	(.079)	(.042)	(.043)	(.150)	(.174)	(.076)	(.078)	(.045)	(.046)
ROA_{t-1}	-.010	-.088	.146	.238	-.103	-.020	-.025	-.031	.285	.451***	.048	.133
	(.171)	(.185)	(.177)	(.168)	(.110)	(.110)	(.232)	(.259)	(.179)	(.161)	(.118)	(.116)
$Tang_{t-1}$	-4.816***	-4.314***	-3.659***	-3.34***	- 2.789***	-2.68***	-4.406***	-4.383***	-3.828***	-3.397***	-2.804***	-2.709***
	(.635)	(.678)	(.428)	(.457)	(.244)	(.264)	(1.025)	(1.045)	(.443)	(.459)	(.28)	(.296)
Age_{t-1}	-.008	-.044	-.001	-.022	.243***	.22***	-.013	-.053	.009	.005	.293***	.274***
	(.112)	(.110)	(.075)	(.071)	(.040)	(.039)	(.140)	(.144)	(.069)	(.065)	(.041)	(.04)
Constant	7.55***	6.848***	6.899***	7.032***	3.222***	2.917***	7.858***	7.548***	5.743***	5.815***	2.238***	2.025***
	(1.516)	(1.708)	(.991)	(1.021)	(.529)	(.541)	(1.902)	(2.186)	(.954)	(.988)	(.558)	(.578)
Observations	4764	4541	8427	7991	13191	12532	3690	3517	8296	7886	11986	11403
R-squared	.118	.102	.105	.112	.055	.054	.099	.111	.105	.110	.052	.053
Time FE	YES	YES	YES	YES	NO	NO	YES	YES	YES	YES	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

5.2.2 The effect of the European sovereign debt crisis on under- and overinvestment

To investigate the direction of the effects of leverage and the European sovereign debt crisis on investment efficiency, the sample is split into under- and overinvesting firms. It is expected that the European sovereign debt exacerbates the effect of leverage on underinvestment via the problem of debt overhang (Hypothesis 3). This is expected since the credit crunch caused firms to be more constrained to borrow external funds. Besides, the interest costs and other financial costs related to debt financing increased because of the poor bank balance positions. Similarly, it is expected that the monitoring role of leverage on investment spending is also higher for overinvesting firms (Hypothesis 3). This means that it is expected that an increase in (long-term) leverage would result in less overinvestment. For the sole effect of the European sovereign debt crisis, all else equal, it is expected that due to the credit crunch and extra constraints, investment decreased despite of the available growth opportunities (Hypothesis 2). Therefore, it is expected that there is less overinvestment and more underinvestment during the European sovereign debt crisis from 2011 to 2014 compared to the post-crisis from 2015 onwards.

Firstly, Table 9 presents the results of the role of the European sovereign debt crisis on the investment behaviour of underinvesting firms. The underinvestment table is constructed similar to Table 8, the only change is that the dependent variable is altered to the absolute value of the negative residuals of the basic (Columns (1) to (6)) and the extended model (Columns (7) to (12)) such that the regressions are done relating to the amount of underinvestment. The two subdivisions of the table are divided into a crisis period for the years 2011 to 2014; the post-crisis period for the years 2015 to 2019 and the addition of the crisis indicator variable as well as an interaction term with the mean-centered measure of leverage.

For the measure of leverage based on total liabilities to assets (Lev), there is no evidence that the effect of leverage on underinvestment changes between the crisis and post-crisis periods. For both the basic model and the extended model, the coefficients are insignificant during the European sovereign debt crisis and the years after the peak of the crisis has ended. Only Column (9) reports a significant positive effect of leverage on the amount of underinvestment for the post-crisis period at the 5% level which is consistent with Table 6. In addition, the interaction terms between the crisis indicator and leverage ($Crisis * Lev$) are insignificant in

Column (5) and (11). Lastly, for all models in Table 9, there is no evidence for an increase in the amount of underinvestment for a firm with an average level of leverage since the small positive coefficients (0.005, 0.007, 0.001 & 0.004) of the crisis dummy variable ($Crisis$) are not significant.

For the effect of long-term leverage ($LtLev$) on underinvestment, dividing the sample into two periods causes the coefficient of long-term leverage on the amount of underinvestment to be insignificant for the crisis period (Column (2): 0.042 & Column (8): 0.000), which is consistent with Table 6. However, during the post-crisis period, long-term leverage has a significant negative effect (-0.12) on the amount of underinvestment for the basic model in Column (4). The negative coefficient for the extended model in Column (10) is insignificant. For the basic model, the results imply that there is difference in the effect of long-term debt on underinvestment between the crisis period and the post-crisis period since the coefficients are positive during the crisis meaning that long-term debt mitigates investment spending while the coefficients during the post-crisis period are positive. In this case, the results imply that an increase in long-term debt enabled firms to invest conform their growth opportunities while this was not the case during the European sovereign debt crisis.

When the role of the European sovereign debt crisis is added via an interaction term ($Crisis * LtLev$) to the models of long-term leverage, the moderating role of the crisis is found consistent with the models of total investment efficiency (Table 8) and the expectation of Hypothesis 3. For the basic model, the interaction term (Column (6): 0.132) is significantly positive at the 1% level, while for the extended model the interaction term (Column (12): 0.065) is marginally significant at the 10% level. This is empirical evidence that the effect of long-term leverage on underinvestment is stronger in the positive direction during the European sovereign debt crisis and supports Hypothesis 3. For example, in the basic model (Column (6)), the main effect of long-term leverage on the amount of underinvestment is negative and insignificant. The main effect in the interaction model resembles the effect of long-term leverage during the post-crisis period. While this coefficient was significant in Column (4), the coefficient is insignificant in the interaction model. The effect of long-term leverage during the crisis period is composed of the sum of the main effect of long-term leverage on underinvestment and the coefficient of the interaction term. This means that the effect of long-term leverage during the European sovereign debt crisis is 0.118 (-0.014+0.132)

for the basic model of underinvestment. Which means that an increase in long-term leverage causes an increase in the amount of underinvestment of a firm during the crisis.

The moderating role of the European sovereign debt crisis on the effect of long-term debt on underinvestment is also economically significant. For the basic model, an increase in long-term debt during the sovereign debt crisis of one standard deviation results in a change of 6.5% compared to the effect of long-term leverage during the post-crisis years. The substantial significance is calculated by multiplying the standard deviation of long-term leverage (0.146) by the significant interaction term (0.132), divided by the average level of underinvestment (0.297). Therefore, for the relationship between long-term debt and underinvestment in relation to the European sovereign debt crisis, there is statistically and economically significant evidence for Hypothesis 3. The European sovereign debt crisis exacerbates the negative effect of long-term leverage on the amount of underinvestment.

Table 10 presents the regression results of the role of the European sovereign debt crisis on the effect of (long-term) leverage on the amount of overinvestment. The overinvestment table is constructed similar to Table 8 and Table 9, the only change is that the dependent variable is altered to the value of the positive residuals of the basic model (Columns (1) to (6)) and the extended model (Columns (7) to (12)). The two subdivisions of the table are divided into a crisis period for the years 2011 to 2014; the post-crisis period for the years 2015 to 2019 and the addition of the crisis indicator variable as well as an interaction term with the mean-centered measure of leverage.

During the crisis period, the amount of overinvestment was significantly lower than the amount of overinvestment during the post-crisis years for with an average level of (long-term) leverage. The coefficients of the crisis dummy variable ($Crisis$) in Table 10 are statistically significant and negative for both the basic and extended models as well as for both specifications of leverage (Columns (5): -0.244, Column (6): -0.209, Column (11): -0.227 & Column (12): -0.201). This effect is also economically significant and, therefore, non-trivial. The amount of overinvestment decreases by 22-26% for firms with an average level of (long-term) leverage during the European sovereign crisis compared to the period after the crisis ended across the four specifications (Columns (5), (6), (11) and (12)) including the crisis dummy. This is a very large decrease in overinvestment. Since the crisis variable was not significantly negative for the total investment efficiency in Table 8, this explains that a lot of

overinvesting firms turned into underinvesting firms and the crisis is strongly related to increased underinvesting and decreased overinvesting. Due to the change in direction of inefficient investment, the absolute value of inefficient investment did not significantly change across the two periods since upwards deviation turned into downwards deviation when pooling all overinvesting and underinvesting firms.

For the sample of overinvesting firms in Table 10, an increase in (long-term) leverage has no significant effect on reducing overinvestment during the European sovereign debt crisis, holding all other variables constant. All coefficients in Table 10 of the effects of leverage (Lev), long-term leverage ($LtLev$) and the interaction terms ($(Lt)Lev * Crisis$) are statistically insignificant except for a marginally significant negative effect of total leverage on the amount of overinvestment during the post-crisis years in Column (9). In fact, the insignificant coefficients are positive during the crisis period and negative during the post-crisis years. This indicates that during the crisis period the amount of leverage did not matter given that a firm was still able to invest above their optimal level of investment. Moreover, a small share of firms is still overinvesting during the European sovereign debt crisis. In addition, the absolute value of overinvestment decreased significantly as can be seen by the crisis dummy variable ($Crisis$) coefficients. Since those firms are able to invest above their growth opportunities, leverage might have an effect on the available funds a firm has to invest. However, the interaction terms are also insignificant. Therefore, there is no empirical evidence that the amount of leverage had a different impact on overinvestment tendencies during the European sovereign debt crisis compared to the years after the crisis.

To conclude on the effects of (long-term) leverage on investment efficiency and the role of the European sovereign debt crisis on the debt-investment efficiency relationship, leverage has a significant relation to an increase in underinvestment following the problem of debt overhang (Myers, 1977). However, due to the monitoring role of debt (Jensen, 1986; Stulz, 1990), firms with an increase in leverage might convert from overinvesting firms into underinvesting firms due to the monitoring role of debt turning in a problem of debt overhang. This is shown by the statistically significant negative effects of leverage on the amount of absolute investment inefficiency. Due to the estimation method, the highest absolute values of inefficiency are related to overinvestment. In addition, the negative effect of leverage on investment efficiency due to the monitoring role of debt is not significant if the sample only

consists of overinvesting firms. While for underinvesting firms, leverage has a significant positive effect on the amount of underinvestment. This means that for firms with excessive levels of leverage, the monitoring role of debt is so strong that it turns into a problem. Consequently, firms need to pass upon valuable investment project that would otherwise increase the value of the firm.

