Three Essays on Empirical Financial Economics

by

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Abstract

This thesis includes three essays on empirical financial economics. The essays discuss factors determining the firm-level cost of borrowing and their impact on aggregate firm investment. The first essay (Chapter 2) shows how capital structure, in particular, asset durability affects the cost of external financing and firm investment in the presence of financial frictions. The second essay (Chapter 3) highlights the importance of macroeconomic factors in determining the cost of borrowing as measured by credit spreads. The third essay (Chapter 4) discusses how asset durability affects the transmission of monetary policy.

In the second chapter, I use the depreciation rate to measure asset durability and find financing frictions can affect firm investment through the asset durability channel. Specifically, asset durability increases external financing costs for financially constrained firms, but the effect is ambiguous for unconstrained firms. Additionally, I find when firms endogenously choose asset durability, more(less) financially constrained firms invest in less (more) durable capital. These results provide mixed support to the idea that the durability of an asset impedes financing.

The third chapter focuses on the importance of macroeconomic factors relative to financial factors in determining credit spreads in the Canadian corporate bond market. I find that although the macroeconomic determinants both in their levels and volatilities have significant effects on credit spreads, their contribution in explaining the variations in spreads is relatively small. Much of the variation in spreads attributes to the unobserved bond-specific heterogeneity.

The fourth chapter builds on the findings from the second chapter to show the heterogeneous response of firms with different asset durability to monetary policy. I find that firms with more durable assets are more responsive to monetary policy than firms with less durable assets. For financially constrained firms, this difference is more prominent. Additionally, less durable assets using firms drive the decline in aggregate sales, while the more durable assets using firms dominate the decline in aggregate inventories. Overall, the findings highlight the role of asset durability in the transmission of monetary policy.

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Chapter 1

Introduction

The 2007-2009 financial crisis led to a massive resurgence in studying the effects of financial frictions on the real economy. In an imperfect market, firms' access to finance depends on their own financial positions and on various external factors like macroeconomic conditions of the economy, investors' perceptions of risk, government policies, etc. In my dissertation, I use empirical models to discuss the determinants affecting borrowing costs at the firm level and explain the consequences of firm-level borrowing constraints on the aggregate economy. The empirical exercises generate findings relevant to investment decisions by both small firms and large corporations. Through this dissertation, my contributions to the literature are as follow: First, I provide empirical evidence that asset durability can influence firms' investment decisions by restricting their access to external financing (Chapter 2). Next, I show that the relative influence of macroeconomic and financial factors on corporate bond credit spreads (a measure of the cost of borrowing) depends on the risk profiles of the issuing firms. While firms with high credit ratings respond more to changes in macroeconomic factors relative to low credit rating firms, idiosyncratic factors influence the riskier firms more relative to low risk firms (Chapter 3). Finally, by applying the intuition from Chapter 2, I show that more durable assets using firms respond more strongly to monetary policy than firms that invest in relatively less durable assets (Chapter 4).

When making new investment decisions, firms use both internal and external sources to finance their investments. The ease of getting external financing depends on the relative cost between the two sources of financing. The larger the cost difference, the more financial constraints a firm face to finance their investments. To obtain the external finances, firms typically place as collateral their existing tangible assets or the assets they want to purchase using debt financing. The amount of loan that the firms can get also depends on the quality of the collateral assets. An asset with a higher resale value can fetch more financing for the borrower. Therefore, the choice of collateral can influence firm investment by impacting firms' borrowing capacity and thereby the financial constraints firms face. If the collateral assets are durable, then it allows the firms to use these assets over multiple periods. But the tangible physical capitals also depreciate over time which reduces the value of those assets and increases their maintenance costs. As a result, firms often replace old assets of less durability with new ones of high durability. So how do firms decide on their choice of more and less durable investment when using debt to finance investments? Does the presence of financial constraints have any role to play in the firm's choice decision? In the first chapter of this dissertation, I seek to answer these questions from an empirical perspective. Financial constraints can influence firms' choice of new and used capital (Eisfeldt and Rampini (2007)). Again, financial constraints can also impact firms' decision between leasing an asset and using debt financing (Eisfeldt and Rampini (2009); Lin et al. (2013)). Although the literature discusses the effects of financial constraints on the composition of firm investment and financing decisions, these studies do not explore the role of physical capital depreciation on constrained firms' choice decisions. Additionally, some theoretical studies establish connections between collateral asset's durability and firms' access to financing. Due to higher liquidation value, more durable assets serve as better collateral and facilitate financing (Hart and Moore (1994)). Again, more durable assets (with low depreciation rates) are more expensive and require a higher down-payment, which increases the overall financing need by firms (Rampini (2019)). But the literature does not have any empirical evidence to quantify the effects of asset durability on firm financing. In addition, the lack of detailed data on the composition of physical capital at the firm-level prevents the calculation of the economic depreciation of physical capital for each firm. In Chapter 2, I apply the methodology proposed by Chen (2014) to construct a proxy of implied asset depreciation rate at the firm level. Using this firm-level proxy of durability obtained from data extracted from Compustat on a panel of U.S. manufacturing firms, I find financing frictions affect firm investment through the asset durability channel. I use the popular investment model proposed by Fazzari et al. (1988) to find that an increase in asset durability makes constrained firms' investment more reliant on internal cash flow. For unconstrained firms, the effect of durability is ambiguous. Specifically, asset durability increases external financing costs for financially constrained firms, but not always for unconstrained firms. Additionally, I use traditional indices of financial constraints (the Kaplan and Zingales (KZ) index, the Whited and Wu (WW) index, and the Hadlock and Pierce (HP) index) to show their impact on firms endogenous choice of asset durability. I find that the average durability of assets decreases as firms become more financially constrained. The latter findings imply that more (less) financially constrained firms invest in less (more) durable capital. Chapter 2 contributes to the literature by providing empirical evidence of the link between asset durability and investment when firms face financial constraints.

In Chapter 3, I discuss the importance of macroeconomic factors relative to financial factors in determining the credit spreads in the Canadian bond market. While small firms significantly use collateral financing, large firms finance their investments primarily by issuing bonds. A corporate bond's credit spread reflects the compensation an investor demands to invest in a risky bond. An increase in credit spreads limits a borrower's ability to obtain further funding. Credit spreads are forward-looking and contain important information on borrower's perception of future risk. Using data on the U.S. bond market Gilchrist and Zakrajšek (2012) show credit spreads as a leading indicator in predicting future changes in real activity. Leboeuf and Hyun (2018) find corporate credit spreads to be an important signal for future economic activity for Canada. The above articles underscore the significance of credit spreads and motivate to study their determinants, which can aid policymakers in designing more targeted economic and financial policies. Although a host of previous studies analyze the determinants of corporate credit spreads in the context of other bond markets (e.g., U.S., EU, and the emerging economies), not much work identifies the determinants of the credit spreads for the Canadian bond market. Canadian corporate bond market has been growing steadily over the past decade. In the past decade, total outstanding Canadian dollar-denominated corporate bonds have increased by almost 70%. In the final quarter of 2019, bonds and debentures accounted for about 61.7% of the total borrowing by the financial sector and 22.3% (approximately 0.3 trillion CAD) for non-financial firms in Canada. This growth in the domestic bond market influences portfolios' composition and risk exposures held by financial institutions, firms, and private investors. It thus calls for a better understanding of the nature of bond spreads and the factors that affect them. In Chapter 3 of this dissertation, I use data on credit spreads for Canadian corporate bonds to analyze the relative importance of macroeconomic factors in determining borrowing costs relative to financial factors. I find that the macroeconomic determinants both in their levels and volatilities have significant effects on credit spreads. A variance decomposition analysis further shows that the contribution of macroeconomic variables in explaining the variations in spreads is quite small (less than 10%). Much of the variation in credit spreads attributes to the unobserved bond-specific heterogeneity. Additionally, I find that the major contributing factor in explaining the variation of spreads depends on the riskiness of the bonds. While macroeconomic factors contribute more to the variation of spreads for higher-rated bonds, the unobserved bond-specific characteristics become the most prominent contributor in the variation of spreads of the riskier bonds. To analyze the effects of various types of macroeconomic uncertainties on credit spreads, I use conditional volatilities of the GDP growth rate, stock returns, and exchange rates as proxies for overall macroeconomic uncertainty, the stock market uncertainty, and external uncertainty, respectively. In addition, I use the economic policy uncertainty (EPU) index to assess the impact of policy uncertainty on the spreads. I find that the aggregate spreads are most sensitive to stock market uncertainty. A rating-wise analysis reveals that the spreads of relatively risky bonds are more sensitive to stock market volatility. In contrast, the less risky bonds are more sensitive to aggregate/policy uncertainty. The findings from Chapter 3 contribute to the literature by providing a detailed empirical analysis of the determinants that affect Canadian corporate bond spreads. The econometric models applied in this chapter carefully controls for various bond-level and firm-level characteristics to identify and quantify the relative contributions of different types of determinants.

Chapter 4 of this dissertation explores the possibility of an asset durability channel in the transmission of monetary policy. Previous literature finds the differential impact of monetary policy on firm fundamentals between financially constrained and unconstrained firms where the ex-ante heterogeneity stems from the firm size or firm age (Gertler and Gilchrist (1994); Cloyne et al. (2018)). In Chapter 2 of my thesis, I find that the durability of new collateral assets increases the financial constraints for already constrained firms. Thus, in the event of a monetary contraction, the contractionary effects of monetary policy can magnify for those financially constrained firms that place more durable assets as collateral compared to their less durable assets using counterparts. The literature on monetary policy transmission does not look at the possibility of an asset durability channel in the propagation of shocks on firm aggregates. In Chapter 4, I use data on U.S. non-financial corporations obtained from Compustat to construct the same firm-level measure of depreciation rate that

I use in Chapter 2 to separate firms according to their asset durability. I find that the cyclicality of firm-level variables is different for high and low durable assets using firms. Using a Vector Autoregression framework, I find that monetary contractions have a stronger impact on the aggregate growth rates of sales, inventories, and short-term debt of the firms using more durable assets relative to less durable assets using firms. The findings from this essay support the conclusions of the first essay that more durable capital can strengthen the effects of financial constraints on firms.

Chapter 2

Asset Durability, Firm Financing, and Investment: An Empirical Approach

2.1 Introduction

Does the choice of the durability of an asset (serving as collateral) affect firms' ability to obtain external financing? In this chapter, I conduct an empirical analysis to answer this question using data on U.S manufacturing corporations. Durability is a central feature of tangible physical assets.[1] More durability allows a firm to use a durable asset for multiple periods. However, physical capital also depreciates over time. The depreciation rate of physical assets varies from as low as 1% for residential structures to as high as 40% for some computing equipment.[2] Due to the depreciation of capital, firms often replace less durable assets with more durable ones. An inter-

[1]Durability measures an asset's shelf life. Durable assets are typically referred to as those tangible assets that have a relatively long shelf life and can be put to productive use for multiple periods. They include residential and non-residential structures and production equipment.

[2]BEA's fixed assets accounts. Weblink https://apps.bea.gov/iTable/index_FA.cfm

esting question to explore in this context is how firms decide on their choice of more durable and less durable assets? Moreover, as firms generally purchase these durable assets through collateral financing, do financial constraints drive this decision?

The role of asset durability in determining a firm's financing capacity is a relatively less explored area in the literature. Durability has a dual effect on a firm's ability to obtain external financing. More durable assets are more expensive, due to which they have a higher liquidation value. The higher liquidation value of durable assets increases their collateral value, facilitating financing (Hart and Moore 1994). On the other hand, liquidity constrained firms may find it difficult to finance durable assets because the relatively costly durable assets also increase a firm's overall financing need (Rampini 2019). Thus, a firm's investment decision on durable assets using external financing relies on the relative size of the two opposing effects and the firm's financial position. In this chapter, I explore this relationship between a firm's access to external financing and the durability of its investments in two steps. In the first specification, I look at how the durability of a firm's new investment affects the firm's access to external financing when the underlying asset is placed as collateral to obtain financing. The findings suggest that a firm's access to external financing depends on the durability of its new investments and the effect of durability is heterogeneous across financially constrained and unconstrained firms. In the second specification, I look at how a firm's investment in durable assets is affected by its financial health. The results suggest that the choice depends on how financially constrained a firm is. To the best of my knowledge, this essay is the first attempt to empirically identify a connection between asset durability, firm financing, and investment.

