The Impact of Leverage on Investment Expenditures:

New Insights from Analyzing Private Enterprises[♣]

TOM FRANCK [1, 2] and NANCY HUYGHEBAERT [1]

[1]*K.U. Leuven;* [2]*Lessius Hogeschool*

Abstract

Recent research shows that firms with more debt invest less. Yet, the underlying reasons remain unclear. In this paper, we exploit some of the specific characteristics of private enterprises to investigate the non-linear and multi-period aspects of theoretical asymmetric information and agency models explaining the leverage-investment relation. After addressing the endogeneity of leverage, our fixed effects regression results on a large sample of 64,246 private firm years support both non-linear and multi-period implications of credit constraints. Specifically, the data reveal a negative impact of leverage on investment, which decreases with the debt ratio but never turns positive. We also find some support for the agency model of underinvestment in a non-linear model, as relatively highly leveraged firms with substantial growth opportunities invest less.

Keywords: multi-period, non-linear, credit constraints, underinvestment, leverage.

JEL-codes: C23, G31, G32.

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I. Introduction

Recent empirical research finds that leverage negatively affects investment expenditures (e.g., Lang *et al*., 1996; Aivazian *et al*., 2005). Yet, according to Stein (2003), we do not know *why*. When considering the impact of leverage on the cost of capital, there are good reasons to believe that – at low to moderate debt ratios – further increases in the debt ratio lower the required rate of return for initiating investment projects and thus more highly leveraged firms should invest more, ceteris paribus. Therefore, to explain *why* firms with more debt invest less, the literature has mainly focused on the ex-post effects of leverage, after the cost of capital has been set. These theoretical and empirical studies on the negative effects of debt generally focus either on credit constraints or on agency conflicts between creditors, shareholders and managers. Yet, a number of these theories has been challenged, both on theoretical and empirical grounds.

In this paper, we use data on a unique and large sample of private enterprises, whose characteristics are particularly suited to disentangle the different explanations for why firms with more debt invest less. First, private enterprises by definition do not access public equity markets, but rather are financed by an entrepreneur(s) and often his/her family and friends. While trade credit is an important source of external funds for private enterprises, it is predominantly short term and is typically used to finance operations, not investments. This implies that their major source of long-term external funds to initiate investment projects is bank debt. Not surprisingly, private enterprises are on average highly leveraged when compared with listed firms, although their debt ratios also show a fairly large variation (e.g., Berger and Udell, 1998). Private firms – once highly leveraged – are generally unable to quickly reduce their debt ratio, and hence, could suffer from

credit constraints.[1] Besides, the literature has argued that underinvestment incentives are likely to arise especially when firms are highly indebted, ceteris paribus. Second, the information asymmetries between firm-insiders and outsiders are generally large, as private enterprises on average are smaller and are subject to less strict rules regarding information disclosure than listed firms. These information asymmetries increase the probability that firms cannot fully borrow against the expected future cash flows of their investment projects. Especially when their debt ratio is already high, firms may have a hard time raising additional loans, thereby pointing out again the role of credit constraints. Third, ownership in private firms is generally not widely dispersed. In fact, most private enterprises are owner-managed,[2] which tends to eliminate agency problems of equity. Consequently, a negative relation between leverage and investment in our sample is unlikely to be driven by Jensen's (1986) free cash flow theory, where debt reduces the free cash flows available to managers for value-destroying empire-building projects. This effect indeed dominates in the context of listed enterprises, where debt is found to have a negative impact on investment expenditures especially for firms with limited growth prospects (e.g., Lang *et al.*, 1996; Aivazian *et al.*, 2005). In contrast, in the context of private enterprises, the theories of credit constraints and underinvestment are likely to be highly relevant.

Another contribution of our study is that we take into account two potentially important aspects of theoretical models explaining the impact of leverage on investment expenditures. These aspects have often been neglected in previous empirical studies that examine the role of credit constraints and underinvestment. First, whereas prior empirical research assumes that increases in

[1] This assumption seems less likely to hold when firms are publicly listed and hence may be able to reduce their leverage via public equity markets. However, the finding that CFOs in Europe and the USA worry most about financial flexibility (Graham and Harvey, 2001; Bancel and Mittoo, 2004; Brounen *et al.*, 2006), defined as the preservation of debt capacity for future investment projects, suggests that this assumption also applies to many listed firms.

[2] In a government-sponsored survey of 1,815 representative small- and medium-sized private firms in Flanders (PASO, 2003), 87% of private firms with less than ten employees and 67.8% of private firms with at least ten employees report that the management holds all or a considerable fraction of the firm's shares.

leverage reduce capital expenditures monotonically, we argue that the impact of firm leverage on investment could well be non-linear, as both the odds of becoming credit constrained and the incentives to underinvest are likely to rise increasingly with the debt ratio. In other words, the negative marginal impact of leverage is unlikely to be the same at low and high debt ratios. This set-up is related to a recent study by Cleary *et al.* (2007), who develop and test the non-linearities in the relation between internal cash flow generation and investment. Second, prior empirical studies have only tested the implications of traditional one-period, i.e., static models. Recent theoretical contributions (e.g., Boyle and Guthrie, 2003; Almeida *et al.*, 2006) have documented that the inferences of these models can change in a multi-period context. Hence, we also conjecture that the leverage-investment relation could be greatly affected once firms incorporate the negative effects of current investment expenditures on future financing and investment decisions into their investment choices today.

In the case of *credit constraints* in a *static* framework, we argue that the negative impact of marginal increases in leverage on investment could rise with the debt ratio because more highly leveraged firms find it increasingly more difficult to borrow additional funds to finance their capital expenditures. In a *multi-period* framework, however, firms may also take into account that marginal increases in leverage today may enhance the probability of credit constraints in future periods and that current investment financed by debt thus can limit the financing sources available for initiating projects in the future. If some of these future investment opportunities have a larger expected net present value (NPV) than projects available today,[3] firms may decide to forego or postpone their current projects. This result is consistent with the static models. Yet, in a multi-period framework, the negative marginal impact of leverage on current investment could *reverse* at relatively high debt ratios. More specifically, there are at least two reasons why the incentive to

[3] This situation could occur, first, when the value of waiting to invest in some currently available investment projects is positive (cfr. real options theory). A second reason may be that firms simply expect more profitable investment projects to arise in the future.

reduce capital outlays today may diminish at relatively high debt ratios and hence why firms still invest reasonable amounts. First, Boyle and Guthrie (2003) and Lyandres and Zhdanov (2006) argue that as the probability of future financial constraints increases, the value of options to wait declines and so firms will exercise their investment options prematurely. We argue that a larger debt ratio progressively increases the odds of future credit constraints. As a result, investment today may no longer fall at an increasingly faster rate with marginal increases in leverage when the debt ratio is already relatively large. Second, when leverage is already high, further increases in debt make both debt and equity increasingly more risky, leading to a rise in the cost of capital at which future cash flows are discounted. Arguably, cash flows arising further in the future will exhibit a larger decrease in present value when compared with cash flows in earlier periods. An increase in the discount rate could then reduce the NPV of future investment opportunities relatively more than the NPV of currently available projects, ceteris paribus. So, once we introduce a discount rate into the model of multi-period credit constraints, the incentives to restrain current investment expenditures at relatively high debt ratios again may decline with marginal increases in leverage. In sum, when considering the importance of future credit constraints for the leverage-investment relation, the negative impact of marginal increases in leverage on capital expenditures can either increase or decrease at relatively high debt ratios. As the static theory of credit constraints merely predicts an increasing effect in the debt ratio, we will only be able to conclude that firms (also) consider future credit constraints once we find evidence that the negative impact of leverage on investment expenditures decreases with the debt ratio.

As far as *underinvestment incentives* are concerned, in a *static* model this agency problem of debt shows up whenever the NPV of an investment project is smaller than the project-induced increase in the value of the firm's debt. As the latter effect is likely to be larger at relatively high debt ratios, we expect to find support for this underinvestment theory especially when leverage is relatively high. In a *multi-period* framework, we also expect to find evidence of underinvestment especially at relatively high debt ratios. Yet, Ju and Hui (2006) argue that the incentives to

underinvest in a multi-period context are generally lower than in a static one. The reason is that firms take into account the adverse effects of current underinvestment on the profitability of future investment projects that would have benefited from undertaking current ones. We further argue that the incentives to underinvest could be lower when firms account for the potentially negative response of outside financiers – in particular banks – to this agency problem. Their reaction could either be an increase in the cost of external funds or reduced access to future financing. Likewise, firms may consider the negative effects of current underinvestment on the expected liquidation costs. To summarize, it is less obvious to find evidence for underinvestment in a data set once the multi-period implications of underinvestment models are taken into account.