The European sovereign debt crisis has a negative effect on the amount of overinvestment. However, since the effect is insignificant for total investment efficiency, the crisis converts overinvesting firms into underinvesting firms since the average size of inefficient investment does not significantly decrease or increase for firms with an average level of (long-term) leverage. Thus, the European sovereign debt crisis causes inefficient investment by turning overinvestment into underinvestment. In addition, the positive effect of long-term leverage on the amount of investment inefficiency is significantly stronger during the crisis. The interaction between long-term leverage and the crisis indicator is statistically and economically significant for total investment efficiency and underinvestment. This means that during the crisis an increase in long-term leverage exacerbates the problem of debt overhang which causes severe underinvestment. There is no empirical evidence for a differential impact of the crisis on the effect of total leverage for total investment efficiency, underinvestment and overinvestment.

Table 9

Role of the European sovereign debt crisis on underinvestment. This table presents regression results on the role of the European sovereign debt crisis on the debt-underinvestment relationship. The measure of underinvestment (UI) is increasing in inefficiency. The variables of interest are the two measures of leverage and the crisis indicator. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. The crisis dummy variable (Crisis) is a binary variable that is 1 during the crisis and 0 in the years after the crisis. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects when specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Basic Model						Extended Model					
	Crisis Period (2011-2014)		Post Crisis (2015-2019)		Interaction Effect		Crisis Period (2011-2014)		Post Crisis (2015-2019)		Interaction Effect	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	UI	UI	UI	UI	UI	UI	UI	UI	UI	UI	UI	UI
Lev_{t-1}	-.004		.056		.074**		.095		.116**		.052	
	(.069)		(.049)		(.034)		(.084)		(.057)		(.039)	
$LtLev_{t-1}$		.042		-.120**		-.014		.000		-.072		-.030
		(.081)		(.047)		(.039)		(.070)		(.059)		(.046)
$Crisis_t$					.005	.007					.001	.004
					(.006)	(.006)					(.006)	(.006)
$Crisis_t * Lev_{t-1}$					-.026						-.008	
					(.027)						(.024)	
$Crisis_t * LtLev_{t-1}$						.132***						.065*
						(.043)						(.038)
$Size_{t-1}$	-.024	.009	-.001	.016	.030**	.042***	.090**	.065	.109***	.123***	.113***	.123***
	(.055)	(.05)	(.019)	(.018)	(.012)	(.011)	(.041)	(.044)	(.022)	(.020)	(.013)	(.012)
ROA_{t-1}	-.164***	-.116**	-.112**	-.148***	-.243***	-.218***	-.037	-.020	.068	.027	-.087**	-.061*
	(.058)	(.049)	(.045)	(.042)	(.037)	(.034)	(.059)	(.053)	(.051)	(.045)	(.037)	(.033)
$Tang_{t-1}$	.411***	.423***	.216**	.338***	.046	.069	.871***	.856***	.143	.244**	.061	.071
	(.149)	(.150)	(.100)	(.104)	(.058)	(.067)	(.188)	(.188)	(.107)	(.110)	(.074)	(.080)
Age_{t-1}	.068*	.049	.032	.041**	.158***	.169***	.084*	.077*	-.014	-.006	.166***	.174***
	(.036)	(.032)	(.022)	(.019)	(.013)	(.011)	(.051)	(.045)	(.022)	(.022)	(.014)	(.014)
Constant	.374	-.025	.131	-.106	-.462***	-.663***	-.890*	-.554	-1.135***	-1.311***	-1.503***	-1.689***
	(.689)	(.626)	(.236)	(.232)	(.152)	(.134)	(.525)	(.554)	(.274)	(.257)	(.157)	(.154)
Observations	3588	3434	6481	6166	10069	9600	2747	2628	6288	5991	9035	8619
R-squared	.082	.082	.312	.356	.070	.083	.163	.18	.293	.332	.088	.105
Time FE	YES	YES	YES	YES	NO	NO	YES	YES	YES	YES	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 10

Role of the European sovereign debt crisis on overinvestment. This table presents regression results on the role of the European sovereign debt crisis on the debt-overinvestment relationship. The measure of overinvestment (OI) is increasing in inefficiency. The variables of interest are the two measures of leverage and the crisis indicator. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. The crisis dummy variable (Crisis) is a binary variable that is 1 during the crisis and 0 in the years after the crisis. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects when specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Basic Model						Extended Model					
	Crisis Period (2011-2014)		Post Crisis (2015-2019)		Interaction Effect		Crisis Period (2011-2014)		Post Crisis (2015-2019)		Interaction Effect	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OI	OI	OI	OI	OI	OI	OI	OI	OI	OI	OI	OI
Lev_{t-1}	1.252		-1.148		-.375		1.040		-1.11*		-.602	
	(1.143)		(.719)		(.46)		(1.086)		(.652)		(.440)	
$LtLev_{t-1}$		.790		-.779		-.451		.428		-.239		-.489
		(.676)		(.834)		(.538)		(1.05)		(.793)		(.520)
$Crisis_t$					-.244***	-.209**					-.227***	-.201**
					(.094)	(.095)					(.086)	(.085)
$Crisis_t * Lev_{t-1}$					-.401						.378	
					(.401)						(.358)	
$Crisis_t * LtLev_{t-1}$						.516						.912
						(.626)						(.595)
$Size_{t-1}$	-.963*	-1.099*	-1.165***	-1.133***	-.438***	-.376**	-.608	-.484	-.866***	-.901***	-.449***	-.399***
	(.517)	(.607)	(.223)	(.228)	(.137)	(.148)	(.635)	(.757)	(.21)	(.213)	(.140)	(.151)
ROA_{t-1}	.803	.642	.686	1.208**	-.300	.225	.660	.427	1.257**	1.235**	.799*	.674
	(.967)	(.793)	(.555)	(.595)	(.417)	(.444)	(.865)	(.816)	(.594)	(.595)	(.434)	(.455)
$Tang_{t-1}$	-8.235***	-8.113***	-10.178***	-9.431***	-7.428***	-6.842***	-6.628***	-6.766***	-9.713***	-10.045***	-7.021***	-6.929***
	(1.249)	(1.821)	(1.287)	(1.267)	(.673)	(.72)	(2.288)	(2.244)	(.986)	(.986)	(.609)	(.677)
Age_{t-1}	.360	.462	.196	-.032	.767***	.666***	.423	.231	.418	.252	.901***	.795***
	(.515)	(.396)	(.285)	(.265)	(.161)	(.160)	(.371)	(.379)	(.289)	(.265)	(.170)	(.167)
Constant	11.74**	13.565**	15.725***	15.365***	5.515***	4.914***	7.412	7.704	11.979***	12.336***	5.268***	4.905***
	(5.93)	(6.848)	(2.697)	(2.734)	(1.506)	(1.649)	(7.09)	(8.474)	(2.526)	(2.526)	(1.54)	(1.696)
Observations	1176	1107	1946	1825	3122	2932	943	889	2008	1895	2951	2784
R-squared	.172	.133	.208	.218	.122	.104	.136	.156	.225	.229	.133	.124
Time FE	YES	YES	YES	YES	NO	NO	YES	YES	YES	YES	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

5.3 Additional analyses

In this section, results are reported of additional tests that lend robustness and extend the reported results. In the previous sections, the results are robust for the two measurements of investment efficiency. In addition, the addition of first-step regressors to the second step did not change the inferences that could be drawn from the models. To improve the robustness and reliability of the results, Section 5.3.1 reports the results of using alternative measures of the proxies of investment (in)efficiency and alternative specifications of the investment efficiency model. Afterwards, Section 5.3.2 takes the effect of dominating countries into account since the sample used in the analysis is composed of a multiple of countries. Furthermore, alternative specifications of the crisis variable to consider the differential effect the European sovereign debt crisis had on certain countries. The argumentation behind doing these robustness and additional tests is explained in Section 3.3.

5.3.1 Alternative measures and specifications of the investment efficiency model

To start off the robustness tests, Chen et al. (2018) find that the typical implementation of the two-step procedure in empirical accounting and finance research (i.e. using ordinary least squares to decompose a dependent variable into its predicted and residual components and using the residuals as the dependent variables in a second regression) can generate biased coefficients and standard errors that cause incorrect inferences. According to Chen et al. (2018), the inclusion of first-step regressors to the regressions with (transformed) residuals accounts for possible estimation errors. Therefore, as a robustness test, the independent variables of the regression used to estimate the measures of investment efficiency (Basic model: Equation (1) & Extended model: Equation (2)) are added to the second step regression models (Equation (3) & (4)) as additional control variables. Table 11 shows the results of regressing the measures of investment efficiency, underinvestment and overinvestment on the combination of the first-step and second-step regressors. Similarly, Table A.3 shows the alternative regression results for the models including the crisis interaction term.

Despite the addition of the first-step regressors to the second-step regression models, the inferences of the regression models in Table 11 are largely the same of the inferences of Table 5 (Effect of leverage on investment efficiency), Table 6 (Effect of leverage on underinvestment) and Table 7 (Effect of leverage on overinvestment). First of all, for both the

basic and extended model, leverage has a significant negative impact on the absolute deviation from the optimal level of investment as shown in Column (1) & (7). In addition, the economic significance of these coefficients is also similar. The positive effect of leverage (0.050) on the amount of underinvestment is insignificant in the extended model (Column (9)) while the positive effect (0.081) is significant at the 1% level for the basic model (Column (3)). Table 6 showed significant positive effects for both models. Lastly, all effects of long-term leverage on the measures of investment efficiency as well as the effects of total leverage on overinvestment are insignificant which is comparable to the results of the models excluding the first-step regressors where those effects are also insignificant.

Table A.3 shows the regression results of the crisis interaction models on the combination of first and second step regressors. The inferences of the regression models in Table 12 with the added interaction terms and the main effect of the crisis variable are largely the same of the inferences of Table 8 (Role of the European sovereign debt crisis on investment efficiency), Table 9 (Role of the European sovereign debt crisis on underinvestment), and Table 10 (Role of the European sovereign debt crisis on overinvestment). In addition, the main effects of leverage and long-term leverage are similar in significance and size compared to Table 11. The fact that long-term leverage has a stronger positive effect during the European sovereign debt crisis on the deviation from the optimal level compared to the post-crisis period is statistically and economically significant in both the investment efficiency models (Column (2) & (8)) and the underinvestment models (Column (4) & (10)). Furthermore, the interaction terms with total leverage are insignificant which is consistent with the models without first-step regressors.

Next, possible estimation error in the lowest deviations from the optimal level of investment is taken into account. Specifically, there is a chance that the lowest values of investment inefficiency are wrongly categorised as being under- or overinvestment. Following Biddle et al. (2009) and Chen et al. (2011), the positive and negative residuals of the two methods to estimate optimal investment are sorted in deciles. For positive residuals (OI), the observations from the bottom decile are excluded. Similarly, for the absolute value of the negative residuals (UI), the observations from the bottom decile are excluded as well. In this way, investment efficiency measures close to zero (the estimated optimal level of investment for a firm) are excluded from the estimations. These values are likely to be misclassified and can also be

defined as efficient investment compared to being defined as low levels of inefficient investment.