The specifications included in the empirical exercise vary in the choice of proxies for financial constraints. In the first specification, I use investment-cash flow sensitivity as a proxy of financial constraints to test how asset durability affects firm investment. Financially constrained firms display excess investment-cash flow sensitivity due to a cost differential between internal and external financing, and this sensitivity increases in the degree of the financial constraints (Fazzari et al. 1988). Thus, by comparing the relationship between durability and investment-cash flow sensitivity across a constrained and unconstrained group of firms, I can infer the differential impact of durability on external financing costs across the two types of firms. Towards this end, I modify the classic investment model by Fazzari et al. (1988) to include a measure of durability as an interaction term. The coefficient of the interaction term captures the effect of asset durability on investment-cash flow sensitivity. For this specification, I divide the sample into sub-samples of constrained, and unconstrained firms following standard ex-ante sample selection criteria (i.e. firm size, dividend payout, short- and long-term debt issuance) suggested in the literature. In the second specification, I use popular financial constraints indices (Kaplan and Zingales (KZ) index, Whited and Wu (WW) index, and Hadlock and Pierce (HP) index) and test how financial constraints affect firms' choice of durable assets. The higher the value of the index of a firm's financial constraints, the costlier it is for the firm to gain external finance. In this specification, asset durability enters as a choice variable that is determined by a firm's financial constraints.

I conduct my empirical analysis using a sample of publicly traded U.S manufacturing firms drawn from COMPUSTAT between 1983 to 2017. I construct a proxy of firm-level durability from the implied depreciation rates of their physical assets. To calculate the implied depreciation rates of physical assets, I follow the methodology proposed in Chen (2014). I estimate the baseline regressions using a standard OLS approach controlling the firm- and year-fixed effects.

The results for the first specification show that asset durability positively affects investment-cash flow sensitivity in constrained firms. For some unconstrained firms, however, durability has no significant effect on the investment-cash flow sensitivity. Excess investment-cash flow sensitivity implies that financially constrained firms become more reliant on internally generated cash flow and face a higher external financing cost if they invest in more durable assets. The results for the second specification show that average durability decreases when a firm becomes more financially constrained, as measured with the KZ index. With the other two indices, namely, the WW and the HP index of financial constraints, the OLS estimates do not remain robust after controlling for endogeneity. Despite contrasting results, the findings using the KZ index are reliable in this analysis. The construction of the KZ index includes cash holdings by a firm with a negative loading, while the other two indices (the WW index and the HP index) do not. As durability also increases the down payment of an asset (Rampini 2019), thus, in the presence of collateral constraints, firms must be able to afford the higher down payment given their financial health, which is appropriately captured by the KZ index.

The findings from the OLS estimation of the baseline regression are sensitive to outliers present in the data. When I use winsorized data to treat for outliers, the difference in the effect of durability on investment-cash flow sensitivity disappears across constrained and unconstrained firms. In contrast, the conclusions of the second specification are relatively robust to outlier treatment for all three financial constraint indices. The overall findings are interesting as they bring out the importance of asset durability in firm-level investment decisions. They also generate mixed support towards the theoretical link between durability and firm financing established in Rampini (2019).[3] The conclusions of this chapter highlight that durable assets may not necessarily alleviate financial constraints for extremely constrained firms despite supporting higher collateral value. As financially constrained firms are heavily reliant on debt financing, the increase in borrowing costs due to investment in durable assets can amplify the effects of adverse financial shocks for these firms. Thus, it may be optimal for firms with low net worth to invest in less durable assets during an economic downturn to relieve their financial constraints.

The article is organized as follows: Section 2.2 gives an overview of the literature on asset durability and investment under financial frictions. Section 2.3 outlines the empirical methodology and summarizes the regression results, and Section 2.4 concludes.

[3] Rampini (2019) argues that the durability of an asset affects both the collateral value and the price of an asset. When durability increases (depreciation falls), it becomes harder for a firm to finance due to a higher down payment of the underlying asset. Owing to this high upfront cost of durable assets, financially constrained firms optimally choose to purchase used and less durable (with high depreciation) assets. In contrast, the unconstrained firms buy only new and durable assets (with low depreciation). Rampini (2019) concludes that the net effect of durability is to impede financing. Section A.1 of Appendix A contains a brief illustration of the model.

2.2 Review of literature

The bulk of literature concerning durability identifies market power as the reason behind firms' decision to produce (Bulow (1982), Bulow (1986)), rent or lease durable goods (Coase (1972), Bulow (1982) and Stokey (1981)). There is, however, very little discussion on what determines firms' investment in durable assets. Previous studies use asset depreciation rates predominantly for analyzing the growth of capital stock, measurement of productivity, and investment behavior (Levy (1995), and Coen (1975)). These studies have used various measures of depreciation rate for their analyses.[4] Schündeln (2012) uses survey data on manufacturing firms in Indonesia to estimate the depreciation rate of physical assets and finds that constrained firms use investment goods with high depreciation. But this paper does not explore what drives this investment decision by financially constrained firms.

Financial constraints can also influence firms' choice of new and used capital (Eisfeldt and Rampini (2007)). Financially constrained firms invest in used capital due to the cheaper upfront cost of used capital. Again, financial constraints can also impact firms' decision between leasing an asset and using debt financing (Eisfeldt and Rampini (2009); Lin et al. (2013)). However, these studies do not explore the role of physical capital depreciation on constrained firms' choice decision.

Rampini (2019) adopts a new theoretical approach by distinguishing between the durability and pledgeability of an asset to address the effect of durability on firm financing in a competitive environment under financing frictions. By defining dura-

[4] Fraumeni (1997) provides a review of the literature on the estimation of depreciation rates.

bility with the depreciation rate of an asset, Rampini (2019) shows that durable assets require a higher down payment, which makes it difficult for financially constrained firms to finance those assets as they require more financing.

The effect of financing frictions on firm investment has been extensively investigated in the corporate finance literature. A large body of literature explores the effectiveness of investment cash-flow sensitivity as an indicator of a firm's financial constraints. Fazzari et al. (1988) argue that when external financing is more costly than internal financing, investment becomes more sensitive to changes in cash flow. They report evidence that firms that pay low dividends display excess investment-cash flow sensitivity to support their hypothesis. Kaplan and Zingales (1997), however, challenge this finding. They argue that the relationship between investment-cash flow sensitivity and financial constraints depends on how firms are grouped into constrained and unconstrained types. Using multiple classification methods, they show that positive investment-cash flow sensitivity can also exist for firms that are classified as financially unconstrained. A similar argument is echoed by Erickson and Whited (2000) and Alti (2003) who identify Tobin's Q as a noisy proxy of investment opportunity. They argue that if cash flow contains information about the investment opportunity, then investment by unconstrained firms can also display higher cash flow sensitivity. Tsoukalas (2011) shows that investment-cash flow sensitivity can be significant even in the absence of financial frictions when time-to-build and time-to-plan features for installation of capital is taken into consideration. Hovakimian (2009) employs a different approach to identify the relationship between investment-cash flow sensitivity and financial constraints. The author calculates investment-cash flow sensitivities at the firm level and classifies firms with high, low, and negative cash flow sensitivity. Consistent with Fazzari et al. (1988), firms that are financially constrained appear to show significant cash flow sensitivity while unconstrained firms' investments do not exhibit sensitivity to internal funds. The paper also finds that among the constrained firms, those that are extremely constrained display negative investment-cash flow sensitivity. Constrained firms may also exhibit excess investment-cash flow sensitivity due to variables that facilitate financing (Almeida and Campello (2007)). Almeida and Campello (2007) use firm-level data to show that for constrained firms, investment-cash flow sensitivity increases with tangibility. For unconstrained firms, however, they find no significant relationship between tangibility and investment-cash flow sensitivity.

Empirical estimation of financial constraints can be pretty challenging as financial constraints are unobservable. Financial constraints are measured using various proxies in the literature. There is little consensus on which proxy provides the most accurate measure of financial constraints.

One strand of literature uses proxies for financial constraints based on one single variable that includes payout ratio, firm size, and the presence of credit rating (e.g., Almeida and Campello (2007), Gilchrist and Himmelberg (1995)). Firms that are smaller, have no credit rating, or belong to the lower end of the payout distribution are classified as constrained. The opposite rules apply to unconstrained firms.

Another strand of literature uses indices based on firm-level characteristics as proxies for financial constraints (e.g., Almeida et al. (2004), Baxamusa et al. (2016), Hadlock and Pierce (2010)). One popular measure of financial constraints is the

Kaplan and Zingales (KZ) index. This measure stems from the above-discussed argument by Kaplan and Zingales (1997) proposed to challenge Fazzari et al. (1988) findings. But Lamont et al. (2001) constructs the actual KZ index. The authors follow the classification by Kaplan and Zingales (1997) and estimate an ordered logit model that relates financial constraints to five accounting variables: cash flow, market value, debt, dividends, and cash holdings, each scaled by total assets. The index was created using the sample of 49 firms originally used by Fazzari et al. (1988). But the general convention in the literature is to use the Lamont et al. (2001) coefficients. Hadlock and Pierce (2010) update Kaplan and Zingales (1997) measure of financial constraints by including the annual reports of 356 randomly selected firms that identify themselves as financially constrained between 1995 and 2004 to the initial sample. Their index of financial constraints is based on firm size, size squared, and firm age. Users of this index construct the index using the original coefficients by Hadlock and Pierce (2010) to their own sample. Whited and Wu (2006) follow a structural model based approach to construct an index of financial constraints. It represents the shadow price of raising equity capital or the Lagrange multiplier on the external finance constraints. Instead of re-estimating the structural model for their own sample, the users of this index use the original coefficients to construct the index. One major drawback of all these index-based approaches is that they all are sample-based indices. Out-of-sample extrapolation may not always generate an accurate measure of financial constraints. In this chapter, I adopt both univariate and index-based proxies of financial constraints.

Although previous studies separately discuss firms' choice of optimal durability and the effect of financial constraints on the composition of firm investment at length, prior work has not empirically examined how asset durability interacts with financial constraints and affects investment. This chapter contributes to the literature by exploring the connection between firm-level asset durability (measured using the depreciation rates of physical assets of a firm) and firm financing in the presence of financial constraints.

2.3 Empirical analysis

The empirical approach adopted in this chapter discusses whether the durability of new investment affects the cost of external financing and whether a firm's financial constraints drive the choice of durability. There is no consensus in the literature on any single correct way of measuring financial constraints. One strand of research uses proxies for financial constraints based on a single variable that includes payout ratio, firm size, and the presence of credit rating. Another strand of literature uses proxies for financial constraints based on indices generated from firm-specific financial status. In my empirical analysis, I use both types of proxies to measure financial constraints. I adopt two separate specifications based on the financial constraints literature. This section provides a detailed empirical approach by describing data used for estimation, empirical specifications, and the results.

2.3.1 Data

My sample selection closely follows the literature (Almeida et al. (2004) and Almeida and Campello (2007)). I consider the sample of manufacturing firms (SIC 2000-3999) over $1983-2017$. The sample consists of firm-level annual data on total asset, market capitalization, capital stock, cash flow, and capital expenditures from COMPUSTAT. There are a number of standard steps in bringing this data to the proposed analysis. First, I eliminate firm-year observations for which total assets (item AT), physical capital (item PPEGT), and sales (item SALE) are either zero or negative. Next, following literature (Almeida and Campello (2007), Gilchrist and Himmelberg (1995)) I eliminate firm-year observations for which capital stock (item PPENT) is less than \$5 million. This strategy eliminates firms that are too small for a linear investment model to be applicable. I also eliminate firm-year observations for which real asset or sales growth exceeds 100% as these large increases are likely due to mergers and acquisitions. Then, I eliminate firm-year observations for which the average yearly depreciation rate is negative, zero, or greater than 1 ($0 < \delta_i < 1$) (see below for the computation of depreciation rate). Finally, I eliminate firm-year observations with negative Q or Q greater than 10 to reduce the impact of mismeasurement of Q on the fitness of the investment model.[5] I deflate all series to 2010 dollars using CPI data retrieved from the Bureau of Labor Statistics.