We use fixed effects regression analysis on a large panel data set of 64,246 private firm years between 1996 and 2005, where we instrument firm leverage on asset tangibility, to test the relevance of non-linear and multi-period aspects of credit constraints and underinvestment models. We find strong support for the relevance of these multi-period as well as non-linear features, but only in the context of credit constraints. Consistent with prior empirical research and the implications of both static and multi-period theoretical models, we find that leverage significantly negatively affects investment expenditures. Another robust finding is that this negative effect decreases with the debt ratio, which indeed can be aligned only with our multi-period credit constraints hypothesis. As in other studies on financial constraints, we also test whether information asymmetries, proxied by firm age, affect the negative relation between leverage and investment. Consistent with the idea that information asymmetries reduce the ability to borrow additional funds especially when firms already exhibit high debt ratios, we find that the interaction term between the quadratic term in firm leverage and firm age is significantly positive in the non-linear model. Further analysis reveals that this effect is driven by the subsample of recently established firms. We do not find an additional effect of firm age in the subsample of more mature firms. Next, in line with the empirical literature on listed firms, we do not find that leverage is more detrimental to investment when firms have more growth opportunities in a linear specification.

However, in a non-linear model, we do find that the interaction term between the quadratic term in firm leverage and growth opportunities is significantly negative. Overall, this latter result supports our conjecture that underinvestment is more likely to occur when the debt ratio is relatively high.

In the following section, we discuss the static models of credit constraints and underinvestment. Also, we develop hypotheses about how both the linear and non-linear implications of these models can change when capital expenditures today affect financing and investment decisions in future periods. In Section III, we describe the sample selection criteria and characteristics. The methodological issues are discussed in Section IV, followed by a discussion of the empirical results in Section V. Finally, Section VI concludes the paper.

II. Development of hypotheses

In this section, we develop both the linear and non-linear consequences of static models of credit constraints and underinvestment for the leverage-investment relation. In addition, we elaborate on their implications in a multi-period setting.

II.A. Current versus future credit constraints

In perfect capital markets, where outside financiers can observe the quality of a firm's investment projects, firms should have no problems in financing their positive NPV projects. Consequently, investment outlays should not depend on the availability of a specific source of financing. Building upon this insight, a large number of papers examine the existence of financial constraints by analyzing the relation between capital expenditures and the accessibility of particular financing sources. The bulk of these papers investigate whether the sensitivity of investment to the size of internally generated cash flows is higher for firms that are more likely to be financially constrained. Yet, the study of these investment-cash flow sensitivities has been criticized, both theoretically and empirically. An important theoretical argument is that internal cash flow generation can pick up some aspects of investment opportunities, especially when information asymmetries distort the

measurement of the firm's growth prospects. This could lead to a higher investment-cash flow sensitivity when information asymmetries are large (e.g., Gilchrist and Himmelberg, 1995; Alti, 2003). Empirically, Kaplan and Zingales (1997), Cleary (1999), Moyen and Platikanov (2006), among others, find that investment-cash flow sensitivities are actually lower for firms that would be classified as facing larger financial constraints based on some specific firm characteristics, such as their dividend payout ratios, financial slack, leverage or size. To circumvent the problems surrounding the analysis of investment-cash flow sensitivities, recent research has used other methodologies[4] or focused on identifiable cash-generating events, such as voluntary asset sales (Hovakiam and Titman, 2004) or reduced contributions to defined pension plans (Rauh, 2006), to determine whether firms benefiting from a cash windfall invest more.

However, when considering the theoretical arguments that motivate this research, namely financial constraints, Lang *et al.* (1996) argue that it seems more relevant to study the impact of leverage instead of internal cash flows, as they find that a surge in a firm's debt ratio reduces not only the funds currently available for investment purposes but also its ability to raise additional debt for future investment projects.[5] In general, very little attention has been paid to the adverse effects of debt on investment. While Lang *et al.* (1996) and Aivazian *et al.* (2005) investigate the impact of leverage on capital expenditures for listed firms, we examine this relation for a large panel of private enterprises, which on average are more highly leveraged. In addition, most research only considers the effects of *current* financial constraints on the sensitivity of investment expenditures to a particular financing source. Yet, Boyle and Guthrie (2003), Mauer and Sarkar (2005), Almeida *et*

[4] Some authors use Euler equations to test whether the assumption of perfect capital markets can be rejected for firms that are more likely to suffer from credit constraints (e.g., Whited, 1992; Almeida and Campello, 2007). Yet, this methodology has some drawbacks, too; see Gilchrist and Himmelberg (1995) for a more detailed discussion.

[5] More specifically, Lang *et al.* (1996) find that a dollar more in interest expenses has a more adverse effect on investment expenditures than a dollar less in generated cash flows. They interpret this as evidence that a larger debt ratio reduces not only the availability of internal funds to finance investment projects by reducing the firm's free cash flow, but also limits the ability to raise additional external funds to initiate new projects.

al. (2006), Lyandres and Zhdanov (2006) all point out that in a multi-period framework, firms also consider the likelihood of *future* financial constraints when deciding on their investment outlays today. This implies that the sensitivity of investment to leverage in a multi-period setting could differ significantly from what is likely to arise in a static framework. In what follows, we develop hypotheses for the impact of leverage on investment expenditures across the debt level, taking into account both the likelihood of current as well as future credit constraints.

II.A.1. Credit constraints in a static, one-period model

In a static setting, a firm's capital expenditures are determined by the quality of its currently available investment projects, and when capital markets are imperfect, today's ease of access to financing sources. Therefore, in a static framework, a negative impact of leverage on investment can arise because a higher current debt ratio reduces the ability to raise additional loans to invest today. The reason is that under asymmetric information, lenders and/or borrowers take into account that future internally generated cash flows may not be sufficient to meet the firm's significant debt-service obligations when the firm is already highly indebted. Whereas Lang *et al.* (1996) and Aivazian *et al.* (2005) already found this negative relation in a sample of listed firms, this effect is likely to be even stronger in a sample of private enterprises, where internally generated cash flows and bank loans are the two main sources of long-term funds for investment purposes.

In addition, we argue in this paper that the negative impact of marginal increases in leverage on investment expenditures is likely to rise *increasingly* with the debt ratio. The reason is that firms that already have a lot of debt outstanding may find it progressively more difficult to raise additional bank loans at a reasonable cost. On the one hand, when the firm is already highly indebted, banks will be less willing to lend or only do this at prohibitive rates. Indeed, if the firm were to default on its outstanding debts then banks might find it difficult to fully recover the amount lent when the firm's debt ratio has grown too large (see, for example, Davydenko and Franks, 2007). On the other hand, in private firms that are relatively highly leveraged, the owner-managers

may dislike the increased failure risk from borrowing additional funds, as their personal portfolio and human capital typically are not well diversified, and as entrepreneurs enjoy sizeable private benefits of control (e.g., Hamilton, 2000; Müller, 2008). Hence, when owner-managers in private enterprises worry about firm survival, they may decide to forgo (or postpone) investment projects today when their firm is already highly indebted. This potentially non-linear relation between leverage and capital expenditures has been ignored in the empirical investment literature up till now.

Static credit constraints hypothesis: The negative impact of marginal increases in leverage on investment expenditures increases with the debt ratio.

II.A.2. Credit constraints in a multi-period model

In a multi-period setting, recent theoretical contributions by Boyle and Guthrie (2003), Mauer and Sarkar (2005), Almeida *et al.* (2006), and Lyandres and Zhdanov (2006) all argue that a financially constrained firm's current investment decisions are determined by the availability and profitability of investment projects at various points in time, and by the access to current as well as future financing sources. Within this multi-period framework, Boyle and Guthrie (2003) and Lyandres and Zhdanov (2006), among others, focus on the optimal timing of investment decisions. In their papers, firms typically have to decide on the optimal moment to invest in *one* specific project, whose profitability differs across time and which can be undertaken only once. Yet, choosing the optimal timing of investment projects that can be initiated only once is not the only inter-temporal investment decision that financially constrained firms have to make in a multi-period context. We provide three examples. First, financially constrained firms often have to choose among *several* projects that (are expected to) become available at different points in time. For instance, should they invest in upgrading their current production process or wait for a potentially better production technology to arise in the future? Second, firms often can initiate the *same* investment project at multiple instants, and financially constrained firms may have to choose. For instance, are they going to launch the same advertising campaign today and/or next year around Christmas? Third,

financially constrained firms may have to decide on the optimal period over which to smoothen the expenditures related to a particular investment project.