Table 12 presents the results of the exclusion of the lowest decile from the underinvesting firms based on the absolute value of the amount of underinvestment. The regression table shows results for the basic model (Columns (1) to (4)) and the extended model (Columns (5) to (8)). In addition, regression results of both the base model (Columns (1), (2), (5) and (6)) and the crisis interaction model (Columns (3), (4), (7) and (8)) are shown in this table. Excluding the lowest decile from the underinvesting firm-year observations does not substantially change the inferences of the effect of (long-term) leverage on underinvestment found in Table 6 and Table 9. Still, there is no concluding empirical evidence for a differential effect of the European sovereign debt crisis for the total measure of leverage. However, leverage does have a significant positive effect on the amount of underinvestment consistent with the previous models. Therefore, robust to this alternative specification, there is empirical evidence for Hypothesis 1a which states that leverage has a positive impact on the amount of underinvestment due to the problem of debt overhang.

For the extended model of underinvestment, the positive interaction term between long-term leverage and the crisis indicator turns insignificant (Column (8): 0.040). By excluding the lowest values from the underinvestment measure, the marginally significant effect at the 10% level in the previous underinvestment models (Table 9) returns insignificant. However, the interaction term in the basic model remains statistically significant at the 5% level. For the basic model of optimal investment, there is empirical evidence for Hypothesis 3 in terms of long-term leverage. H3 states that the European sovereign debt crisis significantly intensifies the problem of debt overhang for firms with high long-term leverage. Nevertheless, for the extended model the moderating effect of the crisis on the effect of long-term leverage on the amount of underinvestment is not robust for the exclusion of the lowest decile.

Table 13 presents the results of the exclusion of the lowest deciles from the overinvesting firms. The regression table shows results for the basic model (Columns (1) to (4)) and the extended model (Columns (5) to (8)). In addition, both the base model (Columns (1), (2), (5) and (6)) and the crisis interaction model (Columns (3), (4), (7) and (8)) are considered in this regression output. Consistent with Table 7 and Table 10, there is no significant effect of (long-term) leverage on the amount of overinvestment. Therefore, there is no empirical evidence

for the beneficial effect of the monitoring role of debt financing (H1b). The exclusion of the lowest deviation from optimal investment does not change the significance of the effects of (long-term) leverage in both the base models and the crisis interaction models.

Considering the role of the European sovereign debt crisis on the amount of overinvestment, the negative effect of the European sovereign debt crisis in reducing overinvestment directly is robust over this alternative specification, all else equal. Despite the removal of the lowest values of the positive deviations from the optimal investment (the most efficient firms), the amount of overinvestment of a firm with an average level of (long-term) leverage is statistically significantly lower compared to the post-crisis period at the 1% level. In addition, this effect is still economically significant. Therefore, the effect of the European sovereign debt crisis on reducing the amount of overinvestment is robust to this alternative sample of overinvesting firms.

Opposed to insignificant interaction terms between the crisis variable and long-term leverage on the amount of overinvestment in Table 10, the interaction term between long-term leverage and the crisis indicator is marginally significant at the 10% level for the extended model in Column (8). In fact, the interaction term (1.208) is significantly positive. This means that after removing the most efficient overinvesting firms, an increase in long-term leverage has a positive effect on the amount of overinvestment given that a firm is overinvesting during the European sovereign debt crisis. This effect is only marginally significant for the extended model and not significant for the measure of total leverage. Therefore, it cannot be concluded with certainty that this indicates that an increase in long-term leverage would result in more funds to spend on value-destroying projects.

As a last robustness test for the measure of investment efficiency, the estimation model which is used to obtain the residuals used to get the measures of investment efficiency is altered. In this thesis, the investment efficiency estimation models of McNichols & Stubben (2008) are used. This is a widely acknowledged method to estimate deviations from the optimal level of investment. Another widely used estimation method is the investment efficiency model of Biddle et al. (2009). This method is based on the growth of sales and also includes Tobin's Q as a proxy of growth opportunities. The estimation method is similar to the basic and extended model of investment efficiency used in the main models of this thesis and is described in Section 3.3. This alternative model of investment efficiency should result in the same

inferences about the effect of leverage on investment efficiency and the role of the European sovereign debt crisis. When the results are similar in statistical and economical significance, the results are robust to multiple methods of measuring investment efficiency.

Table 14 presents the regression results based on the investment efficiency model of Biddle et al. (2009). The table is constructed as follows, Columns (1) to (6) present the regression results of estimating Equation (3) which investigates the effect of (long-term) leverage on the absolute value of investment efficiency (AIE), underinvestment (UI) and overinvestment (OI). In Columns (7) to (12), the crisis interaction term is added following Equation (4) to examine the role of the European sovereign debt crisis on the effect of leverage on investment inefficiency. Similar to the other models, firm fixed effects are applied to the models and the models without the crisis indicator include time fixed effects to account for the influence of certain years on the results.

The previous regression results using the investment efficiency measures of the models of McNichols & Stubben (2008) are largely robust to the regressions results using the model based on sales growth of Biddle et al. (2009) reported in Table 14. Firstly, considering the models without the crisis included (Column (1-6), leverage has a significant effect on reducing the amount of absolute investment efficiency (Column (1): -0.288) at the 5% level. However, this negative effect of leverage on the amount of deviation is not significant for overinvesting firms (Column (5)). While, as expected, the effect of leverage on the amount of underinvestment is significantly positive (Column (3): 0.166) at the 1% level. Following the arguments in the previous sections, this means that an increase in leverage is related to underinvestment. Furthermore, since the effect is insignificant for overinvesting firms it means that excessive levels of leverage intensify the monitoring role of debt into a problem of debt overhang. In other words, the results in Table 14 also indicate that leverage has a positive impact on the amount of underinvestment via the problem of debt overhang and increases in leverage turn overinvesting firms into underinvesting firms.

For the role of the European sovereign debt crisis on the (long-term) leverage – investment efficiency relationship, the inferences of the model of Biddle et al. (2009) are also robust to the results using the basic and extended models of McNichols & Stubben (2008). There is no empirical evidence for a moderating role of the European sovereign debt crisis on the leverage measure based on total liabilities. In addition, Table 14 reports a negative effect of the

European sovereign debt crisis on the absolute investment efficiency and the amount of overinvestment of a firm. However, an increase in long-term leverage during the European sovereign debt crisis results in stronger inefficient investment. Opposed to the previous results, the interaction term of the European sovereign debt crisis with long-term leverage is not only significant for the absolute value of investment efficiency (Column (8): 0.359) and the amount of underinvestment (Column (10): 0.092). The interaction term is also significantly positive (Column (12): 1.265) for the overinvesting firms at the 5% level. This means that an increase in long-term leverage could either result in more underinvestment or overinvestment and depends on the investment behaviour before increasing the long-term debt to assets ratio.

Concluding on this set of robustness tests regarding alternative measures of investment efficiency, there is no large significant difference between the results obtained by the basic and extended models and the results by either adding the first-step regressors following Chen et al. (2018), excluding the lowest deviations following Biddle et al. (2009) and Chen et al. (2011), or using the investment efficiency measurement model of Biddle et al. (2009). The main result that high leverage causes underinvestment and the effect of long-term leverage is intensified during the European sovereign debt crisis is also statistically and economically significant in this set of robustness tests. The only remarkable change from the previous results is that the interaction term between the crisis indicator and long-term leverage for overinvesting firms is significantly positive for several robustness tests. This suggests that when firms are still overinvesting during the European sovereign debt crisis, an extra increase in long-term leverage increases the available funds that is present to managers with value-destroying tendencies. Consequently, the long-term debt issuance could give more capability to overinvest while growth opportunities declined during the European sovereign debt crisis.

Table 11

Investment efficiency regression models with first-step regressors. This table present regression results of the investment efficiency models with additional control variables following Chen et al. (2018). The measures of investment efficiency are increasing in inefficiency. The variables of interest are the two measures of leverage. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects when specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Basic Model						Extended Model					
	Investment Efficiency		Underinvestment		Overinvestment		Investment Efficiency		Underinvestment		Overinvestment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	AIE	AIE	UI	UI	OI	OI	AIE	AIE	UI	UI	OI	OI
Lev_{t-1}	-.195*		.081***		-.475		-.248**		.050		-.503	
	(.104)		(.028)		(.394)		(.121)		(.031)		(.385)	
$LtLev_{t-1}$		-.048		.051		-.260		-.022		-.001		-.246
		(.127)		(.035)		(.502)		(.128)		(.037)		(.486)
$Size_{t-1}$	-.224***	-.215***	.025**	.031***	-.454***	-.445***	-.200***	-.186***	.056***	.056***	-.615***	-.523***
	(.042)	(.044)	(.010)	(.010)	(.147)	(.157)	(.049)	(.050)	(.012)	(.011)	(.147)	(.157)
ROA_{t-1}	.005	.020	-.187***	-.189***	-.177	.244	.062	.103	-.142***	-.142***	.683	.602
	(.106)	(.106)	(.031)	(.029)	(.417)	(.425)	(.117)	(.115)	(.031)	(.028)	(.426)	(.450)
$Tang_{t-1}$	-2.59***	-2.527***	.169***	.189***	-7.22***	-6.708***	-2.306***	-2.298***	.235***	.229***	-6.371***	-6.287***
	(.248)	(.267)	(.054)	(.060)	(.675)	(.720)	(.296)	(.312)	(.068)	(.075)	(.677)	(.740)
Age_{t-1}	.000	-.018	.014	.027**	.184	.067	.004	-.008	.007	.015	.352*	.283
	(.048)	(.048)	(.013)	(.011)	(.178)	(.178)	(.052)	(.051)	(.014)	(.014)	(.193)	(.189)
$TobinQ_{t-1}$	.045***	.051***	.022***	.020***	.080*	.100**	.040***	.055***	.018***	.017***	-.021	.056
	(.014)	(.015)	(.005)	(.005)	(.046)	(.042)	(.015)	(.015)	(.005)	(.005)	(.050)	(.057)
CF_t	-.007***	-.005***	-.004***	-.004***	-.006**	-.002	-.005***	-.004***	-.003***	-.003***	-.006**	-.004
	(.001)	(.001)	(.000)	(.001)	(.003)	(.004)	(.001)	(.001)	(.000)	(.000)	(.003)	(.003)
Net Inv_{t-1}							-.098***	-.092***	.004	.007	-.173***	-.178***
							(.019)	(.020)	(.006)	(.006)	(.054)	(.057)
$Growth_{t-1}$							.213***	.168***	.183***	.188***	.424**	.270
							(.063)	(.058)	(.022)	(.019)	(.175)	(.167)
Constant	3.64***	3.475***	-.136	-.22*	6.806***	6.59***	3.61***	3.459***	-.230	-.249*	8.11***	7.798***
	(.549)	(.558)	(.131)	(.121)	(1.703)	(1.779)	(.63)	(.638)	(.155)	(.145)	(1.748)	(1.802)
Observations	13191	12532	10069	9600	3122	2932	11986	11403	9035	8619	2951	2784
R-squared	.108	.097	.323	.331	.179	.162	.107	.102	.338	.358	.199	.190
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 12