Following Almeida and Campello (2007), I keep those firms that appear for at least three consecutive years in the data. The model's specification requires three years as the minimum number of years required for firms to enter the estimation process, given the lag structure of the regression model. Loss of observations from

[5]These same cut-off points for Q have been used by Almeida and Campello (2007) and Gilchrist and Himmelberg (1995). The average value of Q in the sample used for this study is slightly higher than one which is very close to the average Q reported by the studies that do not use these cut-offs (Kaplan and Zingales (1997) report average Q of 1.2 and Polk and Sapienza (2004) report average Q of 1.6).

each elimination criterion is given in Table A.1. The final sample consists of 2,795 firms and 37,944 firm-year observations.

For industry-level analysis, I use the capital stock of private non-residential fixed assets data and implied depreciation rate data from the Bureau of Economic Analysis for the same sample period.

2.3.2 The Measure of durability

Following Rampini (2019), I link the durability of an asset with its depreciation rate. For any firm i, durability $D_{i,t}$ is defined as $1 - \delta_{i,t}$ where, $\delta_{i,t}$ is the depreciation rate of assets used by firm i at time t. The higher the depreciation, the less durable the asset is and vice versa. It is natural to use the economic depreciation rate for the analysis, but data on the composition of physical capital is unavailable at the firm level. Given this data constraint, I use industry-level data on the implied depreciation rate of physical capital retrieved from BEA to examine the relationship between the durability of physical capital with the share of structures, equipment, and intellectual property for the manufacturing industry. Figure A.1 shows that the share of structure in physical capital ranges from as low as 26% (chemical products) to as high as 60% (apparel products). Looking at Figure A.2 it appears that the sector that has the highest durability of physical assets may not have the highest share of structures in physical capital. However, the pairwise correlation coefficient between the share of structures and durability is positive (0.65) and significant at the 5% level. This implies that industries that use more structures show up having higher durability of capital.

I conduct a firm level analysis using a proxy for economic depreciation rate. Following Chen (2014), I calculate the implied depreciation rate for each firm using the following expression:

$$\delta_{i,t} = \left[\frac{i_{i,t-1}}{k_{i,t-1}} + \frac{k_{i,t-1}}{k_{i,t}} - 1\right] \tag{2.3.1}$$

where $k_{i,t}$ is the book value of physical assets (item #7 PPEGT) and $i_{i,t}$ is calculated as capital expenditures (item #128 CAPX) minus sale of property, plant, and equipment (item #107 SPPE). To check the consistency of these depreciation rates, I group the sample of firms with depreciation rate $0 \leq \delta_i \leq 1$ into 17 industries using classification scheme of Fama and French (1997) and calculate the mean of δ_i for each industry (see Table A.2). The depreciation rate ranges from 6.4% for the steel industry to 10% for the construction industry. I also calculate the implied depreciation rates at the 3-digit level for the manufacturing industry by grouping firms according to the North American Industry Classification System (NAICS). Figure A.3 provides a comparison of the estimates from the sample and the BEA estimates for the same time period. For some sub-sectors, the estimates are very similar (e.g., food, fabricated metals, and primary metals), but the estimates differ substantially for others like textile, automobile, and computers. For the rest of the sub-sectors, the estimates are relatively similar. One probable reason the rates calculated from the sample do not exactly match the rates obtained from BEA is that the sample in this analysis consists only of listed firms and no private firms. However, the BEA rates use data on both private and listed firms.

A potential weakness of this approach is that equation 2.3.1 provides a measure for depreciation of assets already in place. But, the empirical models used in this chapter relate to the depreciation of assets to new investments. The lack of data availability prevents gathering more information on types of assets firms purchase with marginal dollar investment. However, if firms continue to buy new assets similar to the kind of assets already in place, then the depreciation rates of new and existing assets are similar. In this case, depreciation rates of existing assets will remain a good proxy for the depreciation rates of new investments.

2.3.3 Durability of new investment and external financing cost

When firms invest in new assets using external financing, they can obtain those finances in two ways, by placing their existing assets as collateral to obtain financing in order to buy new assets or by placing the assets being purchased as collateral to obtain financing. If firms obtain financing using the earlier approach, then the amount of external finance and the investment decisions would entirely be determined by the pledgeability (resale value of the assets) of the firms' existing assets i.e., the firms endogenously determine the durability of new assets. On the contrary, if firms adopt the latter approach, the investment decision would be determined not only by the pledgeability of the assets but also their durability, which in this case is exogenous. The first specification of my empirical analysis is built upon the assumption that asset durability is exogenously determined. Durability is an important determinant of investment in the latter financing approach because the firms need to pay down payments for these assets, which are paid from firms' internally generated funds. As more durable assets are also more expensive, the amount of internal funds firms use to invest in durable assets will depend on the durability of the new assets.

In the first specification, I look into how investment in durable assets affects the financial constraints firms face. Towards this end, I augment the investment model in Fazzari et al. (1988) to include asset durability (D) and also an interaction term between cash flow and durability ($CF \times D$).[6] The interaction term captures the effect of durability on cash flow sensitivity of investment. The empirical model is written as:

$$I_{i,t} = \alpha_1 Q_{i,t-1} + \alpha_2 CF_{i,t} + \alpha_3 D_{i,t} + \alpha_4 (CF \times D)_{i,t} + \sum_i firm_i + \sum_t year_t + \epsilon_{i,t} \quad (2.3.2)$$

where, $D_{i,t}$ is the durability of assets, $CF_{i,t}$ is the cash flow of firm i at time t. $Q_{i,t}$ is the Tobin's Q for firm i at time t. Q is the ratio of the market value of total assets of a firm over the replacement value of its assets and enters the model as a proxy for investment opportunity. Finally, firm and year capture firm- and year- specific fixed effects.[7] The model is set in contemporaneous time to adequately capture that investment in durable assets and the external financing generated by those assets are being simultaneously determined.

The coefficient of the interaction term (α_4) captures the effect of durability on firms' financing capacity. Suppose durability increases (decreases) the cost of external financing for a firm. In that case, the extent to which a firm's investment is sensitive

[6] The empirical modification of the investment equation closely resembles Almeida and Campello (2007) where the authors included tangibility as an interaction term.

[7] Definitions of the variables are provided in appendix A.

to internal funds should be an increasing (decreasing) function of durability (i.e., α_4 must be positive (negative)). However, the interaction term alone is not informative about durability's net effect on firm investment. Since the empirical investment model contains an interaction term, the partial effect of cash flow on investment is given by $\alpha_2 + \alpha_4 \times D$. In the event of a positive or negative cash flow shock, the partial effect of cash flow essentially captures the heterogeneity in the increase/decrease of the investment expenditures for assets with different durability.

Constraint selection

For this analysis I use proxies for financial constraints based on a single variable. I use several ex-ante constraint selection schemes to distinguish financially constrained and unconstrained firms. I follow the standard approach in the literature (Fazzari et al. (1988), Almeida et al. (2004), Almeida and Campello (2007), Denis and Sibilkov (2009)) to classify firms into financially constrained and unconstrained groups. After separating the sample into subsamples of constrained and unconstrained firms, I estimate equation (2.3.2) for each regime under each criterion. I apply the following schemes to sort the sample:

1. *Annual payout ratio*: In every year over the 1983-2017 period, I rank firms based on their payout ratio. Financially constrained (unconstrained) firms are those that belong in the bottom (top) three deciles of annual payout distribution. The intuition behind this scheme is that financially constrained firms typically have lower payouts (Fazzari et al. (1988)). The payout ratio is computed as the ratio of dividends and common stock repurchases to operating income.[8]

2. *Firm size*: In every year over the 1983-2017 period I rank firms based on their total assets. Financially constrained (unconstrained) firms are those that belong in the bottom (top) three deciles of asset distribution. This scheme is based on the idea that, smaller firms are relatively young and more vulnerable to credit market frictions. This approach resembles the work of Gilchrist and Himmelberg (1995), Erickson and Whited (2000), Almeida et al. (2004) among others.

3. *Debt Rating*: Following Whited (1992), Gilchrist and Himmelberg (1995)), and Almeida et al. (2004) I retrieve data on firms' bond ratings.[9] Firms that have had their long-term debt rated by Standard & Poor's, and their debt is not at default (rating of "D" or "SD") are categorized as unconstrained. Firms that never had their public debt rated are categorized to be constrained. Firms with no debt outstanding and no debt rating are classified as unconstrained.

4. *Commercial Paper Rating*: I construct a similar criterion like debt rating by retrieving data on S&P short-term debt rating. Firms are classified as constrained if they never had their issues rated and report positive debt. Firms that had their issues rated at any point of time during the sample period are classified as unconstrained. Calomiris and Hubbard (1995) follow this approach of classifying firms into constrained and unconstrained groups.

[8]The deciles set using payout distribution generate a different number of observations assigned to each decile. This approach ensures that firms with lower payout ratios are assigned constrained group while firms with the same payout ratios are assigned to the same group. The minimum payout ratio for unconstrained firms is 0.35 which is greater than the maximum payout ratio for constrained firms (0.14).

[9]S&P Long-term debt ratings are available on COMPUSTAT.

Durability and cash flow sensitivity of investment

I first report the summary statistics for durability and other key variables in Table 2.1 and 2.2. I follow standard financial constraints literature for sample selection and variable construction. As durability is the central variable of interest in this study, the descriptive statistics as well as discussion on key findings revolve around that variable. Mean durability for all the firms in the sample is about 91.6% which implies that on average the physical capital of a firm depreciates at 8.4% per year. The variation in the durability of assets ranges from 0.90 for the first quartile of firms to 0.963 for the third quartile. Low standard deviation of durability in the sample implies that the variation in the durability of assets in my sample is not very high.

Table 2.1: Summary statistics for durability

	Mean	Median	Std. Dev	Pct. 5	Pct. 25	Pct. 75	Pct. 95	N
Full Sample	0.916	0.941	0.090	0.77	0.90	0.963	0.987	37,944

This table gives summary statistics for durability. Durability is measured as $1 - \delta_i$ where δ_i is the depreciation rate of physical assets used by firm i. The sample includes manufacturing firms only (SICs 2000-3999) and the sample period is 1983-2017.

Table 2.2 reports the sample characteristics of firms with highly durable assets and less durable assets. High durability firms (with mean durability 0.933) are those firms in the top three deciles of durability distribution, and low durability firms (with mean durability 0.889) are those firms in the bottom three deciles of durability distribution. Firms using highly durable assets have a higher investment/capital ratio and higher cash flow than firms using less durable assets. Firms using highly durable assets seem to display characteristics similar to that of unconstrained firms as unconstrained firms typically have higher investment/capital ratio and cash flow compared to firms that are financially constrained (Fazzari et al. (1988)). The mean value of Q is similar for both types of firms. The resemblance of sample characteristics between high durability (low durability) firms to unconstrained (constrained) firms further motivates examining how asset durability affects firm financing.

Table 2.2: Descriptive statistics of key variables

	Investment			Q			Cash flow			N
	Mean	Median	Std. Dev	Mean	Median	Std. Dev	Mean	Median	Std. Dev	
High durability	0.306	0.239	0.253	1.21	1.03	0.701	0.489	0.397	1.07	8,151
Low durability	0.188	0.156	0.138	1.15	1.00	0.635	0.245	0.250	1.024	8,109

This table displays summary statistics for investment, Q and cash flow for high durable asset firms and low durable asset firms where high durability (low durability) firms are those firms in the top (bottom) three deciles of durability distribution.