In this more general multi-period setting, which allows for the various scenarios discussed above, we argue that if current investment lowers the ability to finance future growth opportunities with a potentially higher NPV than some of the investment projects currently available, firms will take this opportunity cost into account when deciding on their investment outlays today. As a result, they may reduce their capital expenditures at present. This effect will be stronger the higher the probability of future financial constraints.[6] Considering that the likelihood of financial constraints in the short to medium term tends to rise with the current debt ratio, a negative relation between current leverage and current investment expenditures may arise. Acharya *et al.* (2007) show in this respect that a higher cash stock and a higher debt capacity both increase the probability that listed firms can finance their future investment opportunities. The notion that a high current debt ratio may raise the likelihood of future financial constraints is generally also strongly satisfied for private enterprises. By definition, private firms have no direct access to public equity markets. Hence, in order to reduce their leverage, these firms should either use internally generated cash flows to pay off their debts or sell assets to generate the necessary cash. Alternatively, owners

[6] Likewise, Almeida *et al.* (2006) argue that if the probability of facing future credit constraints is positive, firms will take into account the impact of current investment expenditures on the accessibility of funds for future investment projects. Hence, firms have incentives to choose projects that are less risky and more liquid, with cash as an extreme case. Almeida *et al.* also show that these incentives rise with the probability of being credit constrained. Although we do not test the implications of their model, which focuses more on the choice between various investment projects rather than on the level of capital expenditures, the model of Almeida *et al.* (2006) does have implications for the impact of leverage on investment expenditures, as cash is the least risky and most liquid alternative investment project available to firms. The model of Almeida *et al.* (2006) therefore suggests that outlays on fixed assets will reduce with the likelihood of future credit constraints, ceteris paribus. In a similar spirit, Franzoni (2007) argues that for constrained firms, the shadow price of cash includes the higher cost of external financing and the NPV of the projects that are foregone because of the disappearance of these funds. Not surprisingly, Opler *et al.* (1999) find that firms with larger growth opportunities and riskier cash flows hold higher ratios of cash to non-cash items.

could increase their own equity investment. Yet, as divesting assets is not a value-enhancing option for most firms and secondary equity offerings are rare in private enterprises, mostly due to the entrepreneur's limited wealth and/or largely undiversified personal portfolio, it is clear that it usually takes some time to reduce a high current debt ratio. In sum, private enterprises should be highly sensitive to the adverse effects of current investment on future credit constraints if their debt ratio today is relatively high.

Overall, static and linear multi-period credit constraints models are alike in both predicting a negative impact of leverage on investment expenditures. Yet, as in the static credit constraints model, the impact of leverage on investment could be different at relatively high versus lower debt ratios, i.e., a non-linear relation. Interestingly, in a multi-period framework, marginal increases in leverage at relatively high debt ratios can have two – opposite – effects. On the one hand, firms will find it harder to raise additional bank loans at a reasonable cost once their leverage is already relatively high. Hence, marginal increases in the debt ratio may further increase the probability that the firm cannot finance potentially more profitable investment opportunities in future periods. In that case, and consistent with the static model, the incentive to reduce capital expenditures today is further enhanced. On the other hand, there are at least two reasons why the incentive to reduce current investment may decrease at relatively high debt ratios and firms thus still invest reasonable amounts. First, Boyle and Guthrie (2003) and Lyandres and Zhdanov (2006) argue that as the probability of future financial constraints increases, the value of options to wait decreases and so firms have incentives to exercise their investment options prematurely. We argue that a higher debt ratio progressively increases the odds of future credit constraints. As a result, capital expenditures at present may no longer fall at an increasingly faster rate with marginal increases in leverage when the debt ratio is already relatively large. Second, when leverage is already high, further increases in debt make both debt and equity increasingly riskier.[7] Hence, the cost of capital at which future cash

[7] The discount rate rises progressively with leverage because at relatively high debt ratios, further increases in leverage make bankruptcy and/or liquidation increasingly more imminent. Also, the incentive to initiate actions that may harm

flows are discounted rises increasingly faster with marginal increases in leverage at relatively high debt ratios. Arguably, cash flows that arise further in the future will then have a lower present value than cash flows in earlier periods. So, an increase in the discount rate could reduce the NPV of future investment opportunities relatively more than the NPV of currently available projects, ceteris paribus. This mechanism thus lowers the above-mentioned incentives to cut back on current investment in order to increase the likelihood that potentially more profitable projects in future periods can be financed.

Multi-period credit constraints hypothesis: The negative impact of marginal increases in leverage on investment expenditures can either increase or decrease at relatively high debt ratios.

When comparing the static with the multi-period credit constraints hypotheses, it is important to acknowledge that while the inferences of both hypotheses could be the same, the intuitions behind them are quite different. In addition, when analyzing the results from empirical tests on credit constraints, it has to be taken into account that the impact of leverage on investment expenditures can be due to credit constraints in current as well as future periods. However, finding that the negative impact of marginal increases in leverage on investment diminishes at relatively high debt ratios would indicate that the implications of the multi-period credit constraints hypothesis *dominate* those of the static model at relatively high debt ratios. To examine these potential non-linearitities in the leverage-investment relation, we include a quadratic term in firm leverage in our empirical model and investigate whether, and if so how, the impact of marginal increases in leverage on investment expenditures changes with the debt ratio. Alternatively, we also estimate a leverage-spline model, as is done by Campello (2006) and Cleary *et al.* (2007). A leverage-spline model has the interesting feature that it can determine more exactly at what debt ratio the impact of marginal increases in leverage starts to increase or decline.

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creditors to the benefit of shareholders, i.e., an agency problem of debt, becomes progressively more important as the debt ratio rises, thereby adversely influencing the cost of debt.

II.A.3. Asymmetric information and credit constraints

For a given debt ratio, the likelihood of both current and future credit constraints is likely to be larger when outside financiers find it more difficult to determine firm quality. In this respect, Khurana *et al.* (2006) conclude that listed firms with a better overall disclosure, as identified by financial analysts, find it easier to finance their growth externally. For private enterprises, we argue that larger information asymmetries between firms and banks tend to strengthen the negative impact of the debt ratio on capital expenditures. The reason is that firms find it harder to raise additional bank loans to finance their investment outlays when subject to large information asymmetries. Consequently, we can further test whether the impact of leverage on capital expenditures really results from credit constraints by analyzing whether the leverage-investment relation intensifies across some measure of information asymmetries. We will use firm age to proxy for the size of asymmetric information problems (see also Liu, 2006). As the size of information asymmetries diminishes with firm age, we expect a positive coefficient on the interaction term between firm leverage and firm age when examining its relation with investment expenditures.

Moreover, we will also examine what the impact of information asymmetries is on the relation between firm leverage and investment expenditures when debt ratios are relatively large. We already argued that firms facing relatively high debt ratios will find it increasingly difficult to obtain additional reasonably priced bank loans. This effect is likely to be reinforced for firms for which banks may find it more difficult to determine firm quality because of larger information asymmetries. These arguments thus also imply a positive interaction term between the quadratic term in firm leverage and firm age when examining its relation with investment expenditures.

Credit constraints hypothesis: If credit constraints are driving the relation between leverage and investment expenditures, we should observe a significantly positive interaction term between firm leverage (a quadratic term in firm leverage) and firm age when examining its relation with investment expenditures.

II.B. Underinvestment incentives

Underinvestment incentives result from an agency conflict between shareholders and creditors, where shareholders – as residual claimants – lack the incentive to initiate projects whose benefits will largely accrue to the firm's debtholders. More specifically, Myers (1977) shows that managers acting in the best interests of their shareholders may forego (i.e., underinvest in) positive NPV projects if these projects' payoffs mainly benefit the firm's debtholders. This may happen when the firm has too much debt outstanding, i.e., a *debt overhang*, as the large fixed interest expenses and capital installments are to be paid before shareholders receive anything. Based upon this underinvestment theory, the relation between leverage and investment is again expected to be negative. The evidence supporting underinvestment in cross-sectional or panel data models is scarce, however. Whereas McConnell and Servaes (1995) find that leverage reduces firm value (Tobin's Q) for firms with large growth opportunities, neither Lang *et al.* (1996) nor Dessi and Robertson (2003) and Aivazian *et al.* (2005) find evidence for underinvestment in a similar, yet extended set-up.