Underinvestment regressions without the lowest decile. This table present regression results of the models of underinvestment without the values of the lowest decile. The measure of underinvestment (UI) is increasing in inefficiency. The variables of interest are the two measures of leverage and the crisis indicator. Leverage (Lev) is measured as the ratio of total liabilities to total asset and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. The crisis dummy variable (Crisis) is a binary variable that is 1 during the crisis and 0 in the years after the crisis. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects when specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Basic Model				Extended Model			
	Normal		Crisis Interaction		Normal		Crisis Interaction	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	UI	UI	UI	UI	UI	UI	UI	UI
Lev_{t-1}	.082**		.077**		.108***		.077**	
	(.034)		(.037)		(.035)		(.037)	
$LtLev_{t-1}$		.007		-.023		.022		-.001
		(.038)		(.040)		(.041)		(.044)
$Crisis_t$			.006	.007			-.001	.001
			(.007)	(.006)			(.007)	(.007)
$Crisis_t * Lev_{t-1}$			-.040				-.017	
			(.029)				(.026)	
$Crisis_t * LtLev_{t-1}$				.109**				.040
				(.042)				(.042)
$Size_{t-1}$	.011	.022**	.026**	.038***	.083***	.088***	.106***	.114***
	(.013)	(.011)	(.013)	(.011)	(.012)	(.012)	(.013)	(.012)
ROA_{t-1}	-.206***	-.183***	-.223***	-.191***	-.049	-.038	-.083**	-.057*
	(.036)	(.033)	(.037)	(.034)	(.036)	(.031)	(.037)	(.033)
$Tang_{t-1}$	.058	.109	.046	.076	.121	.156*	.072	.090
	(.064)	(.073)	(.061)	(.071)	(.08)	(.087)	(.081)	(.088)
Age_{t-1}	.018	.032**	.157***	.171***	.001	.012	.171***	.180***
	(.015)	(.013)	(.013)	(.012)	(.016)	(.016)	(.015)	(.015)
Constant	.127	-.030	-.381**	-.585***	-.453***	-.534***	-1.399***	-1.552***
	(.161)	(.139)	(.158)	(.138)	(.163)	(.161)	(.161)	(.157)
Observations	9063	8610	9063	8610	8132	7733	8132	7733
R-squared	.219	.255	.066	.08	.252	.285	.090	.107
Time FE	YES	YES	NO	NO	YES	YES	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES

Table 13

Overinvestment regressions without the lowest decile. This table present regression results of the models of overinvestment without the values of the lowest decile. The measure of overinvestment (OI) is increasing in inefficiency. The variables of interest are the two measures of leverage and the crisis indicator. Leverage (Lev) is measured as the ratio of total liabilities to total asset and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. The crisis dummy variable (Crisis) is a binary variable that is 1 during the crisis and 0 in the years after the crisis. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects when specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Basic Model				Extended Model			
	Normal		Crisis Interaction		Normal		Crisis Interaction	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OI	OI	OI	OI	OI	OI	OI	OI
Lev_{t-1}	-.480		-.372		-.501		-.586	
	(.428)		(.487)		(.413)		(.465)	
$LtLev_{t-1}$		-.356		-.497		-.138		-.472
		(.551)		(.573)		(.535)		(.563)
$Crisis_t$			-.275**	-.251**			-.249**	-.217**
			(.11)	(.112)			(.100)	(.100)
$Crisis_t * Lev_{t-1}$			-.299				.435	
			(.447)				(.403)	
$Crisis_t * LtLev_{t-1}$				.188				1.208*
				(.717)				(.677)
$Size_{t-1}$	-.518***	-.453***	-.424***	-.350**	-.652***	-.598***	-.498***	-.458***
	(.153)	(.162)	(.144)	(.155)	(.151)	(.157)	(.150)	(.162)
ROA_{t-1}	-.237	.398	-.158	.405	.768*	.619	.836*	.696
	(.423)	(.446)	(.439)	(.476)	(.446)	(.467)	(.453)	(.477)
$Tang_{t-1}$	-7.527***	-6.81***	-7.628***	-6.85***	-7.618***	-7.514***	-7.231***	-7.144***
	(.749)	(.821)	(.726)	(.797)	(.682)	(.762)	(.633)	(.703)
Age_{t-1}	.119	-.041	.755***	.622***	.329	.237	.981***	.886***
	(.203)	(.190)	(.178)	(.169)	(.211)	(.210)	(.193)	(.191)
Constant	7.861***	7.063***	5.43***	4.75***	8.657***	8.911***	5.689***	5.436***
	(1.736)	(1.787)	(1.564)	(1.716)	(1.806)	(1.803)	(1.620)	(1.779)
Observations	2810	2624	2810	2624	2656	2491	2656	2491
R-squared	.174	.158	.121	.101	.181	.178	.137	.129
Time FE	YES	YES	NO	NO	YES	YES	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES

Table 14

Alternative estimation of investment efficiency following Biddle et al. (2009). This table presents regression results based on the investment efficiency model of Biddle et al. (2009). The measures of investment efficiency are increasing in inefficiency. The variables of interest are the two measures of leverage and the crisis indicator. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. The crisis dummy variable (Crisis) is a binary variable that is 1 during the crisis and 0 in the years after the crisis. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects when specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Normal						Crisis Interaction					
	Investment Efficiency		Underinvestment		Overinvestment		Investment Efficiency		Underinvestment		Overinvestment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	AIE	AIE	UI	UI	OI	OI	AIE	AIE	UI	UI	OI	OI
Lev_{t-1}	-.288**		.116***		-.670		-.327**		.089***		-.689	
	(.129)		(.031)		(.427)		(.133)		(.034)		(.497)	
$LtLev_{t-1}$		-.112		.027		-.310		-.237*		-.008		-.746
		(.129)		(.035)		(.521)		(.135)		(.037)		(.548)
$Crisis_t$							-.048**	-.039*	-.003	-.003	-.287***	-.233***
							(.021)	(.020)	(.006)	(.005)	(.088)	(.088)
$Crisis_t * Lev_{t-1}$							.004		-.025		.283	
							(.079)		(.023)		(.405)	
$Crisis_t * LtLev_{t-1}$								.359***		.092***		1.265**
								(.126)		(.031)		(.618)
$Size_{t-1}$	-.224***	-.202***	.049***	.046***	-.511***	-.454***	-.174***	-.151***	.081***	.079***	-.380**	-.313**
	(.043)	(.044)	(.010)	(.010)	(.150)	(.151)	(.043)	(.044)	(.011)	(.011)	(.153)	(.156)
ROA_{t-1}	-.003	.059	-.104***	-.132***	.041	.408	-.032	.050	-.131***	-.145***	.149	.465
	(.111)	(.115)	(.029)	(.030)	(.412)	(.423)	(.113)	(.116)	(.030)	(.032)	(.433)	(.447)
$Tang_{t-1}$	-2.571***	-2.537***	.286***	.269***	-6.408***	-6.141***	-2.611***	-2.593***	.256***	.227***	-6.431***	-6.114***
	(.301)	(.308)	(.060)	(.061)	(.793)	(.810)	(.297)	(.306)	(.061)	(.061)	(.752)	(.767)
Age_{t-1}	-.020	-.011	-.002	.007	.095	.099	.247***	.245***	.153***	.158***	.678***	.652***
	(.052)	(.050)	(.013)	(.012)	(.207)	(.212)	(.042)	(.041)	(.012)	(.012)	(.187)	(.187)
Constant	4.445***	4.008***	-.027	.040	9.707***	8.187***	2.44***	2.163***	-1.15***	-1.136***	4.874***	4.093**
	(.595)	(.585)	(.136)	(.134)	(2.003)	(1.894)	(.540)	(.559)	(.132)	(.132)	(1.687)	(1.775)
Observations	12042	11661	9125	8865	2917	2796	12042	11661	9125	8865	2917	2796
R-squared	.081	.083	.301	.305	.154	.151	.047	.048	.091	.093	.084	.089
Time FE	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

5.3.2 Alternative crisis and country specifications

In this section, the structure of the sample used to investigate the relations between leverage, investment efficiency and the European sovereign debt crisis is taken into consideration. The sample consists of firms located in seven different countries. Specifically, five of the most affected countries during the European sovereign debt crisis (GIIPS, excluding Greece); two of the biggest countries of the Eurozone (Germany & France) and the United Kingdom which uses a different monetary system but was part of the European Union. To account for the different groups of countries in the sample and the dominating firm-year observations of the United Kingdom (see Section 4.2), multiple subsamples and alternative specifications of the European sovereign debt crisis dummy variable are considered to examine the effects of these countries on the results that were found.

Firstly, the firms from the United Kingdom are excluded from the sample to account for their influence on the regression results. The United Kingdom uses a different monetary system and, consequently, firms of this country are expected to be least affected by the European sovereign debt crisis according to Peia et al. (2020). In addition, the firm-year observations out of the United Kingdom are dominating the total number of firm-year observations compared to the other countries in the sample (see Section 4.2). Therefore, Table 15 presents the regression results of the sample excluding the firm-year observations of the United Kingdom for the basic model of investment efficiency. For the sake of brevity, Table A.4 reports the same regression results of these estimations for the extended model of optimal investment.

When the firms from the potentially less affected United Kingdom are excluded, the significant negative effect of leverage on the absolute value of inefficient investment disappears (Column (1)). Moreover, when the crisis dummy is added to the models of absolute inefficiency, the coefficient during the post-crisis years of long-term leverage is significantly negative (Column (8)). However, the interaction term of the crisis indicator interacted with long-term leverage is significantly positive at the 5% level. The sum of the main effect and the interaction term indicates a small negative effect of long-term leverage on inefficiency, compared to a substantive negative effect during the post-crisis years. Looking at Column (12), the significant negative effect of long-term leverage on the amount of overinvestment due to the monitoring role of debt explains the difference. Therefore, when the United Kingdom is removed from

the sample, the positive effect of the monitoring role of leverage is found during the post-crisis years. There is no empirical evidence that the reduction of overinvestment due to the disciplinary role of debt intensified or changes during the European sovereign debt crisis following these regression estimates. Besides, opposed to previous results, there is no significant negative effect of the European sovereign debt crisis dummy variable on the amount of overinvestment when the firms of the United Kingdom are excluded from the sample.