Table 2.3 displays the regression results for the model of investment (equation 2.3.2), which includes an interaction term between cash flow and durability. I estimate the equation using OLS with firm- and year- fixed effects. The table reports a total of eight regression results (4 constraint criteria $\times$ 2 constraint categories). The results indicate that for each constraint criterion, investment-cash flow sensitivity is increasing in durability for constrained firms. By contrast, for unconstrained firms, investment-cash flow sensitivity becomes unresponsive to an increase in the durability of assets under two out of the four constraint criteria.

The coefficients of the interaction term for constrained firms are higher than unconstrained firms when they are sorted according to their size and bond rating. The differences in the coefficients across samples of constrained and unconstrained firms are statistically significant when firms are classified based on total assets. However,

Table 2.3: Regression Results: Durability and external finance

Dependent Variable Investment	N	Independent Variables Q	CF	D	$CF \times D$
1. **Payout policy**					
Constrained	9,646	0.084**	-0.051**	0.166**	0.077**
		(8.83)	(-3.15)	(8.31)	(4.22)
Unconstrained	9,091	0.044**	-0.091**	0.125**	0.134**
		(8.11)	(-2.23)	(5.64)	(3.01)
2. **Asset size**					
Constrained	8,577	0.063**	-0.071**	0.204**	0.104**
		(6.93)	(-3.23)	(6.95)	(4.22)
Unconstrained	7,416	0.064**	0.008	0.135**	0.033
		(7.85)	(0.28)	(7.52)	(1.04)
3. **Bond rating**					
Constrained	9,596	0.063**	-0.034	0.123**	0.109**
		(7.88)	(-1.23)	(6.30)	(3.50)
Unconstrained	5,322	0.040**	0.015	0.115**	0.038
		(7.40)	(0.61)	(8.55)	(1.57)
4. **CP Rating**					
Constrained	12,068	0.061**	-0.013	0.119**	0.083**
		(8.86)	(-0.59)	(7.87)	(3.57)
Unconstrained	2,850	0.018**	-0.146**	0.058**	0.216**
		(4.62)	(-2.15)	(2.40)	(3.01)
5. **Full Sample**	27,129	0.068**	-0.016	0.164**	0.052**
		(15.02)	(-0.86)	(13.09)	(2.73)

This table presents the results for OLS-FE (firm and year effects) regression of investment. The results are based on priori selection criteria that distinguish between 'constrained' and 'unconstrained' firms. White-Hubar estimator corrects for heteroskedasticity and clustering. The t-scores are reported in parenthesis. ** and * indicate significance at 1% and 5% level respectively.

the differences are not significant for the other three categories of constraints selection.[10] Durability positively affects investment-cash flow sensitivity for unconstrained firms when firms are sorted into constrained and unconstrained classes according to their payout distribution or commercial paper rating.

Notice that the coefficient on cash flow for constrained firms under each constraint criterion is negative in the majority of the regressions. However, this negative sign is not indicative of lower investment due to higher cash flow. These coefficients are not informative unless they are combined with coefficients of the interaction term.

[10] The p-value associated with the F test is 0.10 for firms classified according to total assets and the p-value associated with the F test is 0.17 for firms classified according to bond rating. However, the difference is significant at 5% level (p-value = 0.001) if I consider top and bottom 10% firms of the asset distribution as unconstrained and constrained firms respectively.

Higher cash flow will only generate lower investment if durability is extremely low or the depreciation rate is very high.[11] This is consistent with the findings of Hovakimian (2009). Thus, firms having assets with high depreciation rates are highly constrained.

It is necessary to look at how partial effect of cash flow changes due to asset durability to understand the effect of durability on investment-cash flow sensitivity. For constrained firms classified according to the asset distribution, the partial effect of one standard deviation (1.27) increase in cash flow with very low asset durability (0.77 at 5th percentile) is 0.01. At high asset durability (0.99 at 95th percentile) the partial effect of cash flow is 0.04.[12] For the same increase in cash flow, investment in more durable assets involves pulling out more internal funds. Thus, the constrained firms investing in more durable assets are more reliant on internal financing for marginal investments than firms investing in less durable assets. The finding also implies that in the event of a negative cash flow shock, investment of financially constrained firms will be less impacted if these firms invest in less durable assets.

For firms classified as unconstrained according to their payout distribution or short-term credit ratings, both the coefficients of cash flow and the interaction term are statistically significant. These firms will face a higher cost of financing new investments through external financing with an increase in durability. However, for firms classified as unconstrained according to their asset distribution or bond ratings, both the coefficients of cash flow and the interaction term, both are statistically

[11]The partial effect of cash flow on investment to capital ratio is negative if the depreciation rate is as high as 35%, which is higher than the highest depreciation rate in the sample.

[12]The partial effect of cash flow on investment is equal to the summation of the standard deviation of cash flows times the coefficient of cash flow and the same standard deviation times the coefficient of the interaction term times the level of durability (5 percentile value and 95 percentile value).

insignificant. Thus, investment by these firms is not affected by internal cash flow.

Durability enters all the regressions with a positive and significant coefficient which implies that an increase in asset durability at any level of the cash flow will increase investment. This is plausible if durable assets are more pledgeable (contain more collateral value) compared to less durable assets. Physical assets that are more durable tend to be more expensive and also carry a higher collateral value. Investment in more expensive durable assets thus increases investment expenditure for a firm.

The coefficients of Q are positive and statistically significant across constrained and unconstrained firms. Notice that coefficients of Q are slightly higher for constrained firms compared to unconstrained firms in three out of the four constraint selection criteria (with only one exception of constraint selection criterion - asset size). This implies that the increase in investment opportunity induces more investment for firms that are more financially constrained. This pattern is consistent with the previous literature (Fazzari et al. (1988), Hoshi et al. (1991) and Cummins et al. (1999))

Finally, with no sample separation, durability increases investment-cash flow sensitivity. This implies that durability, on average, increases the cost of external finance for the firms considered in this sample.

Measurement error in Q and sensitivity to outliers

I subject the above findings to a few robustness checks. The use of Q as a proxy for investment opportunity in the investment equation is a highly debatable topic in the literature. Noted works in the literature (Cummins et al. (1999), Erickson and Whited

(2000), Gomes (2001), and Alti (2003)) argue that measurement error associated with Q can produce biased estimates of investment-cash flow sensitivities particularly for firms that are typically classified as financially constrained. Due to the mismeasurement of Q, cash flow might contain information of investment opportunities in the investment regression. Thus, significant investment-cash flow sensitivity can be found for constrained firms even in the absence of financial constraints due to this proxy quality problem associated with Q. To eliminate the potential bias in my estimates associated with the measurement error in Q, I estimate the Euler-type investment model proposed by Bond and Meghir (1994). The authors study the investment behavior of firms based on the Euler equation of an adjustment cost model. Following Bond and Meghir (1994) I add lagged investment to capital ratio, its squared, lagged sales to capital ratio, its squared and lagged debt to capital ratio to the set of regressors.[13] To estimate this dynamic panel data model of investment, I use a two-step dynamic panel GMM estimation proposed by Arellano and Bond (1991). The respective lagged values serve as instruments for the differenced regressors in these regressions.

In addition to the bias arising from measurement error stated above, there is also a possibility of a simultaneity bias due to the model's contemporaneous set-up. As financially constrained firms find it costly to arrange external financing for their investment in more durable assets, they may choose to invest in less durable assets. Again the amount of external finance also depends on the liquidation value of

[13] Almeida and Campello (2007) use this approach to address the issue of measurement error in Q as a proxy for investment opportunities.

assets, which is smaller for less durable assets. Thus, investing in less durable assets can make firms even more financially constrained, and a negative relationship can arise between asset durability and financial constraints (which I show in my second specification). In addition to instrumenting asset durability with its lagged values, I also include two external instruments to address this concern. One of the instruments is a sectoral/industry-level asset durability derived from the implied depreciation rates of private nonresidential fixed assets data available through BEA. The other instrument for durability is a firm-level proxy that I construct using the same industry-level implied depreciation rate data from BEA. To construct this proxy, I use the following equation

$$\Delta_{j,t} = \sum_{i=1}^{N_{j,t}} \eta_{i,j,t} \Delta_{j,t} \tag{2.3.3}$$

where, $\Delta_{j,t}$ is the implied depreciation rate of sector j at year t. This depreciation rate is expressed as a weighted average of the depreciation rates of individual firms operating in that industry. The weights are given by the total sales by firm i in year t divided the total sales by sector j at time t. $N_{j,t}$ denotes the total number of firms in sector j at time t.[14]

Table 2.4 reports the estimates of the coefficients of only the key variable of interest, i.e., the interaction term between cash flow and durability. For constrained firms, the interaction term coefficient remains positive and significant across all constraint

[14]This approach of constructing a proxy of firm-level asset durability is similar to the approach followed by Li and Tsou (2020) where the authors construct the firm-level durability for tangible and intangible assets separately and then take another weighted average of the depreciation rates of the two asset types for each firm to obtain the final firm-level measure of asset depreciation rate. I construct the proxy asset durability using the aggregate measure of the depreciation rates, which sufficiently qualifies as a good instrument for the asset durability measure I use in my analysis.

Table 2.4: Measurement error in Q

	Payout ratio	Asset size	Bond rating	CP rating
Constrained firms	0.084**	0.091**	0.138**	0.142**
	(0.038)	(0.043)	(0.044)	(0.056)
	[0.603]	[0.517]	[0.647]	[0.675]
Unconstrained firms	0.145**	-0.014	-0.023	0.158
	(0.052)	(0.058)	(0.041)	(0.245)
	[0.777]	[0.606]	[0.563]	[0.536]

This table reports the GMM estimates of the coefficients returned for the interaction term $CF \times D$ following Bond and Meghir (1994), where Q is eliminated as proxy for investment opportunity in the baseline model and the lags of investment, sales and debt are added as controls as well as instrumented. All regressions control for firm and year fixed effects. Heteroskedasticity and clustering correct standard errors are reported in the parenthesis. P-values associated with Hansen's J statistic are reported in square brackets. ** and * indicate statistical significance at 1% and 5% level of significance respectively.

selection categories. This result is similar to what I found for the OLS estimation for constrained firms. Hence, increased durability increases investment-cash flow sensitivity for financially constrained firms even after controlling for endogeneity and measurement errors. On the contrary, for unconstrained firms, the coefficients of the same variable are all statistically not significant except for firms classified according to their payout ratio. The results imply that durability does not affect the external cost of financing for firms that are classified as financially unconstrained based on their asset distribution, bond ratings or commercial paper ratings. The advantage of this approach is twofold. Firstly, this approach altogether replaces Q with other regressors. The absence of Q from the regressions eliminates the possibility of getting biased estimates due to measurement error associated with the estimation of Q. Secondly, the inclusion of external instruments for durability also corrects for any bias that can arise due to a simultaneity issue.

I also winsorize the data from both ends at extreme percentiles to mitigate the effect of outliers present in the sample. Table 2.5 reports the estimates for the coefficients of the interaction term between cash flow and durability from the OLS regression at different winsorization thresholds.

Table 2.5: Outlier treatment

	Payout ratio	Asset size	Bond rating	CP rating
A. Winsorization cut-off 2% and 98%				
Constrained firms	0.159*	0.194**	0.319**	0.263**
	(8.57)	(7.72)	(11.14)	(8.92)
Unconstrained firms	0.154**	0.104*	0.107*	0.102
	(4.79)	(2.35)	(1.99)	(1.40)
B. Winsorization cut-off 1% and 99%				
	Payout ratio	Asset size	Bond rating	CP rating
Constrained firms	0.116**	0.135**	0.278**	0.236**
	(5.47)	(4.94)	(10.09)	(9.44)
Unconstrained firms	0.118**	0.108**	0.126**	0.155
	(3.78)	(2.83)	(2.68)	(1.92)

This table reports the OLS estimates of the coefficients returned for the interaction term $CF \times D$ after estimating equation (2.3.2) with data treated for outliers by winsorizing at different cut-off points. All regressions control for firm and year fixed effects. Heteroskedasticity and clustering corrected standard errors are reported in the parenthesis. **, and * indicate statistical significance at 1%, and 5% level of significance respectively.