We argue that this lack of support could result from the omission of both multi-period and non-linear aspects in the theory of underinvestment. It is crucial to recognize that underinvestment only occurs when the NPV of an investment project is smaller than the project-induced increase in the value of the firm's outstanding debt. In a static model, this results in equation (1):

$$\begin{cases} NPV_{current} \geq 0 \\ NPV_{current} \leq \Delta V_{debt} \end{cases} \tag{1}$$

In a multi-period framework, Ju and Hui (2006) argue that the incentives to underinvest are smaller as firms take into account the impact of current investment on future financing and investment decisions. So, firms consider not only the NPV of the project at stake, but also bear in mind (a) the positive effect that future investment projects building further on or benefiting from this particular project will have on firm value, (b) the present value of the costs that result from the firm's

worsened relationships with its bank(s) following behavior that harms debtholders, and (c) the increase in expected liquidation costs when not starting up the current project:

$$\begin{cases} NPV_{current} \geq 0 \\ NPV_{current} + NPV_{future} - \Delta Cost_{credit} - \Delta Exp.Costs_{liquidation} \leq \Delta V_{debt} \end{cases} \quad (2)$$

For a private firm, the latter two effects are likely to be highly important. First, the costs of disrupting a banking relationship as a result of underinvestment can be high. Petersen and Rajan (1994), for example, have stressed the benefits that banking relationships engender for small private enterprises in terms of better access to financing. Also, if banks decide to cut off loans following detrimental firm behavior, firms may have a hard time trying to find new sources of financing as relatively few alternative sources are available and as other banks might interpret the loan cutoff by the current bank as a negative signal about firm quality. Second, the expected liquidation costs on average are relatively large in a private-firm setting. Default and liquidation are more imminent for private firms, in part due to their more leveraged capital structure and limited access to other sources of external funds (see also Franks and Sussman, 2005). In addition, private-firm owners may incur relatively large costs upon firm liquidation. For owners' portfolios are unlikely to be well diversified in firms where ownership is concentrated in the hands of the owner-manager. Also, the value of the owner's human capital may be highly related to the firm's success. Finally, owners may have pledged some of their personal assets as security for the company's debts.[8]

Regarding the non-linear impact of leverage on investment expenditures, we expect to find evidence of underinvestment especially at relatively high debt ratios in the static as well as multi-period frameworks. The reason is that new investments are less likely to change the market value of the debt at low to moderate debt ratios. However, when leverage increases and the outstanding

[8] Berger and Udell (1998) find that 53.82% of bank loans to private businesses in the USA are guaranteed by the owners of the firm. Davydenko and Franks (2007) find that upon firm liquidation, collateral from personal or firm guarantees is valued at 44% of the total debt exposure at the moment of default in France, 12% in Germany, and 13% in the UK.

debt thus becomes riskier, it becomes increasingly more likely that the NPV of new investment projects is lower than the increase in the value of the debt induced by initiating these projects.

Finally, Myers (1977) argues that the occurrence of, and value lost because of, underinvestment problems are positively related to the proportion of firm value accounted for by growth opportunities. The reason is that growth options demand discretionary investment decisions. According to this agency theory of underinvestment, the fraction of firm value that stems from growth prospects thus can influence the extent by which capital structure affects investment decisions, ceteris paribus. Yet, empirical studies by Lang *et al.* (1996) and Aivazian *et al.* (2005) do not find support for Myers' conjecture that the impact of leverage on investment is more negative when a larger percentage of the firm's market value stems from its growth opportunities. Therefore, we wish to examine whether accounting for both the multi-period and non-linear implications of the theory of underinvestment affects the leverage-investment relation for firms that have larger investment opportunities. To test this idea, we will follow Aivazian *et al.* (2005) and include an interaction term between leverage and growth opportunities in our model. Growth prospects will be proxied by various measures capturing actual growth rates in the corresponding industry as well as recent firm-level growth rates, given that the firms in our sample are not publicly quoted. As we hypothesize that the incentive to underinvest rises progressively with the firm's debt ratio, we will also include an interaction term between the quadratic term in firm leverage and growth opportunities, and expect a negative parameter estimate on this interaction variable.

Underinvestment hypothesis: The negative impact of marginal increases in leverage on investment expenditures increases with the debt ratio. Also, if underinvestment incentives are driving the relation between leverage and investment expenditures, we should observe significantly negative interaction terms between firm leverage (a quadratic term in firm leverage) and measures for growth opportunities.

III. Sample selection and characteristics

Private enterprises, which generally represent a dominant fraction of all firms in an economy, have some interesting characteristics that make them particularly suited to disentangle a few competing

explanations for why firms with more debt invest less. In this way, data on private firms provide us with a unique opportunity to test the leverage-investment relation in more detail. Despite their distinguishing characteristics, research on private enterprises is scarce, probably due to the limited data availability on these companies. In Belgium, however, all limited liability firms (corporations) – except for financial institutions, insurance companies, foreign exchange brokers, and hospitals – are legally required to file their annual financial statements with the National Bank as of start-up. This information is commercialized by Bureau Van Dijk Electronic Publishing as a database called Belfirst. The database includes the annual accounts of over 350,000 Belgian corporations, of which more than 95% are privately held.

Starting from this large database, we selected a sample of private enterprises that are located in Flanders, the northern and most developed region of the country. We follow these firms during a ten-year period, from 1996 to 2005. To make sure that the sample firms fit the requirements of our research design, we imposed the following selection criteria. First, we do not include firm years in which total leverage exceeds 100% (see also Campello, 2006) and firms that are reported to be inactive in 2006 to exclude data on failing or failed firms.[9] The latter selection criteria should help to reduce concerns that a declining negative impact of leverage on investment expenditures may simply arise from the fact that firms with extremely high debt ratios cannot finance any investment projects at all. Second, in order to exclude firms that rely on internal capital markets, we also do not consider enterprises that report ties with other firms in our sample. This should remove firms in which financing and investment decisions are made at different levels of the corporate group. Third, we exclude firms without employees. Through this restriction, we remove firms that may have been founded solely for tax reasons. Fourth, in order to perform the leverage-spline model (see Section IV), we focus on firms that operate in only one industry, i.e., firms that report only one

[9] In other words, new firms that entered the industry during the period 1996–2005 have been retained in the sample unless they had failed by 2006. Also, incumbents established before 1996 have been included in the sample provided that they were still in business by 2006.

five-digit NACE code. Using *five*-digit NACE codes should also help us to better delineate industries and increase the comparability of firms within an industry. Finally, we have limited our sample to firms in industries in which at least 40 firms are active in each calendar year to make the industry comparison more meaningful. The above selection criteria resulted in a sample of 12,289 firms for which we have sufficient data between 1996 and 2005, resulting in 64,246 firm-year observations in total. Like most studies in this literature, we choose to work with an unbalanced panel data set as some firms only enter the sample in later years or report insufficient information in a few years. To deal with outliers, we have winsorized the various variables at the 1% and 99% levels. Table 1 reports descriptive statistics on a number of firm characteristics.

<<Insert Table 1>>

Table 1 shows that the firms in our sample are rather young and small. The average firm is fourteen years old and has seven employees. The median firm has an age of eleven years and employs three people. Total assets average €526,674, with a median value of €226,000. Overall, our sample is highly comparable to that of the National Survey of Small Business Finance, as studied by Petersen and Rajan (1994) and Berger and Udell (1998), among others. In this sample of private US firms, the median firm size was $130,000 with a median firm age of 10 years. Yet, this database – unlike ours – does not include panel data and so is less suited to test the relation between leverage and investment expenditures. For the firms in our sample, fixed assets on average represent 43.10% of total assets whereas tangible fixed assets (i.e. property, plant and equipment) on average represent 39.91%. Cash and marketable securities make up 13.06% of total assets.

Firms are highly leveraged on average. The mean total debt ratio is 64.06%, with a median value of 67.95%. Furthermore, the standard deviation of the total debt ratio equals 26.31%, making clear that there is a fairly large variation in debt ratios among the firms in our sample. About half of total debt consists of bank loans, and most bank debt (88.85% on average) is long term. Bank loans are the dominant source of long-term debt as they represent 96.53% of total long-term loans for the average firm. The ratio of long-term bank debt to total assets, which is the main explanatory

variable in this study, equals 27.88% on average, with a median value of 23.08% and a standard deviation of 34.44%. Table 1 further shows that in our sample average gross investment expenditures, defined as the change in fixed assets plus depreciation, equal 36.66% of fixed assets per annum. The median firm only invests 15.91% per year, however. We find that highly indebted firms, whose leverage is more than one standard deviation above the corresponding industry-year average, still invest a considerable amount, with an average investment ratio of 22.10% per year (the median value is 7.94%). For comparison, the average firm in the subsample of firms with a debt ratio less than one standard deviation below the corresponding industry-year average has an average investment ratio of 39.21% per year (the median value is 18.96%). Finally, the average ratio of cash flow to prior-year total assets is 16.02% (the median value is 14.13%).