Turning to the regression results considering, solely, the amount of underinvestment as the dependent variable, the European sovereign debt crisis has a significant positive effect on the amount of underinvestment (Column (9) & (10)). In addition, the effect of long-term leverage on underinvestment due to the problem of debt overhang is substantially intensified during the European sovereign debt crisis (Column (10)). This means that firms with an average level of (long-term) leverage underinvested significantly more during the European sovereign debt crisis and that the effect of the crisis intensified the underinvestment problems of debt when firms increased their level of long-term leverage. These results excluding the firm-year observations from the United Kingdom support Hypothesis 2 and Hypothesis 3 in the direction of increased underinvestment due to intensified financial frictions following a debt issuance and the occurrence of the European sovereign debt crisis. The results in table A.1 for the investment efficiency measures estimated by the extended models yield the same inferences as Table 15.

For the last set of additional analyses to extend the results and check for robustness, two alternative specifications of the European sovereign debt crisis dummy variables are constructed. First of all, following Peia et al. (2020), a crisis variable is constructed as 0 for firms in the United Kingdom. This means that the European sovereign debt crisis only affects firms operating in Eurozone countries from 2011 to 2014. In addition, following Acharya et al. (2020), an alternative crisis variable is defined as 1 for firms who are defined as GIIPS countries (Italy, Ireland, Portugal & Spain) and 0 for all other countries in the sample. This crisis variable indicates that the European sovereign debt crisis only affects firms operating in the GIIPS countries from 2011 to 2014. This crisis variable compares the effect of leverage and the role of the crisis for the potentially most affected countries to the biggest economies of Europe (Germany, France & UK). In the last set of regression results, the countries from the United

Kingdom are excluded following the previous discussion to compare the GIIPS countries to the biggest economies in the affected Eurozone using the crisis variable that only affects the GIIPS countries from 2011 to 2014.

Table 16 reports the regression results of the two alternative crisis specifications for the whole sample of firm-year observations from all seven countries. Table 16 reports the regression results of the basic model while Table A.5 presents the same regression specifications for the extended model of investment efficiency. Columns (1) to (6) present the results for the crisis variable that excludes the firms from the United Kingdom from the affected firm-year observations during the European sovereign debt crisis following Peia et al. (2020). Columns (7) to (12) present the results for the GIIPS crisis variable to compare the most affected countries with the other countries in the sample.

The results of the crisis variable excluding the firms from the United Kingdom in Columns (1) to (6) in Table 16 are roughly similar to the regression results excluding the United Kingdom as a whole from the sample as reported in Table 15. A significant negative effect of leverage on investment inefficiency is found by turning the absolute value of overinvestment into the absolute value of underinvestment. In addition, during the European sovereign debt crisis, Eurozone countries underinvested significantly more which is shown by the statistical significantly coefficients of the European sovereign debt crisis indicator in Column (4). However, this effect is not significant if total leverage is in the model instead of long-term leverage as shown in Column (3). In addition, the role of long-term leverage on the intensification of the problem of debt overhang during the European sovereign debt crisis remains significantly present in this alternative specification. Yet, for the extended model in Table A.5, the moderating role of the crisis on long-term leverage is insignificant. So, the intensification of debt overhang using long-term leverage for non-UK countries during the European sovereign debt crisis is not robust over the basic and extended models of investment efficiency.

When employing the GIIPS crisis variable, the moderating effect of the European sovereign debt crisis is insignificant for the absolute value of investment efficiency, underinvestment and overinvestment. This means that for the firm-year observations of firms operating in the GIIPS countries, an increase in long-term leverage during the European sovereign debt crisis has no significant effect on their amount of deviation from the optimal level compared to firms

in other countries during the full sample and/or compared to the firm-year observations of the GIIPS countries in the post-crisis years. For the extended model in Table A.5, the moderating effect of the crisis on the debt-efficiency relationship is also statistically insignificant. Both tables do report a significant increase in the absolute inefficient investment for an averagely leveraged firm (Column (7) & (8)). The significant positive impact of the European sovereign debt crisis on the amount of overinvestment for an averagely leveraged firm (Column (11) & (12)) can be caused by drastically decreasing growth opportunities compared to firms from the biggest economies in Europe.

These results indicate that there is no robust evidence over the two models of investment efficiency that for the most affected countries (GIIPS) the effect of leverage on investment behaviour during the European sovereign debt crisis changed compared to the rest of the firm-year observations. This implies that the effect of the European sovereign debt crisis that has been found in the other models might affect all Eurozone countries in the sample and not GIIPS countries specifically. To differentiate between the Eurozone countries and the GIIPS countries, Table A.6 presents the regression results of both the basic and extended model for the impact of the crisis for the GIIPS countries compared to other Eurozone countries (Germany & France). The sample that is used excludes the firm-year observations out of the United Kingdom and aims to differentiate between potentially more affected firms and firms in relatively stable Eurozone countries during the peak of the European sovereign debt crisis. In addition, for the countries in the Eurozone, the firm-year observations from Germany and France are dominating.

The results in Table A.6 are similar to the usage of the GIIPS crisis variable in the previous table (Table 16). First of all, the moderating effect of the European sovereign crisis on the damaging effect of long-term leverage does not hold for the basic model. Similarly, the interaction term between leverage and the crisis indicator is also insignificant for the extended model. Moreover, there is marginally significant evidence for the basic models in Column (1), (5) & (6) that averagely leveraged firms operating in GIIPS countries invested more inefficiently which was mostly caused by an increase in overinvestment due to a potential bigger drop in growth opportunities in these countries. However, this result is not robust across all specifications of the model in Table 16. Therefore, when defining the European sovereign debt crisis as only affecting firm-year observations of the GIIPS countries from 2011 to 2014, there

is no significant evidence that the crisis intensified the problems of debt overhang compared to firm-year observations in the post-crisis period and firm-year observations from Germany and France.

Concluding on this set of alternative sample and crisis specifications to compare the effect of (dominating) countries on the inferences of the regression results, there is no significant evidence that the GIIPS countries were severely more affected by the European sovereign debt crisis compared to the big economies in the Eurozone. Therefore, the effects of the European sovereign debt crisis are generalizable over a multitude of European countries. The results of the alternative crisis and sample specifications do imply that countries in the United Kingdom were less affected by the credit crunch and the effects on debt financing compared to the countries in the Eurozone. This follows the prediction that cross-border spillovers and contagion amplify the shock transmission across the eurozone (Acharya et al., 2018; Allegret et al., 2017). Therefore, the effect of leverage on investment efficiency and the role of the European sovereign debt crisis was expected to be similar in direction and size among the European countries.

Table 15

Basic Model excluding UK. This table presents regression results from the basic model based on the subsample excluding the firm-year observations operating in the United Kingdom. The measures of investment efficiency are increasing in inefficiency. The variables of interest are the two measures of leverage and the crisis indicator. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. The crisis dummy variable (Crisis) is a binary variable that is 1 during the crisis and 0 in the years after the crisis. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects when specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Normal						Crisis Interaction					
	Investment Efficiency		Underinvestment		Overinvestment		Investment Efficiency		Underinvestment		Overinvestment	
	(1) AIE	(2) AIE	(3) UI	(4) UI	(5) OI	(6) OI	(7) AIE	(8) AIE	(9) UI	(10) UI	(11) OI	(12) OI
Lev_{t-1}	-.142		.090**		-.486		-.176		.086**		-.813	
	(.112)		(.039)		(.543)		(.124)		(.042)		(.688)	
$LtLev_{t-1}$		-.215		.013		-.944		-.351**		-.050		-1.485*
		(.148)		(.051)		(.785)		(.159)		(.051)		(.791)
$Crisis_t$							-.030	-.030	.035***	.036***	-.204	-.193
							(.026)	(.025)	(.008)	(.007)	(.126)	(.126)
$Crisis_t * Lev_{t-1}$							.016		-.023		.169	
							(.089)		(.029)		(.512)	
$Crisis_t * LtLev_{t-1}$								.332**		.176***		1.235
								(.142)		(.061)		(.786)
$Size_{t-1}$	-.158***	-.149***	.026**	.018	-.369	-.325	-.120***	-.111**	.052***	.043***	-.321	-.274
	(.049)	(.047)	(.013)	(.012)	(.232)	(.233)	(.046)	(.044)	(.014)	(.013)	(.201)	(.199)
ROA_{t-1}	-.103	-.059	-.181***	-.196***	-.359	-.259	-.165	-.113	-.222***	-.229***	-.597	-.521
	(.119)	(.116)	(.048)	(.039)	(.723)	(.684)	(.121)	(.119)	(.051)	(.045)	(.729)	(.693)
$Tang_{t-1}$	-1.804***	-1.83***	.344***	.349***	-4.759***	-4.747***	-1.869***	-1.907***	.270***	.271***	-5.010***	-5.055***
	(.389)	(.395)	(.079)	(.079)	(1.155)	(1.189)	(.383)	(.391)	(.083)	(.083)	(1.096)	(1.129)
Age_{t-1}	-.071	-.067	.052***	.066***	.089	.102	.159***	.159***	.217***	.228***	.581***	.568**
	(.061)	(.063)	(.016)	(.015)	(.254)	(.258)	(.048)	(.049)	(.015)	(.014)	(.223)	(.222)
Constant	2.808***	2.645***	-.260*	-.150	5.504**	4.794*	1.816***	1.700***	-.974***	-.887***	4.000*	3.452
	(.679)	(.642)	(.157)	(.149)	(2.714)	(2.716)	(.624)	(.598)	(.169)	(.156)	(2.312)	(2.329)
Observations	7344	7297	5789	5752	1555	1545	7344	7297	5789	5752	1555	1545
R-squared	.066	.067	.338	.349	.108	.104	.031	.033	.109	.114	.066	.069
Time FE	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 16