Panels A and B of Table 2.5 report the estimates at different winsorization cut-offs. In both cases, durability continues to have a positive and significant effect on cash-flow sensitivity of investment for constrained firms regardless of the constraint selection criterion. For unconstrained firms, increased durability increases the cost of external funding when firms are sorted according to their payout distribution, asset distribution, or bond ratings. However, durability has no significant effect on the cash-flow sensitivity of investment for firms classified as unconstrained using sort-term credit rating as a proxy for financial constraint. These findings are in contrast to those I obtained from the OLS estimation of equation (2.3.2) with non-winsorized data. Coefficients from OLS estimation thus demonstrate significant sensitivity to winsorization thresholds chosen i.e., they remain sensitive to outliers.

To check if GMM estimates also demonstrate a similar sensitivity to outliers, I also estimate the Euler-type investment model by Bond and Meghir (1994) for winsorized data. Table 2.6 reports the coefficients from GMM estimation using winsorized data with the cut-offs set at 1% and 99%. The estimates from GMM estimation also show sensitivity to outlier treatment.

Table 2.6: Measurement error in Q and outlier treatment

	Payout ratio	Asset size	Bond rating	CP rating
	0.128**	0.107*	0.402**	0.308**
Constrained firms	(0.044)	(0.056)	(0.06)	(0.047)
	[0.320]	[0.728]	[0.400]	[0.437]
	0.120**	-0.095	0.115**	-0.019
Unconstrained firms	(0.05)	(0.295)	(0.043)	(0.205)
	[0.758]	[0.636]	[0.601]	[0.683]

This table reports the GMM estimates of the coefficients returned for the interaction term $CF \times D$ following Bond and Meghir (1994), where Q is eliminated as a proxy for investment opportunity in the baseline model and the lags of investment, sales and debt are added as controls as well as instrumented. The data is winsorized using cut-offs of 1% and 99%. All regressions control for firm and year fixed effects. Heteroskedasticity and clustering correct standard errors are reported in the parenthesis. P-values associated with Hansen's J statistic are reported in square brackets. **, and * indicate statistical significance at 1%, and 5% level of significance respectively.

The results show that the GMM estimates also demonstrate high sensitivity to outlier treatment. Thus, outliers remain a concern even after controlling for the measurement error in Q and the endogeneity. Overall, the findings suggest that when firms invest in tangible physical assets, more durable assets make constrained firms' investment more sensitive to changes in the internal cash flow due to being more expensive relative to less durable assets. On the contrary, for unconstrained firms effect of durability on financing remains ambiguous.

2.3.4 Choice of durability and financial constraints

The previous specification highlights the role of asset durability on the financial constraints faced by firms. On the flip side, the extent to which a firm is financially constrained can also influence its investment decisions on durable assets as set forth by the theoretical propositions of Rampini (2019). Thus asset durability can be endogenously determined by firms facing financing frictions. In the following specification, I investigate how firms choose the level of durability in the presence of financial constraints. I model durability (D) as a function of firms' financial constraints and some firm-specific controls. The empirical model used in this approach is as follows

$$D_{i,t} = \beta_1 + \beta_2 FC_{i,t} + \gamma X_{i,t} + \sum_i firm_i + \sum_t year_t + \varepsilon_{i,t} \tag{2.3.4}$$

In this specification, $D_{i,t}$ is the durability of assets of firm i at time t. To measure financial constraints ($FC_{i,t}$), I employ the index-based proxies for financial constraints. The coefficient β_2 captures how asset durability is affected by the change in a firm's financial constraints. A negative value of β_2 implies that firms invest in less durable assets as they become more financially constrained. $X_{i,t}$ is a vector of all firm-specific controls, which include Q (a proxy for investment opportunity), cash flow, size, return on assets (ROA), and leverage. I include these controls following the previous literature. $firm_i$ and $year_t$ are firm- and year- fixed effects.

Constraint selection

To estimate equation (2.3.4) I use proxies of financial constraints based on commonly used indices of financial constraints namely, the KZ index, the WW index and the HP index. Below I describe the construction of the indices and the variables used.

The KZ index: I follow Lamont et al. (2001) to construct the index as, kz = –1.001909[$(ib + dp)$/lagged $ppent$] + 0.2826389[$(at + prcc_f \times csho$ - ceq - $txdb)/at$] + 3.139193[$(dltt + dlc)/(dltt + dlc + seq)$] – 39.3678[$(dvc + dvp)$/lagged $ppent$] - 1.314759[che/lagged $ppent$], where, all the variables in italics are Compustat items. Lamont et al. (2001) estimate an ordered logit model that measure the degree of financial constraints using five variables reflective of a firm's financial status namely, cash flow, market value, debt, dividends, and cash holdings.

The WW index: Following Whited and Wu (2006) and Hennessy and Whited (2007) I construct the index as, ww = –0.091 [$(ib + dp)/at$] – 0.062[dividend] + 0.021[$dltt/at$] – 0.044[log(at)] + 0.102[isg]– 0.035[sg], where, dividend is an indicator variable that takes the value of 1 if $(dvc + dvp)$ is positive and 0 otherwise, sg is sales growth and isg is industry sales growth rate which is the estimated separately for 3-digit SIC industry. This index is derived using the coefficients obtained from a structural model. It represents the shadow price of raising equity capital or the Lagrange multiplier on the external financial constraints.

The HP index: Following Hadlock and Pierce (2010) I construct the index as, hp = -0.737[Size] + 0.043[Size^2]– 0.040[Age], where, Size is the natural logarithm of inflation adjusted total assets (Compustat item *at*) and Age is the number of years the firm is listed with a non-missing stock-price on Compustat. Following Hadlock and Pierce (2010) I cap the size at $4.5 billion and age at 37 years.

I follow standard convention in the literature to winsorize the top and bottom 1% of the data. Table (2.7) provides the summary statistics of the financial constraints indices. It appears from the standard deviation of the indices that compared to the WW index and the HP index, there is more variability in the level of financial constraints of firms when the KZ index measures financial constraints.

Table 2.7: Summary statistics for measures of financial constraints

Measures of financial constraints	Mean	Std. Dev	No of Observations
KZ index	-2.88	6.539	37,486
WW index	-.295	0.102	34,230
HP index	-3.14	0.471	37,731

This table provides summary statistics for three index based proxies of financial constraints namely, the KZ index, the WW index and the HP index. I winsorized the data at 1% and 99% before constructing the indices.

From Table (2.8), I find that all three financial constraints measures positively correlate at the 1% level of significance. The KZ index weakly correlates with the WW index and the HP index. Again, the WW index and the HP index share a moderate correlation. The departure of the KZ index from the WW index and the HP index in separating the financially constrained firms from the unconstrained ones is well documented in the literature (Farre-Mensa and Ljungqvist (2016)).[15] Except

[15] Farre-Mensa and Ljungqvist (2016) show that firms classified as constrained by the KZ index

firm leverage, all other firm-level control variables share a statistically significant negative correlation with all three financial constraints indices. These correlations are consistent, as firms with lower cash flows and smaller sizes are typically financially constrained. Durability is negatively correlated with all three measures of financial constraints, which indicates that more financially constrained firms invest in less durable assets.

Table 2.8: Correlations among the variables

Variables	KZ index	WW index	HP index	Durability (D)	Q	cash flow	size	ROA	leverage
KZ index	1.0000								
WW index	0.2404**	1.0000							
HP index	0.1346**	0.5669**	1.0000						
Durability (D)	-0.0628**	-0.0923**	-0.0861**	1.0000					
Q	-0.1877**	-0.1135**	-0.0549**	0.0320**	1.0000				
cash flow	-0.4590**	-0.2450**	-0.1719**	0.1507**	0.1618**	1.0000			
size	-0.1494**	-0.9439**	-0.5262**	0.0357**	0.0737**	0.1474**	1.0000		
roa	-0.2034**	-0.3435**	-0.2757**	0.1592**	0.2701**	0.6030**	0.1986**	1.0000	
leverage	0.3008**	-0.0767**	0.0219**	-0.0841**	0.0120*	-0.2337**	0.1684**	-0.1211**	1.0000

This table provides the correlation coefficients among the key variables. **, and * denote 1%, and 5% level of significance respectively.

Does choice of durability depend on financial constraints?

Table 2.9 provides results for the estimation of the regression given by equation (2.3.4). Panel A reports the OLS estimation results of the regression. The estimations correct the standard errors for heteroskedasticity and clustering using the White-Huber

are marginally younger, have less cash, and more tangible capital in their balance sheets compared to their unconstrained counterpart. On the contrary, firms classified as constrained by the WW index and the HP index are relatively younger, have more cash and less tangible capital in their balance sheets. My sample also demonstrates these contrasting features between the KZ index and the other two indices.

sandwich estimator.[16] The results indicate a statistically significant negative relationship between financial constraints index and durability. A higher value of the index of the financial constraint indicates a higher cost of obtaining external finance. Hence, the negative coefficient of financial constraints implies that the durability of capital decreases as firms become more financially constrained. The partial effects of one standard deviation increase in the financial constraints measured using the KZ index, the WW index, and the HP index are all very small (-0.006, -0.115, and -0.003, respectively). Thus, a slight increase in the index will reduce the average durability of investment by a small percentage. Therefore, firms will invest in less durable assets only if they are extremely financially constrained (have a very high value of the KZ, the WW, or the HP index). The results also indicate that firms facing less financial constraints invest in more durable assets. This finding supports the theoretical prediction made in Rampini (2019).

The coefficient of Q is positive and significant for all three regressions in panel A. Hence, firms with more investment opportunities choose to invest in more durable capital for further growth. Firm size significantly affects a firm's durability choice, i.e., the bigger firms invest in more durable assets.[17] The negative relationship between durability and leverage suggests that firms that use more debt to purchase their assets are likely to increase investment in less durable capital. As durable assets are expensive to purchase, highly levered firms invest in less durable capital to reduce the

[16] The White-Huber sandwich estimator corrects standard errors allowing for observations to be independent across firms but not necessarily within firms.

[17] The coefficient associated with the firm size is negative in the second regression in which the WW index measures the financial constraints. This negative value is due to the strong correlation (0.98) present between the WW index and the firm size. Removing WW from the regression gives a coefficient of size as 0.029.

amount of debt. Finally, firms with higher cash flow and a higher return on assets (higher profitability) invest more in durable capital.

Robustness to endogeneity and outliers

The contemporaneous relationship between financial constraints index and choice of durability can cause concerns of simultaneity bias. A severely constrained firm finds it difficult to invest in more durable assets. Again, the lower collateral value of less durable assets can make it even more difficult for the firm to obtain external finance for those assets and increase the likelihood of a firm to be financially constrained. As a result, the financial constraints measure might become endogenous and correlated with the error term of the equation that determines durability. To address this, I instrument the financial constraints variables with their respective first lags for all the regressions presented in panel A of Table 2.9. Panel B of Table 2.9 provides the results of the 2SLS estimation of equation (2.3.4).

When the KZ index measures financial constraints, the original finding of a small but negative relationship between the financial constraints index and asset durability continues to hold. On the contrary, the negative relationship no longer holds for the WW index or the HP index of financial constraints. The coefficient turns out to be positive, larger in magnitude, and statistically significant for both WW and HP indices. The coefficients of firm-specific controls are mostly similar to those returned from OLS estimations. Hence, the results remain qualitatively unchanged if the financial constraints are measured using the KZ index. In contrast, the OLS estimation of equation (2.3.4) returns biased estimates with the WW index or the

HP index used as proxies of financial constraints.