IV. Methodology

While most previous studies in the leverage-investment literature have used the pooling regression methodology, Aivazian *et al.* (2005) point out that the assumption of zero unobservable firm heterogeneity is too strong. Also, the dynamic structure of the data can be better exploited using panel data analysis. For our sample, the Hausman test selects a fixed effects over a random effects specification (*p*-value <0.0001). Also, the *F*-test for the overall relevance of including fixed effects supports our choice of a fixed effects specification over a pooled OLS model (*p*-value <0.0001). Hence, this specification should increase the robustness of our results to static omitted firm variables, for example the ability of the owner-manager. Also, it will reduce endogeneity concerns related to these static omitted variables (Verbeek, 2002). We start from the empirical specification used by Aivazian *et al.* (2005) to investigate the impact of leverage on investment expenditures:

$$I_{i,t} / K_{i,t-1} = \alpha + \mu_i + \beta_1 * Lev_{i,t-1} + \beta_2 * (CF_{i,t} / K_{i,t-1}) + \beta_3 * Gr.Opp_{i,t} + \beta_4 * Size_{i,t-1} + \beta_5 * Age_{i,t} + \varepsilon_{i,t} \qquad (3)$$

where $I_{i,t}$ is gross investment in fixed assets of firm *i* in year *t*; $K_{i,t-1}$ is lagged fixed assets; α is a constant; μ_i is the individual effect of firm *i*. We measure leverage by the first lag of the ratio of

long-term bank debt to total assets ($Lev_{i,t-1}$). We focus on *long-term* loans as these tend to have a more direct effect on the probability of both current and future credit constraints. Also, long-term debt is more likely than short-term loans to lead to agency problems, in particular underinvestment after the debt contract has been written. Besides, short-term loans are more frequently used for liquidity reasons rather than to finance investment outlays. The reason for concentrating on *bank* loans, as shown by our summary statistics, is that these are the dominant source of long-term debt for private enterprises. Also, banks are expected to be less lenient in periods of financial distress than suppliers that are extending trade credit (see Franks and Sussman (2005), for example). $CF_{i,t}$ is the cash flow generated in year *t*. Consistent with the literature, we lag leverage but not cash flow to take into account that the former is a stock variable whereas the latter is a flow variable. As the market value of private enterprises is unknown, we cannot measure the size of the firm's growth opportunities by means of either Tobin's Q or the market-to-book ratio. Although many recent studies (e.g., Konings *et al.*, 2003; Audretsch and Weigand, 2005) use the growth rate in sales to measure firm-level growth opportunities for unlisted enterprises, small Belgian firms are not required to report their sales figures. They do have to report their gross margin, which is calculated as sales minus cost of goods sold. As positive NPV projects result from ways to increase sales as well as ways to reduce costs, we measure the size of growth opportunities by the three-year lagged moving average (henceforth 'historical') growth rate in gross margin in the corresponding industry. We also check the robustness of our results when using the historical growth rate in total assets in the corresponding industry. Finally, we also calculate these historical measures at the individual firm level. The results of these robustness checks are reported and discussed in Section V.D. We include firm size and firm age as control variables in Equation (3), as our sample contains many small and recently established ventures that are expected to grow faster (Dunne and Hughes, 1994; Yasuda, 2005), and thus could invest more than the large, established firms in the same industry.

Equation (3) assumes that the impact of leverage on investment expenditures is linear, while we argued in Section II that the static as well as multi-period credit constraints and underinvestment

models also have non-linear implications. We use two methods to test for the existence of such a non-linear effect. First, we enter a quadratic term in firm leverage, $Lev_{i,t-1}^2$, in equation (3) to determine whether the marginal impact of leverage increases or decreases with the debt ratio. Second, we use a leverage-spline model similar to that developed by Campello (2006) and Cleary *et al.* (2007). This model relaxes the assumption of a monotonic relation by partitioning $Lev_{i,t-1}$ into n variables $(k_1 Lev_{i,t-1}, k_2 Lev_{i,t-1}, ..., k_n Lev_{i,t-1})$, each representing one distinct interval in which the marginal effect of leverage can differ. To maintain continuity in the functional form, these variables must be joined at the knots, which we denote by l_k with k = 1,…, n–1. To align the knots across the different sections, we standardize our leverage variable by the industry average and standard deviation and use $[-1.5\sigma, 0, 1.5\sigma]$ as cutoff points.[10] Alternatively, we will also use $[-\sigma, 0, \sigma]$ as knots, to test the robustness of our findings. The following expressions show how the standardized leverage variable is transformed into n new variables:

$$\begin{aligned} k_1 Lev_{i,t-1} &= \min\left[z - Lev_{i,t-1}, l_1 \right] \\ k_k Lev_{i,t-1} &= \max\left[\min\left[z - Lev_{i,t-1}, l_k \right], l_{k-1} \right] - l_{k-1}, k = 2, ..., n. \end{aligned} \tag{4}$$

We then replace $\beta_1 * Lev_{i,t-1}$ in equation (3) with $\sum_{k=1}^{n} \beta_k * k_k Lev_{i,t-1}$ to examine whether or not the impact of leverage on investment expenditures is non-linear. We perform *F*-tests on the subsequent β_k's to more formally gauge the importance of a non-linear relation. Overall, this leverage-spline model will allow us to determine more precisely at what debt ratio the negative impact of marginal increases in leverage starts to increase or decline.

[10] Whereas Campello (2006) uses three standard deviations above or below the industry average, we will use 1.5 (one as a robustness check) standard deviation as cutoff, as the average debt ratio is already high for the private enterprises in our sample when compared with the listed firms – that are retrieved from Compustat – in Campello's (2006) study.

Most importantly, we have to deal with a potential endogeneity problem regarding leverage. Indeed, Myers (1977) suggests that firms may reduce potential underinvestment incentives ex ante by restricting their debt ratio. Leverage could thus be inversely related to the ratio of the value of growth options relative to the value of assets in place. When our proxy for growth opportunities does not adequately control for the firm's expected investment opportunities, an endogeneity problem will arise. As we are interested, in this paper, in the impact of leverage on investment expenditures, we have to address this issue. So, we will use two-stage least squares (2SLS) estimation and utilize asset tangibility, calculated as tangible fixed assets relative to total assets, as an instrument for firm leverage (see also Aivazian *et al.* 2005; Campello, 2006). Whereas asset tangibility bears no theoretical links with the ratio of investment expenditures to fixed assets, it has an important effect on leverage as it reduces bank concerns about information asymmetries and liquidation costs. Hence, banks may be more willing to lend when firm assets are largely tangible. This link between asset tangibility and leverage is further established in the empirical literature. For instance, Chanay *et al.* (2007) show that increases in the value of a firm's collateral significantly increase its long-term leverage. Vicente-Lorente (2001) and Almeida and Campello (2007) document that a firm's credit status is positively affected by the tangibility of its assets. Berger and Udell (1998) find that more than 90% of small-firm loans are collateralized whereas Degryse and Van Cayseele (2000) argue that firms find it more difficult to obtain bank loans when they cannot offer sufficient collateral. Finally, Antoniou *et al.* (2008) find that the positive effect of asset tangibility on firm leverage is even more prominent in bank-oriented countries (Germany, France and Japan) than in capital market-oriented countries (the USA and the UK). In our sample, the correlation coefficient between asset tangibility and leverage is indeed 0.61 whereas the correlation coefficient between asset tangibility and investment expenditures is only -0.01, thereby suggesting that asset tangibility is a good instrument for firm leverage.[11]

[11] We also separately instrument the quadratic term in leverage and the interaction terms between leverage and firm age, leverage and growth opportunities, the quadratic term in leverage and firm age and the quadratic term in leverage and

Finally, we adjust the 2SLS standard errors of all parameter estimates for heteroskedasticity by means of the White procedure.

V. Empirical results

V.A. The impact of leverage on investment expenditures

We use equation (3) to test whether firms with more debt invest less in a linear manner. The results in Table 2, column 1 indeed reveal that increases in leverage significantly negatively affect investment expenditures. This result is in line with the findings of previous empirical research on listed firms (e.g., Lang *et al.*, 1996; Aivazian *et al.*, 2005).[12] Also, it is consistent with the linear predictions of the two models – credit constraints and underinvestment – that we referred to when explaining the impact of leverage on capital expenditures.

<<Insert Table 2>>

The negative parameter estimate is robust to alternative definitions of leverage (e.g., total leverage, total financial leverage or the second lag of the long-term bank debt ratio), to scaling investment expenditures and cash flow by total assets instead of fixed assets, and to measuring investment expenditures as outlays on property, plant, and equipment (tangible fixed assets) rather than on fixed assets in general. This finding is also robust across different industries (manufacturing, construction, and services) and to standardizing all variables by their corresponding

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growth opportunities by the quadratic term in asset tangibility and the interaction terms between asset tangibility and firm age, asset tangibility and growth opportunities, the quadratic term in asset tangibility and firm age and the quadratic term in asset tangibility and growth opportunities, respectively.