Alternative crisis specifications for the basic model. This table presents regression results from the basic model with two alternative specifications of the crisis variable. The measures of investment efficiency are increasing in inefficiency. The variables of interest are the two measures of leverage and the crisis indicator. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. The crisis dummy variable (Crisis) is a binary variable that is 1 during the crisis and 0 in the years after the crisis. For Columns (1) to (6), the crisis variable is 0 for all firms operating in the UK. For Columns (7) to (12), the crisis variable is 1 for all firms operating in the GIIPS countries during 2011-2014. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects when specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Crisis = 0 for UK						Crisis = 1 for GIIPS					
	Investment Efficiency		Underinvestment		Overinvestment		Investment Efficiency		Underinvestment		Overinvestment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	AIE	AIE	UI	UI	OI	OI	AIE	AIE	UI	UI	OI	OI
Lev_{t-1}	-.251**		.066*		-.554		-.251**		.066**		-.561	
	(.116)		(.034)		(.449)		(.110)		(.033)		(.419)	
$LtLev_{t-1}$		-.143		-.005		-.407		-.102		.027		-.286
		(.137)		(.038)		(.527)		(.131)		(.040)		(.515)
$Crisis_t$	-.003	-.006	.010	.017***	-.142	-.141	.130***	.095*	.005	.000	.668**	.594*
	(.022)	(.021)	(.007)	(.006)	(.104)	(.107)	(.048)	(.050)	(.019)	(.015)	(.328)	(.341)
$Crisis_t * Lev_{t-1}$	.067		-.009		.094		.122		-.039		.225	
	(.091)		(.028)		(.432)		(.164)		(.062)		(1.278)	
$Crisis_t * LtLev_{t-1}$		.308**		.164***		.748		.374		.100		-.149
		(.146)		(.060)		(.820)		(.308)		(.082)		(2.422)
$Size_{t-1}$	-.228***	-.197***	.029**	.042***	-.393***	-.335**	-.23***	-.199***	.028**	.040***	-.395***	-.331**
	(.041)	(.041)	(.013)	(.011)	(.133)	(.140)	(.040)	(.04)	(.012)	(.011)	(.128)	(.136)
ROA_{t-1}	-.107	-.032	-.242***	-.219***	-.344	.168	-.108	-.028	-.242***	-.220***	-.361	.183
	(.111)	(.110)	(.037)	(.034)	(.422)	(.449)	(.110)	(.110)	(.036)	(.034)	(.421)	(.444)
$Tang_{t-1}$	-2.801***	-2.692***	.044	.065	-7.399***	-6.741***	-2.814***	-2.703***	.046	.071	-7.384***	-6.727***
	(.244)	(.263)	(.058)	(.066)	(.671)	(.708)	(.243)	(.262)	(.058)	(.066)	(.671)	(.713)
Age_{t-1}	.275***	.249***	.159***	.173***	.887***	.771***	.287***	.262***	.153***	.162***	.964***	.850***
	(.037)	(.037)	(.013)	(.011)	(.160)	(.161)	(.034)	(.033)	(.012)	(.010)	(.157)	(.161)
Constant	3.068***	2.741***	-.451***	-.675***	4.648***	4.136***	3.068***	2.735***	-.432***	-.628***	4.459***	3.869***
	(.498)	(.508)	(.151)	(.130)	(1.404)	(1.505)	(.479)	(.490)	(.146)	(.127)	(1.316)	(1.426)
Observations	13191	12532	10069	9600	3122	2932	13191	12532	10069	9600	3122	2932
R-squared	.055	.053	.070	.083	.119	.101	.056	.054	.070	.081	.120	.102
Time FE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

6. Conclusion

A fundamental question in financial research is what determines the capital allocation of corporations. This thesis aimed to investigate the effect of leverage on the efficiency of investments in relation to the European sovereign debt crisis of 2011 to 2014. Following prior research, there are two streams of theory on the efficiency of investment. Leverage could either decrease the efficiency of investment due to the problem of debt overhang (Myers, 1977) or increase the efficiency of investment due to the monitoring role of debt on the overinvesting tendencies of managers (Jensen, 1986; Stulz, 1990). In late 2010, Europe encountered a severe crisis that affected the financial markets. This thesis aimed to investigate the effect of this shock on the two streams of potential effects of leverage on investment efficiency by answering the following research question:

What is the impact of the European sovereign debt crisis on the effect of leverage on corporate investment (in)efficiency?

To answer this research question, regression analysis was used regressing measures of leverage on a direct estimation of investment efficiency for a sample of listed European firms from seven countries from 2011 to 2019. To measure investment efficiency, models of McNichols & Stubben (2008) were used to estimate the optimal level of investment based on growth opportunities. Using this model, the deviation from the optimal level of investment was estimated via the residuals of the regression model. Any deviation from the optimal level is defined as inefficient investment. A positive residual is defined as overinvestment, while a negative residual is defined as underinvestment.

Three hypotheses were tested. Firstly, following Hypothesis 1 it is expected that leverage has a strong negative effect on the inefficiency of investment due to the problem of debt overhang. Following previous research, it was expected that excessively leveraged firms encountered severe problems of debt overhang following extra financial costs and not being able to issue extra funds. In addition, it is expected that leverage increases underinvestment and decreases overinvestment following the theories of investment efficiency. Based on the regression models, it can be concluded that an increase in leverage is related to underinvestment. While there was a statistically and economically significant negative effect of leverage on the absolute value of investment efficiency, this thesis did not find empirical

evidence of the beneficial effect of the disciplinary role of debt on overinvesting firms. There is significant evidence for the theory of debt overhang on investment decisions by turning overinvestment into underinvestment for heavily leveraged firms that were overinvesting and increasing underinvestment for heavily leveraged underinvesting firms.

Secondly, Hypothesis 2 stated that the European sovereign debt crisis had a significant positive impact on the amount of inefficiency. Across the models, this thesis does not find empirical evidence for an increase in inefficiency. There is empirical evidence for an increase in the amount of underinvestment and a high decrease in the amount of overinvestment during the European sovereign debt crisis compared to the post-crisis firm-year observations. However, due to overinvestment turning into underinvestment during the European sovereign debt crisis, there is no evidence that the absolute/total value of inefficiency increased or decreased. Nevertheless, the share of underinvesting firms to overinvesting firms increases during the crisis. Thus, the impact of the European sovereign debt crisis is largely related to an increase in the amount of underinvestment due to the credit crunch which made firms financially constrained.

Lastly, the role of the European sovereign debt crisis on the debt-investment efficiency relationship was investigated. Hypothesis 3 stated that the European sovereign debt crisis intensified the effects of leverage on, respectively, investment efficiency, underinvestment and overinvestment. This thesis finds substantial empirical evidence for the intensification of the problem of debt overhang for the effect of long-term leverage on investment decisions. An increase in long-term leverage severely limits the ability to invest and, therefore, increases the amount of investment below the optimal level estimated by growth opportunities. There is no evidence found for a differential effect of the European sovereign debt crisis on the effect of total leverage. However, the subsampling approach did suggest that the effect of leverage turned from the problem of debt overhang during the crisis to the monitoring role of debt in the post-crisis period. Therefore, long-term debt pressures investment decisions more via the problem of debt overhang compared to debt financing with shorter maturities. Thus, the effect of long-term leverage on investment efficiency is significantly stronger during the crisis compared to the post-crisis period.

These conclusions are largely robust for the widely used two measures of investment efficiency constructed by McNichols & Stubben (2008) and the widely used investment

efficiency model constructed by Biddle et al. (2009). In addition, following Chen (2018), the variables used to estimate the proxies of investment efficiency were added to the models. This was done to increase the reliability and reduce estimation errors by using residuals from a first-step regression as the dependent variable in a second-step regression. Similar to the results of Chen et al. (2018), the inclusion or exclusion of these variable does not change the inferences that could be drawn from the models. This is due to the fact that the residuals were transformed into absolute values and therefore contained different information compared to the residuals from the optimal investment level regression results. Lastly, deleting the lowest deciles from the measures of underinvestment and overinvestment to mitigate potential estimation errors by either misclassifying a firm as under- or overinvestment or defining an efficient level of investment as inefficient investment, does not change the results that were found.

The contribution of this thesis to the literature and practice is threefold. Firstly, this thesis contributes to the literature based on the effect of leverage on investment decisions (e.g., Ahn et al., 2006; Aivazian et al., 2005a, 2005b; Firth et al., 2008; Lang et al., 1996) in relation to the theories of debt overhang (Myers, 1977) and the disciplinary role of debt (Myers, 1977). This thesis extended the literature by directly measuring the effect of leverage on measures of investment efficiency. Prior research made conclusions based on the interaction terms between measures of leverage and growth opportunities measured by Tobin's Q. This thesis shows empirical evidence that an increase in leverage decrease the absolute value of investment inefficiency because of the fact that leverage is related to underinvestment and the deviation of underinvestment is lower than the deviation related to overinvestment. In addition, there is empirical evidence found for the direct positive impact of leverage on the amount of underinvestment. This thesis does not find consistent empirical evidence for a direct negative or positive effect of long-term leverage on the amount of investment inefficiency of a firm.

Secondly, this thesis contributes to the literature on the role of the European sovereign debt crisis on the effect of leverage on investment behaviour (Barbiero et al., 2020; Gebauer et al., 2018). While the effect of the European sovereign debt crisis on investment levels and the debt-investment relationship has proven to be negative, the effect of leverage on the investment efficiency of European firms during the crisis has been untouched. In this thesis,

there is no empirical evidence found for the role of the European sovereign debt crisis on the effect of total leverage on investment efficiency. However, the impact of long-term leverage on underinvestment is statistically and economically significant during the European sovereign debt crisis compared to the post-crisis years. This indicates that firms with high long-term leverage were effectively hindered to invest in all positive NPV-investment projects. While the European sovereign debt crisis had a strengthening moderating role on the positive effect of leverage on the amount of underinvestment, the European sovereign debt crisis on itself had a strong impact on reducing the amount of overinvestment. Due to the extra financial constrained on the financial markets, overinvesting tendencies were less pronounced compared to the post-crisis period.

Lastly, this thesis has a practical contribution to the investment behaviour of listed European firms. The results contribute to the understanding of companies' investment policies and capabilities during crises. A direct relation between relying on debt to invest and investment efficiency during a crisis is analysed. This provides European firms more insight on how to determine the optimal capital structure of the firm. For instance, a high reliance on long-term debt effectively increases the amount of underinvestment of a firm during a credit crunch. This is because of the fact that long-term debt is related to large long-spanning financial costs and this decreases the incentive to invest in risky projects during a crisis.

Moreover, the use of multiple countries and definitions of the European sovereign debt crisis in the sample and analysis, adds to the understanding of the effects of specific countries on efficient investment and capital structure policies. The results of this thesis suggest that the Eurozone countries were affected more by the European sovereign debt crisis due to contagion and spillovers because of the large government bond holdings of European banks. These problems fed back into firms from all the countries of the Eurozone. In addition, the results do not suggest that there is a large difference between the GIIPS countries and the biggest economies of the European Union (France, Germany and the UK). Nevertheless, the effect of long-term leverage was more pronounced for the most affected countries.