Table 2.9: Durability and financial constraints

	Panel A OLS estimation			Panel B 2SLS estimation		
Durability	1	2	3	4	5	6
KZ	-0.001**			-0.003**		
	(-3.54)			(4.29)		
WW		-1.124**			2.68**	
		(-14.45)			(10.30)	
HP			-0.006			0.268**
			(-0.33)			(11.69)
Q	0.005	0.005*	0.005	0.005	0.001	0.006*
	(1.99)	(5.55)	(1.75)	(1.69)	(0.39)	(2)
cash flow	0.026**	0.021**	0.029**	0.022**	0.045**	0.028**
	(6.66)	(5.55)	(7.57)	(5.13)	(9.07)	(7.20)
size	0.029**	-0.027**	0.029**	0.028**	0.165**	0.055**
	(9.16)	(-5.58)	(8.70)	(8.77)	(11.53)	(12.66)
ROA	0.184**	0.087**	0.182**	0.188**	0.419*	0.206**
	(6.81)	(3.22)	(6.77)	(6.90)	(11.02)	(7.48)
leverage	-0.014	-0.005	-0.017*	-0.007	-0.074 **	-.026**
	(-1.74)	(0.66)	(-2.24)	(-.091)	(-6.80)	(-3.03)
constant	0.763**	0.757**	0.746**	0.763**	0.756**	1.47**
	(62.93)	(41.5)	(13.33)	(41.61)	(32.74)	(23.92)
F statistic first stage				67.66	404.96	251.41
No of observations	26,878	26,943	26,943	26,828	24,268	26,943

This table reports the OLS-FE estimates of the coefficients returned for the regression in equation (2.3.4). Panel A consisting of columns 1, 2, and 3 reports OLS regression results for financial constraints measured by Kaplan and Zingales index, Whited and Wu index, and Hadlock and Pierce index respectively. Panel B consisting of columns 4, 5 and, 6 reports the results from 2SLS estimation of the baseline regression for the respective financial constraints indices. For 2SLS estimation each financial constraints index is instrumented by first lags of the respective financial constraints index. The data is winsorized using cut-offs of 1% and 99%. All regressions control for firm and year fixed effects. The White-Huber estimator is used to correct for heteroskedasticity and clustering. The t-statistics are reported in parenthesis. **, and * indicate significance at 1%, and 5% level, respectively.

Despite contrasting results, the findings using the KZ index are reliable in this analysis. The construction of the KZ index includes cash holdings by a firm with a negative loading, while the other two indices (the WW index and the HP index) do not. Thus, according to the KZ index, firms with more cash holdings are relatively unconstrained. As durability increases the down payment of an asset; therefore, in the presence of collateral constraints, firms must be able to afford the higher down payment given their financial health. Firms with more cash holding may find themselves in a better position to finance the down payment, which is appropriately captured by the KZ index.

I also change the winsorization thresholds to check how the findings vary with outlier treatment. I winsorize the data using 2% and 98% cut-offs to test the robustness of the results. The findings remain relatively robust to changes in the winsorization cut-offs. The negative relation between financial constraints and asset durability continues to hold only when the KZ index measures the financial constraints. Similarly, the coefficients remain relatively robust for WW and HP indices at different winsorization cut-offs for both OLS estimation and 2SLS estimation of the baseline regression. These findings indicate that when the financial status of a firm is measured using the KZ index, extremely financially constrained (unconstrained) firms choose to invest in less (more) durable assets.

Table 2.10: Outlier treatment: Durability and financial constraints

Durability (D)	OLS estimation	2SLS estimation
KZ	-0.001**	-0.002**
	(-3.87)	(-4.49)
WW	-0.868**	2.08**
	(-14.33)	(10.97)
HP	-0.011	0.232**
	(-0.79)	(11.67)

This table reports the coefficients returned for OLS and instrumental variable estimation of the regression in equation (2.3.4). The data is winsorized using cut-offs of 2% and 98%. All regressions control for firm and year fixed effects. White-Hubar estimator is used to correct for heteroskedasticity and clustering. The t-statistics are reported in parenthesis. **, and * indicate significance at 1%, and 5% level respectively.

2.3.5 Durability of asset and composition of physical capital

The industry-level data on physical capital and implied depreciation rate demonstrate a positive correlation between the share of structures in physical capital and the durability of capital in the manufacturing industry. In this section, I examine if firms belonging to sectors that use a lot of structures show different investment behavior compared to those with a relatively lower share of structures in physical assets. I match firm-level data of my sample with industry-level data from BEA according to NAICS codes. For firms belonging to sectors that use many structures, the choice of durability is not affected by financial constraints. On the contrary, firms with a relatively lower share of structure invest in less durable capital as they become more financially constrained. The following table reports the estimated regression coefficients associated with financial constraints from equation (2.3.4) for high and low structure share firms. I only report results using the KZ index as a measure of financial constraints.

The effect of financial constraints on durability choice is significant for firms having a relatively lower share of structures in physical capital at the sectoral level. On the other hand, the coefficient of the financial constraints index is not significant for firms with a relatively higher share of structures. According to these findings, the effect of financial constraints on firm-level investment in durable assets also depends on the composition of physical capital at the sectoral level.

Table 2.11: Durability of asset and composition of physical capital

Durability	KZ index
High structure share firms	0.0005
	(0.52)
No of observations	5,854
Low structure share firms	-0.002**
	(-4.91)
No of observations	17,538

This table reports the estimates of the coefficients returned for the KZ index of financial constraints from OLS estimation of the baseline model. Firm-level data in the sample is matched with the industry level data from BEA using NAICS codes at the 3-digit level. High (low) structure share firms are those firms that belong to sectors that have a share of structure above (below) the median in the manufacturing industry for the sample period. The data is winsorized using cut-offs of 1% and 99%. All regressions control for firm and year fixed effects. Heteroskedasticity and clustering correct standard errors are reported in the parenthesis. **, and * indicate statistical significance at 1%, and 5% level of significance respectively.

2.4 Conclusion

In this chapter, I explore the role of asset durability as a link between financial constraints and investment. Durability is an important feature of tangible assets, which has a dual effect on a firm's ability to obtain external financing. The higher resale value of durable assets increases their collateral value, which facilitates external financing. On the other hand, more durability makes durable assets more expensive, which increases the overall financing need of a firm, making it harder for a firm to finance the asset. Rampini (2019) proposes a theoretical model which shows that for financially constrained firms, the latter effect dominates over the first one and that durability can obstruct financing for these firms. In this chapter, I find that durability can adversely affect constrained firms' access to external financing. Additionally, I find that firms choose to invest in less (more) durable assets as they become more financially constrained (unconstrained).

For my empirical analysis, I use a firm-level depreciation rate to measure a firm's asset durability. In the first specification, I examine the effect of durability on investment-cash flow sensitivity, a widely used measure of financial constraints. The results show that an increase in asset durability increases investment-cash flow sensitivity for constrained firms. The results imply that due to excess sensitivity of investment to internal cash flow, the investment will reduce more if liquidity constrained firms invest in more durable assets in the event of a negative cash flow shock. On the contrary, for unconstrained firms, the effect of durability on the cost of external finance is ambiguous and largely depends on constraint selection. In the second specification, I use index-based measures of financial constraints to find that extremely constrained firms choose to invest in relatively less durable capital compared to relatively unconstrained firms. At the industry level, this effect of financial constraints on durability choice is more prominent for firms that belong to sectors with a relatively lower share of structures in physical capital.

One limitation of this chapter is, the sample consists only of listed firms that are not entirely financially constrained. These firms can often turn to equity financing whenever debt financing is unavailable. The findings thus give a general idea of how financial constraints can affect firm investment through asset durability. Additionally, some of the findings of this chapter show sensitivity to certain robustness checks. The overall findings are successful in bringing out the importance of asset durability in firm-level investment decisions and they also generate mixed support towards the theoretical link between durability and firm financing established in Rampini (2019). The implications of the findings suggest that investing in more durable assets may not necessarily alleviate the financial constraints of extremely constrained firms. Thus, in the event of an economic downturn, firms that are struggling with financing their assets can choose to invest in less durable assets and increase investment in more durable assets as their financial situation improves.

Chapter 3

Macroeconomic Determinants of Corporate Credit Spreads: Evidence from Canada

3.1 Introduction

Since the financial crisis of 2007-2009, the analysis of credit spreads and how they behave with different economic scenarios has gained significant momentum. Following suit of the U.S. and the EU, Canada's bond market has been expanding in size. Moreover, the inflation targeting interest rate remaining low in Canada (0.25%) encourages Canadian investors to divert their investments from low-yielding government bonds to higher-yielding investment grade, high yield, or global bonds. In the past decade, total outstanding Canadian dollar-denominated corporate bonds have increased by almost 70% (see Figure:B.1). In addition, the new issuance of domestic corporate bonds in Canada is also on the rise since 2010 (see Figure:B.2). This domestic bond market growth greatly influences the composition of portfolios held by financial institutions, firms, trusts, and private investors. An increase in new issuance and the amount outstanding of risky corporate bonds are also associated with higher risk and thus call for better risk management to prevent the negative consequences wider credit spreads can have on real activity. This chapter explores the determinants of credit spreads and analyzes the relative importance of various macroeconomic and financial factors in explaining the variation of corporate credit spreads in the Canadian bond market.

A corporate bond's credit spread is the additional yield a (risky) corporate bond pays over a (riskless) government bond with matching maturity. It is a widely used measure of a company's cost of borrowing and creditworthiness. The spread reflects the premium an investor demands to invest in risky security. An increase in spread limits a borrower's ability to obtain further funding, which negatively affects the value of its assets and curbs its growth. This reduction in a firm's value through the financial accelerator channel further cuts the firm's borrowing potential, resulting in an even wider spread. Moreover, credit spreads are forward-looking and thus contain important information about investors' perception of future risk. The high information content of bond spreads acts as a leading indicator in providing early warnings of changes in real activity (Gilchrist and Zakrajšek (2012); Bleaney et al. (2016)).

Therefore, it is crucial to identify the driving factors behind movements in credit spreads, which can help policymakers better understand the risks associated with fixed-income securities and stabilize the economy in a risky event by providing appropriate policies. Previous studies attempt to identify the determinants of corporate bond credit spreads both from theoretical and empirical perspectives. Theoretical models have adopted two separate approaches to model credit risk: structural approach and reduced-form approach. Despite challenges associated with the implementation, these models have been able to identify variables such as the risk-free rate, slope of the yield curve, equity return and volatility, and recovery rate as important determinants of credit spreads.[1] However, the predicted spreads generated by the structural models do not match with empirical data. Collin-Dufresn et al. (2001) show that most of the determinants proposed by the structural models have very limited explanatory power. A theoretical study by Tang and Yan (2006) incorporates factors containing macroeconomic influence such as cash flow beta instead of firm value in their model. The default probabilities and credit spreads generated by this model perform better than the traditional structural models in matching the data.