[12] An exception is Liu (2006), who finds that while publicly listed firms with more debt invest less, firms relying more on bank loans invest more. He argues that the presence of bank loans provides a quality signal to other financiers, making it easier for firms to attract alternative financing sources, such as public debt, to finance their investment outlays. Due to a lack of alternative financing sources, this signaling effect from bank loans is simply not present in our sample of private enterprises.

industry mean and standard deviation. The results from all these robustness checks are not reported, but can be obtained from the authors upon request.

The control variables have the expected impact on investment expenditures. Firms that generate more internal cash flows or firms in high-growth industries invest significantly more, while larger and older firms invest significantly less. Overall, the adjusted R^2 of the model equals 34.67%. This is considerably larger than in earlier studies on listed firms. For instance, the R^2 in Aivaizian *et al.* (2005), whose empirical set-up is closest to ours, is only 8.90%. Firm fixed effects are always significant, confirming that the fixed effects specification is a better model than pooled OLS to estimate equation (3) for our sample of private enterprises. Results are also robust to entering fixed effects per calendar year. Yet, firm age then becomes insignificant.

In the next three sections, we examine the specific implications of our hypotheses on credit constraints and underinvestment in more detail, to advance the research question *why* private firms with higher leverage invest less. In Section V.B, we investigate whether the marginal impact of leverage on capital expenditures differs across the debt ratio. In Section V.C, we test whether the sensitivity of investment to leverage depends on the size of information asymmetries, measured by firm age. Finally, we use a similar set-up as Aivaizian *et al.* (2005) to analyze the underinvestment hypothesis in more detail in Section V.D.

V.B. Non-linearities in the leverage-investment relation

In Table 2, we also report the results from fixed effects panel regressions of equation (3) where we include a quadratic term in leverage (column 2), and from fixed effects panel regressions where we replace leverage with the leverage-spline model of equation (4). In the latter model, we use the industry-year average of leverage and 1.5 standard deviation below and above this average as cutoff points (column 3). A robustness test using only one standard deviation to define cutoff points is reported in column 4 of Table 2. In this way, we can examine within a single model whether the impact of leverage on investment expenditures differs between (a) firms whose debt ratio is lower

than 1.5 (one) standard deviation below the industry average, (b) firms whose leverage is between 1.5 (one) standard deviation below the industry average and the industry average, (c) firms whose leverage is between the industry average and 1.5 (one) standard deviation above the industry average, and (d) firms whose leverage is above 1.5 (one) standard deviation above the industry average. The last rows of Table 2 also report the *p*-values of *F*-tests that examine whether the coefficients of subsequent leverage splines differ significantly from one another or not.

Table 2, column 2 shows that the coefficient of leverage remains significantly negative whereas the coefficient of its quadratic term is significantly positive. Likewise, the leverage-spline models in columns 3 and 4 indicate a significantly decreased, yet still significantly negative impact of leverage at relatively high debt ratios. We find – in both columns 3 and 4 – that the parameter estimates of leverage differ significantly across subsequent leverage splines. Also, the results show that the largest change in coefficients of subsequent splines is never between the third and fourth leverage spline, consistent with a decreased negative impact of leverage on investment when the debt ratio grows larger. Again, all results are robust to the various alternative definitions of leverage, investment expenditures, and the control variables, and across different industries (manufacturing, construction, and services).

The above results are inconsistent with the predictions of the static credit constraints and the underinvestment model; yet, they can (only) be reconciled with our multi-period credit constraints hypothesis. We argued that future credit constraints can induce manager-owners of private enterprises to reduce their capital expenditures today in order to assure that future, more profitable investment opportunities can be grasped. However, a higher debt ratio increases the likelihood of future credit constraints. As a result, the value of waiting to invest will be lower, thereby providing an incentive to invest in projects today rather than tomorrow. Also, a further increase in the debt ratio will substantially raise the discount rate when leverage is already large. This could lower the expected NPV of future investment opportunities by more than the NPV of projects available today. Overall, these arguments can explain why the negative relation between leverage and investment

expenditures declines with the debt ratio. Interestingly, the results of the leverage-spline model also suggest that for firms with a relatively high debt ratio the decrease in the negative impact of marginal increases in leverage is not due to the inability to make any investment expenditures at all. Indeed, we find that the largest decrease between two subsequent leverage splines occurs either from the first to the second (column 3) or from the second to the third spline (column 4).

Finally, in columns 5 and 6 of Table 2, we examine whether the non-linear result for the leverage-investment relation could be due to the typically negative relation between internal cash flow generation and leverage, on the one hand, and the non-linearities in the relation between cash flows and investment expenditures, as documented by Cleary *et al.* (2007), on the other hand. More specifically, Cleary *et al.* (2007) find that marginal increases in cash flows boost investments for firms with relatively high levels of internal cash flows whereas marginal increases in cash flows reduce capital expenditures for firms with relatively low levels of internal cash flows To test this alternative explanation, we perform a spline model on the ratio of cash flow to fixed assets, with $[-1.5\sigma; 0; 1.5\sigma]$ times the industry-year average cash flow as cutoff points. In column 5, we also include the simple and quadratic terms in firm leverage whereas we perform spline models on both leverage and cash flow in column 6. The results for the cash flow splines are consistent with those of Cleary *et al.* (2007). Regarding leverage, the results in both columns are generally robust in this alternative model. Overall, we can safely conclude that the non-linear leverage-investment relation is not just an artifact of the non-linear cash flow-investment relation.

V.C. The impact of firm age

In this section, we further test whether the relation between leverage and investment expenditures really results from credit constraints by examining whether the effect of the debt ratio on capital expenditures intensifies with asymmetric information. After all, outside financiers are generally reluctant to reward firms with additional loans when they are unsure about firm quality. This effect is likely to occur especially when debt ratios are relatively high. By including interaction terms

between firm leverage and firm age and between the quadratic term in firm leverage and firm age, respectively, we can also test whether our non-linear finding in Section V.A intensifies with the level of information asymmetries. Table 3 reports the results.

<<Insert Table 3>>

Based upon the assumption that information asymmetries decline with firm age, we expect the negative impact of leverage on investment expenditures to be smaller for older firms. Yet, we only find that the interaction term between the quadratic term in firm leverage and firm age is marginally significantly positive (columns 1 and 2). Although this result is weak, it does confirm that the impact of leverage on investment expenditures is less negative for older firms at relatively high debt ratios. However, while information asymmetries are likely to gradually decline with firm age in the start-up context, it is possible that firm age is a less relevant measure for information asymmetries for the more established firms in our sample. To further examine this conjecture, we also perform our analyses separately in columns 3 to 6 on the subsamples of start-up firms, i.e., firms younger than five years, and more mature firms, i.e., firms older than ten years. In our subsample of start-up firms, column 3 reveals that the negative impact of leverage on investment expenditures reduces with firm age. The results in column 4 point out that this reduction is stronger at relatively high debt ratios as the interaction term between the quadratic term in firm leverage and firm age is significantly positive. In contrast, in the subsample of more established firms (columns 5 and 6), we do not find that firm age influences the impact of leverage on investment expenditures. In sum, the above results on the effect of information asymmetries on the leverage-investment relation support the conjecture that asymmetric information increases the likelihood of current and/or future credit constraints, especially when debt ratios are already relatively high.

V.D. Underinvestment incentives

To further investigate whether also underinvestment incentives could explain the negative impact of leverage on capital expenditures, we hypothesized that the impact of the debt ratio should be more

negative when the incentives to underinvest are larger, ceteris paribus. Myers (1977) argues that this will be the case especially for firms that have a lot of growth opportunities relative to the value of their assets in place. Following Aivazian *et al.* (2005), we use an interaction term between firm leverage and various measures of growth opportunities to test this idea. Again, we interact firm leverage and its quadratic term, respectively, with these measures. Table 4 presents the results. Growth opportunities are measured by the historical growth rate in gross margin (columns 1 and 2) or total assets (columns 3 and 4), calculated at the corresponding five-digit NACE industry level during 1996–2005. Alternatively, we use the lagged growth rate in the firm's gross margin (columns 5 and 6) or total assets (columns 7 and 8).

<<Insert Table 4>>

Consistent with Lang *et al*. (1996), Dessi and Robertson (2003), and Aivazian *et al.* (2005), we find no evidence for underinvestment in a linear model, as the interaction terms between leverage and our measures of growth opportunities are always insignificant (columns 1, 3, 5 and 7). However, in line with our conjecture that Myers' agency problem of underinvestment is more likely to occur at relatively high debt ratios, we find that the interaction term between the quadratic term in firm leverage and growth opportunities is significantly negative when measuring the size of growth opportunities either by the historical industry growth rate in gross margin (column 2), the historical industry growth rate in total assets (column 4) or by the historical firm-level growth rate in gross margin (column 6). The results for the historical firm-level growth rate in total assets are only marginally significant (*p*-value of 0.1174 in column 8). Overall, these findings thus suggest that firms with larger growth opportunities are more likely to underinvest at relatively high debt ratios.