Lastly, to further extend the literature, a few recommendations of further research are discussed based on potential limitations of the research methodology adopted by this thesis. Firstly, the regressions are based on a sample of listed firms of 7 countries from 2011 to 2019 because of the storage limitations of the Orbis Database. Therefore, the effect of the European

sovereign debt crisis could not be investigated in relation to either the financial crisis or the period before the crisis hit Europe. Investigating a longer sample period extends the reliability of the results and potentially increase or decrease the effects of leverage on investment inefficiency. In addition, it is likely that the shock of the European sovereign debt crisis still had an influence on the investment decisions of European firms after the crisis ended. Therefore, a longer sample period could improve the comparison between the effects of certain periods. In addition, future research could investigate the role of the crisis on the debt-efficiency relationship for a larger sample size. Further research could extend the research to more European countries or include unlisted firms. For example, unlisted firms could be more constrained due to the European sovereign debt crisis because they cannot issue equity.

Another limitation of the estimation methodology that is used in this thesis is that a linear effect of debt is modelled in the regression equations while it is possible that the effect of an increase in a low leverage regime on investment inefficiency is different than increasing leverage when a firm is already excessively leveraged. However, using a linear effect of leverage on the amount of inefficiency each effect of an increase or decrease is expected to be similar in size. For example, Gebauer et al. (2018) do find evidence for a non-linear effect of leverage on the level of investment. Therefore, future research could investigate the effect of non-linearity between debt thresholds on investment efficiency. Following Gebauer et al. (2018), these non-linearities in the debt-investment behaviour relationship could also potentially change between crisis periods and non-crisis periods.

Lastly, there are a few potential limitations of the method used to estimate investment efficiency. First of all, all countries and industries were pooled in the estimation of the optimal level of investment to allow the firms to experience the same booms and busts following (Bae et al., 2019). In addition, the models were estimated by year, following all prior research on the estimation of investment efficiency. However, this could possibly influence the effect of the sovereign debt crisis since the estimates indirectly control for time effects. In addition, other research on investment efficiency change the absolute values of the residuals after estimation into categories based on the amount of deviation to account for potential errors (e.g., Biddle et al., 2009, Goodman et al., 2014). In this way, there is a baseline group of firms that are investing efficiently which can be compared with under- and overinvesting groups via categorical regressions. Future research could address these potential estimation errors in the

results to get an extended picture of the effects of leverage on the measures of investment efficiency and the influence of the European sovereign debt crisis on the debt-investment efficiency relationship.

Appendix

This appendix consists of additional descriptive statistics and additional regression models that are referenced in the main text. The additional tables consist of descriptive statistics for subsamples, regression models of additional robustness tests and regression models with alternative investment efficiency estimation methods compared to the tables that were reported in the main text.

Table A.1 and Table A.2 present descriptive statistics of the sample for either all underinvesting firms or all overinvesting firms. A firm-year observation is defined as underinvesting if the firm-year observation has a negative residual based on the basic model of investment efficiency in Equation (1). Similarly, a firm-year observation is defined as an overinvesting firm if the residual using the basic model of investment efficiency is positive. Table A.1 and Table A.2 are related to Table 3 which present the descriptive statistics of the whole sample.

Table A.3 presents regression results of the crisis interaction models including the first-step regressors following Chen et al. (2018). These regressions are done as a robustness test since Chen et al. (2018) found that residual analysis could produce estimation errors. Table A.3 is related to Table 11 which presents the normal investment efficiency models including the first-step regressors.

Table A.4, Table A.5 and Table A.6 present the results of the alternative crisis and country specifications for the extended model. Table A.4 considers the regression models excluding the United Kingdom for the extended model and is related to Table 15. Table A.5 considers the regression models with the two alternative specifications of the crisis and is related to Table 16. Lastly, Table A.6 presents the regression results of the GIIPS specification of the crisis variable for the sample excluding the countries from the United Kingdom.

Table A.1

Summary statistics for underinvesting firms. This table presents the descriptive statistics of all continuous dependent and independent variables used in the first and second step regressions for all firm-year observations with a negative deviation from their estimated optimal level of investment. For each variable, the number of observations for each variable (N), average and standard deviation (Mean & St. Dev.), range (Min & Max) and quartiles (p25, Median & p75), are reported. All variables are defined in Table 1. The reported measure of underinvestment is based on Equation (1) and is referred to as the basic model of investment efficiency. All financial variables, except the investment efficiency measures, are winsorized at 1% and 99%.

Variables	N	Mean	Std. Dev.	Min	p25	Median	p75	Max
UI_t	10069	.297	.303	.000	.115	.208	.383	4.306
Lev_{t-1}	10069	.533	.258	.026	.360	.531	.692	1.465
$LtLev_{t-1}$	9600	.137	.147	.000	.006	.098	.215	.676
$TobinQ_{t-1}$	10069	1.798	1.526	.424	.998	1.313	1.973	10.492
CF_t	10069	-4.275	28.703	-234.271	.000	.292	.890	36.941
$Growth_{t-1}$	9185	.044	.245	-.695	-.049	.030	.115	1.261
$Size_{t-1}$	10069	12.190	2.368	7.306	10.455	11.989	13.803	17.987
ROA_{t-1}	10069	-.009	.222	-1.157	-.020	.048	.090	.327
$Tang_{t-1}$	10069	.199	.203	.000	.039	.132	.288	.858
Age_{t-1} (in years)	10069	15.392	13.244	1	8	13	18	95

Table A.2

Summary statistics for overinvesting firms. This table presents the descriptive statistics of all continuous dependent and independent variables used in the first and second step regressions for all firm-year observations with a positive deviation from their estimated optimal level of investment. For each variable, the number of observations for each variable (N), average and standard deviation (Mean & St. Dev.), range (Min & Max) and quartiles (p25, Median & p75), are reported. All variables are defined in Table 1. The reported measure of overinvestment is based on Equation (1) and is referred to as the basic model of investment efficiency. All financial variables, except the investment efficiency measures, are winsorized at 1% and 99%.

Variables	N	Mean	Std. Dev.	Min	p25	Median	p75	Max
OI_t	3122	.958	1.784	.000	.078	.250	.818	8.665
Lev_{t-1}	3122	.487	.246	.026	.315	.484	.644	1.465
$LtLev_{t-1}$	2932	.112	.139	.000	.000	.062	.174	.676
$TobinQ_{t-1}$	3122	1.896	1.557	.424	1.046	1.400	2.109	10.492
CF_t	3122	-3.649	34.742	-234.271	-.007	.482	2.763	36.941
$Growth_{t-1}$	2850	.124	.298	-.695	-.018	.075	.203	1.261
$Size_{t-1}$	3122	11.683	2.115	7.306	10.159	11.492	12.951	17.987
ROA_{t-1}	3122	-.001	.214	-1.157	-.023	.051	.097	.327
$Tang_{t-1}$	3122	.144	.189	.000	.017	.057	.202	.858
Age_{t-1} (in years)	3122	12.908	10.92	1	6	11	16	93

Table A.3

Crisis regression models with first-step regressors. This table present regression results of the crisis interactions models with additional control variables following Chen et al. (2018). The measures of investment efficiency are increasing in inefficiency. The variables of interest are the two measures of leverage and the crisis indicator. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. The crisis dummy variable (Crisis) is a binary variable that is 1 during the crisis and 0 in the years after the crisis. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects when specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Basic Model						Extended Model					
	Investment Efficiency		Underinvestment		Overinvestment		Investment Efficiency		Underinvestment		Overinvestment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	AIE	AIE	UI	UI	OI	OI	AIE	AIE	UI	UI	OI	OI
Lev_{t-1}	-.211*		.074**		-.333		-.292**		.015		-.581	
	(.113)		(.031)		(.458)		(.127)		(.034)		(.441)	
$LtLev_{t-1}$		-.130		.016		-.457		-.117		-.031		-.527
		(.132)		(.037)		(.528)		(.134)		(.041)		(.504)
$Crisis_t$	-.025	-.023	.008	.010*	-.205**	-.182*	-.028	-.020	.008	.011*	-.206**	-.171**
	(.023)	(.022)	(.006)	(.006)	(.096)	(.096)	(.022)	(.021)	(.006)	(.006)	(.088)	(.087)
$Crisis_t * Lev_{t-1}$	-.015		-.025		-.354		.028		.001		.329	
	(.083)		(.023)		(.401)		(.086)		(.024)		(.362)	
$Crisis_t * LtLev_{t-1}$		.241*		.122***		.492		.266**		.064*		.851
		(.128)		(.037)		(.622)		(.134)		(.036)		(.598)
$Size_{t-1}$	-.195***	-.184***	.040***	.047***	-.360***	-.342**	-.158***	-.140***	.082***	.086***	-.470***	-.397**
	(.042)	(.043)	(.011)	(.010)	(.137)	(.149)	(.048)	(.049)	(.013)	(.011)	(.145)	(.160)
ROA_{t-1}	-.020	.006	-.206***	-.197***	-.102	.239	.018	.084	-.178***	-.156***	.714	.658
	(.107)	(.107)	(.033)	(.030)	(.429)	(.446)	(.117)	(.115)	(.032)	(.030)	(.440)	(.466)
$Tang_{t-1}$	-2.606***	-2.563***	.156***	.158***	-7.324***	-6.806***	-2.344***	-2.368***	.186***	.154**	-6.12***	-6.104***
	(.246)	(.266)	(.052)	(.059)	(.663)	(.708)	(.290)	(.305)	(.070)	(.076)	(.626)	(.680)
Age_{t-1}	.238***	.219***	.152***	.163***	.776***	.679***	.296***	.273***	.191***	.197***	.959***	.834***
	(.039)	(.039)	(.012)	(.011)	(.158)	(.159)	(.043)	(.042)	(.013)	(.013)	(.177)	(.175)
$TobinQ_{t-1}$	.042***	.045***	.018***	.014**	.089*	.111**	.035**	.048***	.015***	.012**	-.009	.062
	(.014)	(.015)	(.005)	(.006)	(.048)	(.044)	(.015)	(.015)	(.005)	(.005)	(.050)	(.057)
CF_t	-.007***	-.005***	-.004***	-.004***	-.005**	-.002	-.005***	-.004***	-.003***	-.003***	-.006*	-.003
	(.001)	(.001)	(.000)	(.001)	(.002)	(.004)	(.001)	(.001)	(.000)	(.000)	(.003)	(.003)
Net Inv_{t-1}							-.094***	-.088***	.005	.009	-.152***	-.156***
							(.019)	(.020)	(.006)	(.006)	(.052)	(.055)
$Growth_{t-1}$							.217***	.166***	.182***	.181***	.436**	.277*
							(.061)	(.056)	(.022)	(.019)	(.170)	(.165)
Constant	2.630***	2.554***	-.641***	-.763***	4.357***	4.262**	2.013***	1.846***	-1.266***	-1.345***	5.253***	4.565**
	(.527)	(.549)	(.131)	(.123)	(1.53)	(1.679)	(.587)	(.609)	(.155)	(.142)	(1.607)	(1.78)
Observations	13191	12532	10069	9600	3122	2932	11986	11403	9035	8619	2951	2784
R-squared	.08	.064	.163	.151	.131	.108	.077	.066	.168	.171	.152	.138
Time FE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table A.4