Huang and Huang (2012) show that for higher rated bonds, the credit spreads predicted by the structural models are significantly below the actual numbers giving rise to the so-called - credit spread puzzle. The limitations in the empirical application of the theoretical models prompted the empirical literature to identify the determinants

[1]Structural models (Black and Scholes (1973); Merton (1974); Black and Cox (1976); Longstaff and Schwartz (1995)) assume that corporate bond defaults when the company value falls below a threshold level. These models are based on the contingent claim hypothesis that assumes a firm's liabilities as a contingent claim to its assets. Thus, the firm value becomes the only source of uncertainty in these models. Although structural models provide better insights into the determinants of credit spreads, they are difficult to implement as firm value is not directly observable. On the other hand, the reduced-form models attempt to model the probability of default instead of firm value. The reduced form models specify default as a random event governed by some exogenous hazard rate that follows a Poisson distribution (Jarrow et al. (1997)). However, these models are better suited to price derivatives as they are heavily reliant on default intensity and lack economic interpretation.

of credit spreads beyond those proposed by the theoretical models. The empirical literature suggests that incorporating a set of macroeconomic factors in addition to the theoretical determinants can explain a significant proportion of the variation in credit spreads. The determinants identified by the empirical literature ranges from bond- and firm-level variables like individual bond characteristics, liquidity risk, equity volatility, issuer credit rating to macroeconomic factors like monetary policy, taxation, and inflation (Collin-Dufresn et al. (2001); Elton et al. (2001); Campbell and Taksler (2003); Avramov et al. (2006); Duffie et al. (2007); Cenesizoglu and Essid (2012)). But even after including determinants additional to the theoretical determinants, the empirical literature has not been able to explain a significant portion (75%) of the variation in the spreads. Collin-Dufresn et al. (2001) finds that the returns of the S&P 500 have significant explanatory power to explain the spreads for U.S. corporate bonds. But they find that even after incorporating the returns with the determinants suggested by the theoretical literature, their model can explain only about a quarter of the variance in the spreads of U.S. corporate bonds as measured by the adjusted R squared. Elton et al. (2001) find significant improvement in explaining the variations in spreads (R^2 equal to 0.32 for industrial bonds and 0.58 for financial bonds) after including tax effects in their model. Thus, a lot of the variation in the corporate bond credit spreads remains unexplained. Some studies try to explain the gap between observed credit spreads, and the estimated credit spreads from the existing empirical models with credit risk and liquidity risk (Perraudin and Taylor (2003); Driessen (2005)). Amato and Remolona (2003), however, suggest that this gap attributes to the diversification risk. Gilchrist and Zakrajšek (2012) try to explain the puzzle in the context of ‘excess bond premium’. The literature is yet to reach a conclusive solution to this puzzle.

My research is also partly motivated by this credit spread puzzle in the context of the Canadian bond market. Majority of the studies in the literature use data on U.S. corporate bonds. Despite being highly integrated with the U.S. market, the Canadian bond market has some distinctive features that make it well suited to examine the determinants of spreads of Canadian corporate bonds. Compared to the U.S., the bond market in Canada is much smaller, less liquid, and a tiny fraction of total debt issuance are high-yield bonds.[2] In the final quarter of 2019, bonds and debentures accounted for about 61.7% of the total borrowing by the financial sector and 22.3% (approximately $0.3 trillion CAD) for non-financial firms in Canada. In the U.S., bonds constituted about $5.7 trillion USD in liabilities by U.S. non-financial corporate sector in the same quarter.[3][4] Although the size of the corporate bond market in Canada is quite small, previous studies find corporate credit spreads to be important as a signal for economic activity in Canada (Leboeuf and Hyun (2018)). However, not much work has been done on identifying the determinants of these spreads for the Canadian corporate sector. Analyzing the contribution of different risk components, Leboeuf et al. (2017) find default risk arising from falling oil prices

[2] High-yield bonds are the bonds that pay higher interest rates than investment-grade bonds. The high-yield bonds have a lower credit rating (below BBB from S&P or below Baa3 from Moody's) than the investment-grade bonds. Due to their high probability of default, the high-yield bonds pay a higher interest rate to compensate the investors for the increased risk.

[3] Quarterly balance sheet and income statement by industry, Statistics Canada. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3310000701

[4] Balance sheet of Nonfinancial Corporate Business, Board of Governors of the Federal Reserve System (U.S.), Nonfinancial Corporate Business; Debt Securities; Liability, Level [NCBDBIQ027S], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/NCBDBIQ027S

explain the increase in spreads for the energy sector in Canada but the variations in spreads for other investment-grade firms remains largely unexplained. This chapter aims to contribute to the literature by identifying the individual determinants driving the corporate credit spreads and their relative contribution towards explaining the variation in spreads in the Canadian bond market.

I use quarterly panel data on option-adjusted spread (OAS) of individual bonds, denominated in Canadian dollars issued by Canadian nonfinancial corporations, to estimate a bond-level OLS regression and examine the impact of a list of macroeconomic variables along with some firm-specific and bond-specific controls.[5] I estimate the baseline regressions both by pooling the data as well as by incorporating bond fixed effects to account for potential bias that might arise from bond-specific heterogeneity. A variance decomposition analysis further shows which factor accounts for the most substantial variation in the spreads. To explore if the findings vary with default probabilities, I estimate the baseline regression (with bond F.E.) and perform the variance decomposition analysis for bonds with different rating classes separately.

The results show that macroeconomic factors significantly affect credit spreads in their levels and volatility. Although the exchange rate has the strongest effect on spreads in the level form, as far as the volatilities of the determinants are concerned, spreads are more sensitive to a volatile stock market. The findings associated with firm fundamentals show that firm liquidity and firm leverage have a moderate impact on the bond spreads, but firm size and profitability do not significantly affect the spreads.

[5]Sections 3.3.1 and 3.3.2 provide a detailed explanation OAS and the full list of firm-specific, bond-specific and macroeconomic variables included in the model.

However, the effects of firm fundamentals substantially vary in magnitude, sign, and statistical significance across sub-samples of bonds with different ratings. While the bonds' maturity significantly affects spreads in the full sample, but across ratings, the effects are significant only for A rated bonds. A variance decomposition analysis shows that macroeconomic variables have a small contribution in explaining the variation in spreads across all rating classes. Interestingly, bond-specific fixed effects have a large contribution towards explaining the aggregate spreads. A critical finding from this analysis is that the major contributing factor in the spread variation is different for different rating classes. While macroeconomic factors contribute more to the variation of spreads for higher rated bonds, the unobserved bond-specific characteristics become a more prominent contributor in the variation of spreads of the riskier bonds. The results are robust across different model specifications and also for different data frequencies.

The findings of this chapter contribute to the literature in multiple ways. This chapter analyzes different determinants of corporate credit spreads and their relative contribution towards explaining the variations in the spreads using the Option Adjusted Spreads data for Canadian non-financial corporations. The findings show that when the economy performs well, i.e., when the GDP growth and the stock returns are high, the spreads decline, but at the same time, if the economy or the stock market is more volatile, the spreads rise. In addition, increased uncertainty about economic policies can increase spreads in the future. These findings will help policymakers determine the overall impact targeted policies can have on investors' perceptions and risk appetite. Another significant contribution of this chapter is that it highlights the importance of unobserved firm-specific (embedded in bond-specific F.E.) characteristics in explaining the variations in the spreads. Without controlling for these characteristics, the model can explain only a small fraction of the total variation (R^2=0.17) in spreads. When pricing risk, it is important to carefully consider the time-invariant heterogeneity between firms, e.g., corporate governance, managerial attributes, a firm's compensation structure, etc. Moreover, the lack of portfolio diversification opportunities in the Canadian corporate bond market may prevent investors from diversifying risks and increase the cost of borrowing by firms.

The chapter is organized as follows: Section 3.2 provides a theoretical model on credit spread, Section 3.3 provides description of data and econometric methodology, Sections 3.4, 3.5, and 3.6 summarize the regression results across different specifications and data frequencies, and Section 3.7 concludes.

3.2 A theoretical model on credit spread

One of the first structural models of credit spreads is the Merton model. The Merton model is based on the Black-Scholes-Merton option pricing theory. The simplest form of the model assumes that the firm does not pay dividends, has only one liability claim (a zero-coupon bond), and the financial markets are perfect.

Suppose that the firm's only debt liability is a zero-coupon bond with a face value of F with the bond maturing at time T. At maturity T, if the firm value V_T is so low that the firm is unable to pay the principal amount, then the equity holders receive nothing, and the firm is bankrupt. Alternatively, suppose the firm's value at time T is sufficiently large enough to pay back the principal of the bond. In that case, the equity holders receive the remaining value net of payments to debt holders, i.e., the equity holders receive $V_T - F$. This payoff combination is the same as the payoff from holding a call option with firm value as the underlying asset and an exercise price of F, the face value of the debt. The value of equity at maturity is, therefore,

$$S_T = max(V_T - F, 0) \tag{3.2.1}$$

If the debt were risk-less, the debt holders would always receive the face value of the debt (F) regardless of the firm value (V_T). But because debt is risky, if the firm value is less than the face value ($V_T < F$), then the debt holders receive a payment that is less than the face value (F) by the amount $F - V_T$. However, if the firm value is higher than the face value of debt (i.e., if $V_T > F$), then the debt holders' receive a payment of F regardless of the firm value. So the value of the debt is

$$D_T = min(F, V_T) = F - max(F - V_T, 0) \tag{3.2.2}$$

This payoff is equivalent to buying a zero-coupon bond with a face value of F and selling a put option written on the firm value with an exercise price of F.

In the Merton model, the dynamics of firm value follows a Brownian motion which is given by the equation below:

$$\frac{dV}{V} = \mu dt + \sigma_V dW_t \tag{3.2.3}$$

where, μ is the mean rate of return on the value of assets of the firm, σ_V is the volatility of firm value, and W_t is a standard Weiner process.[6]

We know that the value of the firm equals the summation of the values of its debt and equity. Thus

$$V_T = D_T + S_T$$
$$or, D_T = V_T - max(V_T - F, 0) \tag{3.2.4}$$

So the value of the debt can also be expressed as the difference between the value of the firm and a call option written on the value of the firm with an exercise price of F.

Then the Black-Scholes-Merton option-pricing model for the European call option can be modified to value equity of the firm at a time period prior to T, (T-t). The value of the equity then becomes:

$$S_t = V_t N(d_1) - Fe^{-r(T-t)} N(d_2) \tag{3.2.5}$$

where, $N(d_1) = \dfrac{ln(\frac{V_t}{Fe^{-r(T-t)}})}{\sigma_V \sqrt{T-t}} + \dfrac{1}{2}\sigma_V \sqrt{T-t}$; $N(d_2) = \dfrac{ln(\frac{V_t}{Fe^{-r(T-t)}})}{\sigma_V \sqrt{T-t}} - \dfrac{1}{2}\sigma_V \sqrt{T-t}$

$N(d_i)$ = cumulative normal distribution evaluated at d_i; r = continuously compounded risk-free rate.

Now, a zero-coupon risky bond with face value 1 and maturity T will have the

[6] A Weiner process has the following properties; (i) The increments in W_t are unpredictable and uncorrelated with past increments, (ii) The increments $W_{t+s} - W_t$ are normally distributed with mean 0 and variance s; (iii) W_t is continuous in time t.

price $P(T) = D_t/F$. The credit spread on a defaultable/risky bond with maturity T can then be calculated as the difference between the yield of a defaultable zero-coupon bond (Y^d) and the yield of a risk-free zero-coupon bond (R_f) with maturity T,

$$CS = Y^d - R_f = -\frac{1}{T-t} ln(\frac{D_t}{Fe^{-r(T-t)}}) = -\frac{1}{T-t} ln(e^{r(T-t)} \frac{V_t}{F}(1 - N(d_1) + N(d_2)) \tag{3.2.6}$$

Equation 3.2.6 shows that, credit spread depends on the risk-free rate, the firm's asset value (V_t), and the volatility of firm value (σ_V).

3.3 Data and methodology

I construct a panel data set of individual bonds denominated in the Canadian dollar issued by Canadian non-financial corporations. The primary data source for the firm-specific and bond-specific variables is Bloomberg Professional, which provides comprehensive coverage of bond and firm fundamentals data. I am using the option-adjusted spread (OAS) of individual bonds as a measure of credit spreads, which I obtain from Bloomberg Professional. Firm fundamentals data are only available in quarterly frequency through Bloomberg, while spread data are available on a daily frequency. As the choice of frequency is constrained by data availability, I convert the daily spread data into a quarterly average. I retrieve data on macroeconomic variables from Statistics Canada (real GDP), Bank of Canada (policy rate/interest rate, inflation rate), FRED St.Louis (exchange rate), and Yahoo Finance (S&P/TSX Composite index). The sample period of the empirical study spans from 2012-Q1 till 2019-Q3.[7] All data are adjusted for seasonality. The final sample contains 336 bonds with 5224 bond-quarter observations. Table 1 provides a summary of the rating distribution of the bonds in the sample.