VI. Conclusions

In this paper, we advance the research question *why* debt hurts investment expenditures by developing and testing the non-linear and multi-period implications of models on credit constraints

and underinvestment. For this purpose, we exploit some of the unique characteristics of private enterprises, such as their high reliance on bank loans as a source of long-term funds, their relatively high level of information asymmetries, and their lack of agency problems of equity. Our database includes information on a unique and large unbalanced panel of 64,246 private firm years between 1996 and 2005. We use fixed effects panel regression analysis to examine the relation between leverage and investment expenditures in this sample. In our regressions, we take into account the endogeneity of leverage using an instrumental variable technique.

In line with research on listed firms (e.g., Lang *et al.*, 1996; Aivazian *et al.*, 2005), we find that more highly leveraged firms invest less. Another robust finding is that this negative effect decreases with the debt ratio, which can be aligned only with our multi-period credit constraints hypothesis. This hypothesis is built upon the idea that firms take the influence of current investments on future financing and investment decisions into account. According to the acceleration theory of Boyle and Guthrie (2003), the value of options to wait decreases as the likelihood of future financial constraints increases. As a result, when debt ratios are relatively large, current investment may no longer decline at an increasingly faster rate with marginal increases in leverage. Also, when leverage is already high, further increases in the debt ratio to finance investment projects increase the rate at which future cash flows are discounted. The result is that the value of investment projects whose cash flows arise further in the future tends to decline more than that of projects whose cash flows will realize earlier. This effect reduces the incentive to postpone or forgo investments today in order to initiate more profitable projects in the future. Next, we find that at relatively high debt ratios, the negative relation between leverage and investment expenditures is weaker when firms are older. Further analysis reveals that this effect is driven by the subsample of recently established firms. As the odds of both current and future credit constraints are likely to be larger when outside financiers – in particular banks – find it more difficult to determine firm quality, our findings may reflect that firms subject to larger asymmetric information problems may find it harder to raise additional bank loans at a reasonable cost to

finance their investment outlays. Finally, we also find some support for the agency model of underinvestment in a non-linear model specification, as relatively highly leveraged firms with substantial growth opportunities invest significantly less.

In sum, the theoretical arguments and empirical results in this paper point out that both the multi-period consequences and non-linear predictions of theoretical models on the leverage-investment relation should be taken into account when studying this relationship. Although research on listed firms is required to determine to what extent our results can be generalized to publicly quoted firms, the findings in this paper may provide a first explanation for some recently observed empirical puzzles that arose in samples of listed firms. First, Kaplan and Zingales (1997), Cleary (1999), and Moyen and Platikanov (2006) all find that the investment expenditures of firms that are more likely to be financially constrained show a lower sensitivity to the availability of internal and external funds. This finding is consistent with our multi-period credit constraints hypothesis that the investments of firms with a relatively high debt ratio, which are more likely to be financially constrained, respond less negatively to marginal increases in leverage than the investments of less indebted firms. Second, survey papers by Graham and Harvey (2001), Bancel and Mittoo (2004), and Brounen *et al.* (2006) find that many listed firms highly value the retention of funds for potential growth opportunities in future periods. The results in this paper are consistent with this finding, too, as we find that firms also take the likelihood of future credit constraints into account when deciding on their investment expenditures today. They even suggest that firms may build up this debt capacity by reducing their current capital outlays. Finally, our study suggests that the lack of evidence supporting the underinvestment theory in large panel data studies on listed firms (Lang *et al.*, 1996; Aivazian *et al.*, 2005) could result from the omission of non-linear effects in the development of underinvestment hypotheses. Documenting more specific conditions under which underinvestment is likely to arise seems necessary in this respect.

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Table 1 Characteristics of private firms

	Mean	median	5^{th} pctl	95^{th} pctl	std. dev
FIRM AGE	14	11	1	31	10.2786
FIRM SIZE					
Number of employees	7	3	1	25	14.3772
Total assets (€)	526,674	226,000	12,000	981,000	1554.31
ASSET STRUCTURE					
Fixed assets/total assets	0.4310	0.3987	0.0401	0.9017	0.2603
Tangible fixed assets/total assets	0.3991	0.3698	0.0397	0.8701	0.2577
Cash and marketable securities/total assets	0.1306	0.0753	0	0.4631	0.1543
FINANCIAL STRUCTURE					
Total liabilities/total assets	0.6406	0.6795	0.1587	0.9545	0.2631
Bank debt/total assets	0.3138	0.2791	0	1	0.3328
Long-term bank debt (>1 year)/bank debt	0.8885	1	0	1	0.2142
Long-term bank debt/total long-term debt	0.9653	1	0.7299	1	0.1530
Leverage: Long-term bank debt/total assets	0.2788	0.2308	0	0.7392	0.3444
INVESTMENT EXPENDITURES					
Investment expenditures/fixed $assets_{t-1}$	0.3666	0.1591	-0.0024	1.6461	0.8931
PROFITABILITY					
Cash flow/total $assets_{t-1}$	0.1602	0.1413	-0.0638	0.4464	0.1659
Cash flow/fixed $assets_{t-1}$	0.4855	0.3880	-0.2291	1.9526	0.4402

Note: This table provides descriptive statistics on the age, size, asset structure, financial structure, investment expenditures and profitability for the sample of 12,288 private firms during the period 1996–2005, as studied in this paper. These firms meet the following sample selection criteria. First, firm years in which total leverage exceeds 100% and firms that are reported as inactive in 2006 are excluded. Second, sample firms do not report ties with other firms. Third, firms employ at least one employee. Fourth, they operate in only one industry, i.e., sample firms report only one five-digit NACE code. Finally, the sample is limited to firms in industries in which at least 40 firms are active in each calendar year to make the industry comparison meaningful.

Table 2 The impact of leverage on investment expenditures

	(1) $I_{i,t}/K_{i,t-1}$	(2) $I_{i,t}/K_{i,t-1}$	(3) $z(I_{i,t}/K_{i,t-1})$	(4) $z(I_{i,t}/K_{i,t-1})$	(5) $z(I_{i,t}/K_{i,t-1})$	(6) $z(I_{i,t}/K_{i,t-1})$
Cte	-2.1022	-1.2236	-4.4620	-3.1902	-2.3985	-5.3482
	(0.0001)	(0.0126)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
$Lev_{i,t-1}$	-0.8203	-1.7184			-0.8641	
	(<0.0001)	(<0.0001)			(<0.0001)	
$(Lev_{i,t-1})^2$		1.3246			0.5726	
		(<0.0001)			(<0.0001)	
$k1_{1.5\sigma}(z-Lev_{i,t-1})$			-1.8990			-1.7895
			(<0.0001)			(<0.0001)
$k2_{1.5\sigma}(z-Lev_{i,t-1})$			-1.1061			-1.0122
			(<0.0001)			(<0.0001)
$k3_{1.5\sigma}(z-Lev_{i,t-1})$			-0.8562			-0.7351
			(<0.0001)			(<0.0001)
$k4_{1.5\sigma}(z-Lev_{i,t-1})$			-0.6403			-0.5204
			(<0.0001)			(<0.0001)
$k1_{1\sigma}(z-Lev_{i,t-1})$				-1.4860		
				(<0.0001)		
$k2_{1\sigma}(z-Lev_{i,t-1})$				-1.2161		
				(<0.0001)		
$k3_{1\sigma}(z-Lev_{i,t-1})$				-0.7941		
				(<0.0001)		
$k4_{1\sigma}(z-Lev_{i,t-1})$				-0.5975		
				(<0.0001)		
$CF_{i,t}/K_{i,t-1}$	0.3924	0.3435				
	(<0.0001)	(<0.0001)				
$z-(CF_{i,t}/K_{i,t-1})$			0.3488	0.3495		
			(<0.0001)	(<0.0001)		
$k1_{1.5\sigma}(z-(CF_{i,t}/K_{i,t-1}))$					-0.5802	-0.6451
					(<0.0001)	(<0.0001)
$k2_{1.5\sigma}(z-(CF_{i,t}/K_{i,t-1}))$					0.0229	-0.0414
					(0.4720)	(0.1493)
$k3_{1.5\sigma}(z-(CF_{i,t}/K_{i,t-1}))$					0.6010	0.7066
					(<0.0001)	(<0.0001)
$k4_{1.5\sigma}(z-(CF_{i,t}/K_{i,t-1}))$					0.3408	0.3556
					(<0.0001)	(<0.0001)
$Gr.Opp._{i,t}$	0.6690	0.7716	0.5565	0.5566	0.6217	0.6167
	(0.0032)	(0.0007)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
$Firm\ size_{i,t-1}$	-1.5742	-1.5037	-0.5978	-0.5979	-0.5864	-0.6199
	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
$Firm\ age_{i,t}$	-0.1138	-0.1107	-0.0611	-0.0613	-0.0657	-0.0603
	(<0.0001)	(<0.0001)	(0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
Adj. R²	34.67%	36.44%	33.49%	33.46%	37.00%	36.43%
F-statistic	3.7027	3.9196	3.5637	3.5601	3.9900	3.9168
Prob(F-statistic)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)