Extended Model excluding UK This table presents regression results from the extended model based on the subsample excluding the firm-year observations operating in the United Kingdom. The measures of investment efficiency are increasing in inefficiency. The variables of interest are the two measures of leverage and the crisis indicator. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. The crisis dummy variable (Crisis) is a binary variable that is 1 during the crisis and 0 in the years after the crisis. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects when specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Normal						Crisis Interaction					
	Investment Efficiency		Underinvestment		Overinvestment		Investment Efficiency		Underinvestment		Overinvestment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	AIE	AIE	UI	UI	OI	OI	AIE	AIE	UI	UI	OI	OI
Lev_{t-1}	-.172		.078*		-.436		-.218*		.055		-.821	
	(.123)		(.045)		(.503)		(.132)		(.049)		(.633)	
$LtLev_{t-1}$		-.226		-.042		-.756		-.337**		-.082		-1.097
		(.156)		(.051)		(.782)		(.164)		(.056)		(.770)
$Crisis_t$							-.016	-.015	.035***	.034***	-.182*	-.133
							(.024)	(.024)	(.008)	(.007)	(.110)	(.113)
$Crisis_t * Lev_{t-1}$							.012		-.041		.591	
							(.096)		(.032)		(.452)	
$Crisis_t * LtLev_{t-1}$								.269*		.064		1.027
								(.157)		(.049)		(.802)
$Size_{t-1}$	-.105**	-.092*	.094***	.089***	-.465**	-.375*	-.059	-.045	.129***	.123***	-.359*	-.249
	(.049)	(.047)	(.016)	(.014)	(.194)	(.191)	(.046)	(.044)	(.018)	(.016)	(.188)	(.191)
ROA_{t-1}	.024	.079	-.042	-.048	.662	.733	-.048	.021	-.100*	-.091**	.599	.677
	(.125)	(.122)	(.047)	(.035)	(.745)	(.747)	(.127)	(.125)	(.051)	(.04)	(.719)	(.727)
$Tang_{t-1}$	-1.988***	-2.003***	.309***	.334***	-5.321***	-5.162***	-2.054***	-2.086***	.243**	.261***	-5.244***	-5.072***
	(.503)	(.509)	(.090)	(.092)	(1.347)	(1.381)	(.496)	(.503)	(.096)	(.097)	(1.280)	(1.331)
Age_{t-1}	-.071	-.067	.020	.034*	.215	.230	.196***	.195***	.235***	.243***	.603**	.563**
	(.064)	(.065)	(.019)	(.018)	(.296)	(.307)	(.050)	(.051)	(.018)	(.018)	(.253)	(.254)
Constant	2.368***	2.145***	-.787***	-.716***	6.224***	5.003**	.995	.823	-1.973***	-1.927***	4.391**	3.104
	(.682)	(.651)	(.225)	(.206)	(2.225)	(2.17)	(.615)	(.601)	(.222)	(.203)	(2.179)	(2.249)
Observations	6720	6678	5193	5160	1527	1518	6720	6678	5193	5160	1527	1518
R-squared	.070	.069	.364	.375	.104	.098	.034	.035	.138	.143	.07	.069
Time FE	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table A.5

Alternative crisis specifications for the extended model. This table presents regression results from the extended model with two alternative specifications of the crisis variable. The measures of investment efficiency are increasing in inefficiency. The variables of interest are the two measures of leverage and the crisis indicator. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. The crisis dummy variable (Crisis) is a binary variable that is 1 during the crisis and 0 in the years after the crisis. For Columns (1) to (6), the crisis variable is 0 for all firms operating in the UK. For Columns (7) to (12), the crisis variable is 1 for all firms operating in the GIIPS countries during 2011-2014. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects when specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Crisis = 0 for UK						Crisis = 1 for GIIPS					
	Investment Efficiency		Underinvestment		Overinvestment		Investment Efficiency		Underinvestment		Overinvestment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	AIE	AIE	UI	UI	OI	OI	AIE	AIE	UI	UI	OI	OI
Lev_{t-1}	-.272**		.053		-.514		-.275**		.051		-.460	
	(.129)		(.039)		(.442)		(.124)		(.038)		(.414)	
$LtLev_{t-1}$		-.075		-.021		-.333		-.049		-.011		-.203
		(.135)		(.046)		(.508)		(.130)		(.045)		(.502)
$Crisis_t$	.020	.016	.011	.014**	-.057	-.057	.130***	.113**	.006	.001	.434	.450
	(.022)	(.021)	(.007)	(.007)	(.092)	(.098)	(.049)	(.054)	(.020)	(.015)	(.290)	(.315)
$Crisis_t * Lev_{t-1}$	.050		-.031		.393		.193		-.082		.370	
	(.098)		(.030)		(.390)		(.187)		(.073)		(1.228)	
$Crisis_t * LtLev_{t-1}$		.223		.046		.724		.318		-.014		-1.751
		(.161)		(.047)		(.880)		(.346)		(.088)		(1.876)
$Size_{t-1}$	-.154***	-.134***	.114***	.124***	-.406***	-.354**	-.158***	-.138***	.113***	.123***	-.402***	-.352**
	(.044)	(.044)	(.013)	(.012)	(.137)	(.148)	(.043)	(.044)	(.012)	(.012)	(.135)	(.145)
ROA_{t-1}	.043	.124	-.087**	-.061*	.747*	.603	.044	.127	-.087**	-.062*	.741*	.611
	(.118)	(.116)	(.037)	(.033)	(.439)	(.458)	(.117)	(.116)	(.036)	(.032)	(.437)	(.455)
$Tang_{t-1}$	-2.818***	-2.726***	.058	.067	-6.886***	-6.818***	-2.829***	-2.735***	.062	.073	-6.878***	-6.814***
	(.280)	(.295)	(.074)	(.080)	(.620)	(.684)	(.278)	(.293)	(.074)	(.080)	(.619)	(.687)
Age_{t-1}	.336***	.309***	.170***	.179***	1.072***	.931***	.338***	.311***	.165***	.170***	1.104***	.971***
	(.039)	(.038)	(.013)	(.013)	(.162)	(.163)	(.037)	(.036)	(.012)	(.012)	(.160)	(.162)
Constant	2.028***	1.823***	-1.523***	-1.711***	4.290***	3.979**	2.075***	1.866***	-1.504***	-1.677***	4.154***	3.849**
	(.527)	(.546)	(.152)	(.149)	(1.457)	(1.614)	(.511)	(.530)	(.147)	(.145)	(1.407)	(1.56)
Observations	11986	11403	9035	8619	2951	2784	11986	11403	9035	8619	2951	2784
R-squared	.052	.052	.089	.105	.129	.120	.053	.053	.089	.104	.129	.120
Time FE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table A.6

Crisis = 1 for GIIPS countries compared to Eurozone countries. This table presents regression results with regards to the Eurozone countries and the GIIPS crisis variable. The measures of investment efficiency are increasing in inefficiency. The variables of interest are the two measures of leverage and the crisis indicator. Leverage (Lev) is measured as the ratio of total liabilities to total assets and long-term leverage (LtLev) is measured as the ratio of long-term debt to total assets. The crisis dummy variable (Crisis) is a binary variable that is 1 for all firms operating in the GIIPS countries during 2011-2014. All other control variables are defined in Table 1. All regressions include firm fixed effects and time fixed effects when specified. Reported standard errors are robust and clustered at the firm level. The symbols ***, **, and * denote two-sided statistical significance at the 1%, 5%, and 10% levels, respectively.

	Basic Model						Extended Model					
	Investment Efficiency		Underinvestment		Overinvestment		Investment Efficiency		Underinvestment		Overinvestment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	AIE	AIE	UI	UI	OI	OI	AIE	AIE	UI	UI	OI	OI
Lev_{t-1}	-.191*		.085**		-.828		-.233*		.049		-.617	
	(.112)		(.041)		(.562)		(.123)		(.047)		(.538)	
$LtLev_{t-1}$		-.267*		.010		-1.102		-.276*		-.061		-.791
		(.147)		(.054)		(.751)		(.153)		(.053)		(.752)
$Crisis_t$	.085**	.061	.013	.006	.656**	.586*	.082*	.073	.016	.009	.379	.409
	(.042)	(.047)	(.020)	(.016)	(.315)	(.324)	(.045)	(.052)	(.020)	(.016)	(.277)	(.306)
$Crisis_t * Lev_{t-1}$	.071		-.050		.310		.144		-.089		.560	
	(.144)		(.064)		(1.242)		(.173)		(.074)		(1.207)	
$Crisis_t * LtLev_{t-1}$		.348		.109		.176		.295		.006		-1.229
		(.262)		(.084)		(2.128)		(.309)		(.088)		(1.819)
$Size_{t-1}$	-.119***	-.108***	.047***	.037***	-.297*	-.233	-.061	-.046	.124***	.118***	-.294*	-.208
	(.043)	(.041)	(.013)	(.012)	(.165)	(.169)	(.044)	(.042)	(.016)	(.015)	(.175)	(.175)
ROA_{t-1}	-.168	-.110	-.221***	-.231***	-.720	-.506	-.048	.025	-.099**	-.093**	.503	.637
	(.121)	(.119)	(.050)	(.044)	(.712)	(.674)	(.127)	(.124)	(.050)	(.040)	(.704)	(.714)
$Tang_{t-1}$	-1.896***	-1.921***	.282***	.288***	-4.866***	-4.882***	-2.08***	-2.103***	.258***	.276***	-5.051***	-4.943***
	(.380)	(.388)	(.083)	(.083)	(1.061)	(1.096)	(.494)	(.500)	(.096)	(.096)	(1.278)	(1.328)
Age_{t-1}	.202***	.199***	.183***	.190***	.809***	.778***	.226***	.221***	.204***	.209***	.755***	.702***
	(.038)	(.038)	(.013)	(.012)	(.217)	(.216)	(.043)	(.043)	(.015)	(.015)	(.243)	(.241)
Constant	1.691***	1.565***	-.815***	-.710***	3.095*	2.369	.945*	.762	-1.823***	-1.773***	3.174*	2.215
	(.551)	(.529)	(.156)	(.148)	(1.741)	(1.837)	(.560)	(.548)	(.203)	(.189)	(1.877)	(1.938)
Observations	7344	7297	5789	5752	1555	1545	6720	6678	5193	5160	1527	1518
R-squared	.032	.033	.105	.106	.068	.066	.034	.035	.134	.138	.068	.068
Time FE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

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