F-tests for linearity				
k1 = k2?	<0.0001	<0.0001		<0.0001
k2 = k3?	0.0114	0.0014		<0.0001
k3 = k4?	0.0345	0.0419		0.0023
k1 = k2 = k3 = k4?	<0.0001	<0.0001		<0.0001

Note: This table presents the 2SLS fixed effects regression results on the determinants of investment expenditures for an unbalanced panel of 64,246 private firm years between 1996 and 2005. All firms are single-sector private firms from the Flemish region in Belgium with at least one employee. Investment expenditures are measured as gross investment relative to lagged fixed assets. Leverage is measured as long-term bank debt relative to total assets, instrumented by asset tangibility. The quadratic term in leverage is instrumented by the quadratic term in asset tangibility. *p*-values are reported in parentheses. We use White-adjusted standard errors to correct for heteroskedasticity. The last rows report the *p*-values for *F*-tests on the coefficients of the leverage splines in columns 3, 4, and 6.

Table 3 The case of static credit constraints

	(1) $I_{i,t} / K_{i,t-1}$	(2) $I_{i,t} / K_{i,t-1}$	(3) $I_{i,t} / K_{i,t-1}$	(4) $I_{i,t} / K_{i,t-1}$	(5) $I_{i,t} / K_{i,t-1}$	(6) $I_{i,t} / K_{i,t-1}$
			Start-up (<= 5 y.)	Start-up (<= 5 y.)	Mature (> 10 y.)	Mature (> 10 y.)
Cte	-2.0699	-1.0355	-5.0867	-5.2496	-2.0323	-1.0800
	(0.0004)	(0.0623)	(<0.0001)	(<0.0001)	(0.0001)	(0.0406)
$Lev_{i,t-1}$	-0.8315	-1.7383	-1.2131	-1.1304	-0.8438	-1.9457
	(<0.0001)	(<0.0001)	(<0.0001)	(0.0001)	(<0.0001)	(<0.0001)
$(Lev_{i,t-1})^2$		1.2320		0.2263		1.5074
		(<0.0001)		(0.4709)		(<0.0001)
$Lev_{i,t-1}$ * *Firm age*$_{i,t}$	0.0093	-0.0076	0.0301	-0.2810	0.0029	0.0659
	(0.5199)	(0.8781)	(<0.0001)	(<0.0001)	(0.8492)	(0.2481)
$(Lev_{i,t-1})^2$ * *Firm age*$_{i,t}$		0.1209		0.4670		0.0034
		(0.0826)		(<0.0001)		(0.9644)
$CF_{i,t} / K_{i,t-1}$	0.3924	0.3574	0.4803	0.4036	0.3627	0.3173
	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
$Gr.Opp._{i,t}$	0.6700	0.7813	0.1734	0.0821	0.2873	0.3646
	(0.0033)	(0.0007)	(0.5550)	(0.6743)	(0.0363)	(0.0900)
Firm size$_{i,t-1}$	-1.5748	-1.5094	-2.7346		-1.6130	-1.5555
	(<0.0001)	(<0.0001)	(<0.0001)		(<0.0001)	(<0.0001)
Firm age$_{i,t}$	-0.1163	-0.1239	-0.3470	-0.0837	-0.1020	-0.1162
	(<0.0001)	(<0.0001)	(<0.0001)	(0.1099)	(<0.0001)	(<0.0001)
Adj. R²	34.67%	36.52%	43.13%	45.41%	34.93%	36.27%
F-statistic	3.7025	3.9287	3.0112	3.2072	3.6757	3.7082
Prob(F-statistic)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
# firms	12288	12288	6504	6504	9490	9490
# firm-years	64217	64217	16442	16442	47775	47775

Note: This table presents the 2SLS fixed effects regression results on the determinants of investment expenditures for an unbalanced panel of 64,246 private firm years between 1996 and 2005. All firms are single-sector private firms from the Flemish region in Belgium with at least one employee. Investment expenditures are measured as gross investment relative to lagged fixed assets. Leverage is measured as long-term bank debt relative to total assets, instrumented by asset tangibility. The quadratic term in leverage is instrumented by the quadratic term in asset tangibility, the interaction term between leverage and firm age is instrumented by the interaction term between asset tangibility and firm age, and the interaction term between the quadratic term in leverage and firm age is instrumented by the interaction term between the quadratic term in asset tangibility and firm age. *p*-values are reported in parentheses. We use White-adjusted standard errors to correct for heteroskedasticity.

Table 4 The case of underinvestment

	(1) $I_{i,t} / K_{i,t-1}$	(2) $I_{i,t} / K_{i,t-1}$	(3) $I_{i,t} / K_{i,t-1}$	(4) $I_{i,t} / K_{i,t-1}$	(5) $I_{i,t} / K_{i,t-1}$	(6) $I_{i,t} / K_{i,t-1}$	(7) $I_{i,t} / K_{i,t-1}$	(8) $I_{i,t} / K_{i,t-1}$
Cte	-2.2727	-1.0669	0.5813	1.5019	-2.2195	-1.4663	-2.0874	-1.7553
	(<0.0001)	(<0.0001)	(0.0001)	(<0.0001)	(0.0002)	(<0.0001)	(<0.0001)	(0.0361)
$Lev_{i,t-1}$	-0.8463	-1.9835	-0.9682	-2.2227	-0.8490	-1.9325	-0.9069	-2.0031
	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
$(Lev_{i,t-1})^2$		1.7602		1.9140		1.7183		1.9304
		(<0.0001)		(<0.0001)		(<0.0001)		(<0.0001)
$Lev_{i,t-1} * Gr.Opp_{i,t}$	-0.3360	0.2041	-0.1305	0.2025	-0.0779	0.2665	-0.1519	0.0788
	(0.1810)	(0.3201)	(0.2031)	(0.3104)	(0.1935)	(0.2597)	(0.1659)	(0.1840)
$(Lev_{i,t-1})^2 * Gr.Opp_{i,t}$		-0.4571		-0.3736		-0.3332		-0.3214
		(0.0311)		(0.0671)		(0.0418)		(0.1174)
$CF_{i,t} / K_{i,t-1}$	0.4094	0.3502	0.3937	0.3539	0.4083	0.3630	0.3647	0.3238
	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
$Gr.Opp._{i,t}$	0.5617	0.5791	0.1178	0.1004	0.1473	0.1288	0.0491	0.0307
	(0.0003)	(0.0007)	(0.0409)	(0.0801)	(0.0002)	(0.0005)	(0.2049)	(0.2413)
$Firm\ size_{i,t-1}$	-1.4851	-1.4960	-1.5638	-1.5667	-1.4640	-1.4287	-1.6604	-1.6815
	(<0.0001)	(0.0071)	(0.0007)	(<0.0001)	(<0.0001)	(0.0061)	(<0.0001)	(<0.0001)
$Firm\ age_{i,t}$	-0.1020	-0.1007	-0.1046	-0.1022	-0.1113	-0.1087	-0.1186	-0.1189
	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(0.0015)
Adj. R²	34.71%	36.64%	34.73%	36.77%	34.78%	36.87%	34.81%	36.79%

Note: This table presents the 2SLS fixed effects regression results on the determinants of investment expenditures for an unbalanced panel of 64,246 private firm years between 1996 and 2005. All firms are single-sector private firms from the Flemish region in Belgium with at least one employee. Investment expenditures are measured as gross investment relative to lagged fixed assets. Leverage is measured as long-term bank debt relative to total assets, instrumented by asset tangibility. The quadratic term in leverage is instrumented by the quadratic term in asset tangibility, the interaction term between leverage and growth opportunities is instrumented by the interaction term between asset tangibility and growth opportunities, and the interaction term between the quadratic term in leverage and growth opportunities is instrumented by the interaction term between the quadratic term in asset tangibility and growth opportunities. Growth opportunities are measured by the historical (three-year moving average) growth rate in gross margin in the corresponding industry in columns 1 and 2, by the historical growth rate in total assets in the corresponding industry in columns 3 and 4, by the historical growth rate in the firm's gross margin in columns 5 and 6 and by the historical growth rate in the firm's total assets in columns 7 and 8. *p*-values are reported in parentheses. We use White-adjusted standard errors to correct for heteroskedasticity.