Table 3.1: Distribution of bonds

Rating	AA	AA-	A+	A	A-	BBB+	BBB	BBB-	Total
Frequency	1	9	11	45	107	103	43	17	336

Due to the high volume and liquidity of the U.S. bond market, the majority of high-yield bonds by Canadian corporations are issued in the U.S. bond market. Since the focus of this chapter is to study Canadian bonds issued in local currency in the domestic market, my sample only includes investment-grade bonds issued in local currency (CAD). Table B.1 provides a summary of all variables, their definitions, and sources. Since I use a sample of investment-grade bonds, it is important to check to what extent the sample represents the risk profile of the corporate sector. Towards this, I compute the average OAS for each quarter from my sample data and compare the time series with the quarterly OAS of the S&P Canada investment-grade bond index. Figure B.3 plots the two series and displays high correlation (with correlation coefficient 0.84) between the two series.[8]

[7]Historical OAS data on Canadian dollar-denominated bonds are not available before 2012-Q1 through Bloomberg.

[8]The sample period starts from 2014 Q4 due to the unavailability of data for the S&P Canada investment-grade bond index series prior to 2014 Q4.

3.3.1 Option adjusted spread (OAS)

As a measure of credit spreads, I use the option-adjusted spread (OAS) of individual bonds. Option adjusted spread (OAS) calculates the yield difference between a bond and treasury security after accounting for embedded options. It is the spread that must be added to the yield of benchmark security (i.e., the yield of a zero-coupon bond) such that the discounted cash flows of a bond match the market price of the bond. Typically, credit spreads are calculated by taking the yield difference between a bond and a treasury security of matching duration. When bonds embed options in them, due to the possibility of being called early, it becomes difficult to identify the date of maturity of a bond (Gilchrist and Zakrajšek (2012)). Using OAS as a measure of spread adds advantage because it calculates the spread of a bond over an issuer's spot rate curve (i.e., the yield of a zero-coupon Treasury bond) after adjusting (removing) cash flows generated from embedded options. Thus, matching maturity remains no more a concern. Moreover, this allows to include a variety of corporate bonds in the sample conditional on their structure. In my sample, more than 60 percent of the bonds embed options in them. Hence, using OAS as a measure of spread is best suited for this analysis.

Table 3.2 presents the summary statistics for OAS (a measure of credit spread). The average spread of bonds included in my sample is approximately 166 basis points. Bonds with lower ratings are riskier, and therefore investors expect higher compensation to account for the increased risk. This is reflected in the higher value of spread for bonds with a lower rating.

Table 3.2: Summary statistics of OAS

	Full sample	**BBB**	**A**	**AA**
Average OAS	166.34 (bp)	192.38 (bp)	142.73 (bp)	98.10 (bp)
No of bonds	336	163	163	10

bp is basis points. This table displays the average OAS of bonds for the full sample as well as for different rating categories. The sample consists of investment-grade bonds issued in domestic currency by non-financial Canandian corporations.

3.3.2 Explanatory variables

Below, I briefly describe the explanatory variables included in the empirical model distributing them in 3 categories:

Macroeconomic determinants: Previous studies have identified GDP growth rate (Tang and Yan (2010)) and inflation rate (Chun et al. (2014)) as macroeconomic determinants of credit spreads. In my analysis, in addition to the growth rate of real GDP, I include the CPI inflation rate to account for changes in the aggregate economy. Most of the previous studies (Longstaff and Schwartz (1995), Collin-Dufresn et al. (2001)) use the short-term or the long-term risk-free rate as a measure of interest rate. But in my analysis, I include the overnight interest rate as the Bank of Canada issues its monetary policy targeting this interest rate. Changes in the overnight rate influence the liquidity in the overall economy. Return data on the S&P TSX index enters the model as an explanatory variable to see how domestic stock market movements affect the corporate spreads. I also include the CAD/USD exchange rate as another macroeconomic determinant of credit spreads to see how external factors affect domestic corporations' credit conditions. I choose to include the bilateral exchange rate between the U.S. and Canada instead of the real effective exchange rate due to the high volume of trade (nearly half of total trade by Canada) between the two countries.

Firm-specific determinants: The firm-level determinants are primarily derived following Altman (2013). The variables include a measure on firm profitability (Earnings before interests and taxes (EBIT)/Asset)), liquidity (Working capital/Asset), leverage (Debt/Asset) and firm size (natural logarithm of total asset). Return on asset (EBIT/Asset) measures the effectiveness of a firm's assets before any tax or leverage considerations. Altman (2013) shows EBIT/Asset outperforms other profitability measures in predicting the financial distress of a firm. Working capital is the difference between current assets and current liabilities. Reduction in current assets relative to total assets is an indicator of a firm in financial distress, and Altman (2013) finds the Working capital/Asset ratio to be a better predictor of financial distress compared to other liquidity measures. The debt/Asset ratio measures how much of a firm's total assets are financed by borrowing. Too much debt can increase the risk of default by a firm. Previous empirical studies (e.g., Charalambakis and Garrett (2019)) find leverage ratio (Debt/Asset) to be a significant predictor of financial distress. Finally, firm size is also found to be a significant predictor of financial distress by Altman (2013).

Bond-specific determinants: For bond-specific determinants, I follow Cavallo and Valenzuela (2010) to include time to maturity of bonds and an interaction term between time to maturity and firm leverage. Firms with low levels of debt may face higher interest rate risk with longer maturity bonds because longer maturity bonds are more sensitive to interest rate changes in the future. Again, firms with high debt levels may face lower liquidity risk with longer maturity debt. The interaction term captures the possible correlation that can arise between firm leverage and term structure.

Table 3.3: Summary statistics of explanatory variables (2012 Q1 - 2019 Q3)

	Mean	**Median**	**Std. Dev**	**CV**	**No of observations**
Firm-specific					
Earnings before interests and taxes (EBIT)/Asset	2.005	1.760	1.627	81.147	5224
Debt/Asset	50.860	39.733	35.253	69.314	5224
Working capital/Asset	3.889	1.036	10.980	282.335	5224
Size	9.888	9.570	2.202	22.269	5224
Bond-specific					
Time to maturity	18.557	19.238	10.035	54.077	5224
Macroeconomic					
GDP growth rate	0.487	0.542	0.438	0.899	5224
Policy rate	0.997	0.997	0.425	0.426	5224
CAD-USD exchange rate	1.245	1.291	0.112	0.090	5224
Inflation rate	1.657	1.600	0.502	0.303	5224
Stock market index return	0.993	1.417	5.423	5.461	5224

Tables 3.3 and 3.4 summarize the descriptive statistics of the explanatory variables and the correlations among them. The firms included in the sample, on average, are highly levered. The distribution of their debt to asset ratios is also rightly skewed. The bonds included in the sample overall are long-maturity bonds with median maturity of 19 years. Most firm-level and bond-level variables have large variances as apparent from their coefficients of variation. Except for the moderate correlation between firm profitability (EBIT/Asset) and leverage (Debt/Asset), the majority of the firm-level variables do not share a substantial correlation with each other. In the set of macroeconomic variables, only inflation rate and the policy rate share a moderate correlation which is expected given that I use the overnight interest rate as a proxy which is a nominal measure and affected by inflation.

Table 3.4: Correlation matrix

	Firm-specific determinants				
	EBIT/Asset	Debt/Asset	Working capital/Asset	Size	
EBIT/Asset	1.00				
Debt/Asset	0.45*	1.00			
Working capital/Asset	0.02	-0.25*	1.00		
Size	-0.3*	-0.26*	-0.03*	1.00	
	Macroeconomic determinants				
	GDP growth	Policy rate	Exchange rate	Inflation rate	Return
GDP growth rate	1.00				
Policy rate	-0.01	1.00			
CAD-USD exchange rate	-0.04*	-0.00	1.00		
Inflation rate	0.21*	0.56*	0.29*	1.00	
Stock market index return	-0.01	0.06*	-0.04*	-0.09*	1.00

This table displays the correlations among the firm-specific and macroeconomic variables used in the baseline analysis for the sample period between 2012 Q1 - 2019 Q3. * indicates significance at 5% level.

3.3.3 Econometric specification

The baseline specification I estimate is,

$$S_{i,t} = \alpha_0 + \alpha_1 F_{j,t-1} + \alpha_2 B_{i,t-1} + \alpha_3 M_{t-1} + \alpha_4 trend + \delta_i + \epsilon_{i,t} \tag{3.3.1}$$

where, $S_{i,t}$ is the OAS (in basis points) of bond i in quarter t, $F_{j,t}$ is a vector of firm-specific variables for issuer j, $B_{i,t}$ are bond characteristics, M_t is a vector of macroeconomic determinants of credit spread, and $\epsilon_{i,t}$ is the error term. I also add a trend term (a linear term in time variable, quarter) to control any spurious relationship the time-varying variables share. To further control for unobserved time-invariant heterogeneity at the bond level, I include bond-specific fixed effects denoted by δ_i.[9] The regressors enter the regression with a lag to avoid any bias that might

[9] I use bond-specific fixed effects because my analysis is based on bond level spreads. Also, as bonds are nested in firms, controlling for bond-specific unobserved heterogeneity also controls the fixed-effects at the firm/issuer level.

arise due to endogeneity stemming from simultaneity. The baseline specification does not include individual time dummies as the macro variables have no variation across bonds and only vary over time. I estimate the baseline regression using OLS for the whole sample as well as for different rating categories. Besides estimating the baseline specification, I provide a variance decomposition analysis to quantify the relative importance of various classes of determinants in explaining variations in the spreads. I also perform some robustness exercises, which I present in Section 3.5. Finally, in addition to analyzing the level effects of the macroeconomic determinants, in Section 3.2.6 I examine how the volatilities of some key macroeconomic variables affect the credit spreads.

3.4 Empirical results

Table 3.5 presents the OLS estimation results of the baseline model. Panel A reports the results from the baseline estimation of equation (3.3.1), and panel B reports results from pooled OLS estimation of the same equation, which additionally controls for bond ratings.

Both regressions produce similar coefficients for macroeconomic variables, which is expected as the macroeconomic variables do not vary across bonds. For bond- and firm-specific variables, the results vary between the two specifications. Although the Hausman test identifies OLS-FE estimation as the better fit for this model, I present the results from pooled OLS estimation to check how much the coefficients change due to the cross-sectional variation.

The coefficient of GDP growth rate is negative in both regressions, as expected from the counter-cyclical nature of credit spreads. High GDP growth indicates a well-performing economy which translates to higher asset value for firms and a narrower spread. The exchange rate coefficient is positive, which is consistent with the exchange rate risk faced by foreign investors. When exchange rates go up (the Canadian dollar depreciates), foreign investors face exchange rate risk on their expected cash flow from investment in Canadian bonds. This increased risk results in a higher yield paid by the debt issuers.

Table 3.5: Determinants of OAS, 2012 Q1 - 2019 Q3

Dependent variable OAS	**Panel A (OLS FE)**	**Panel B (Pooled OLS)**
Macroeconomic factors		
GDP growth rate	-13.351**	-13.172**
	(-21.97)	(-10.58)
Policy rate	25.995**	24.245**
	(18.38)	(10.38)
CAD-USD Exchange rate	337.489**	320.430**
	(32.59)	(23.20)
Inflation rate	8.930**	9.374**
	(10.93)	(6.99)
Return	-0.918**	-0.905**
	(-25.06)	(-10.75)
Bond specific		
Time to maturity	-0.777*	3.200**
	(-2.53)	(32.28)
Time to maturity x Debt/Asset	0.013**	-0.007**
	(3.13)	(-5.30)
Firm specific		
EBIT/Asset	-0.085	1.563**
	(-0.19)	(3.80)
Debt/Asset	-0.535**	-0.044
	(-3.29)	(-1.02)
Working capital/Asset	0.692**	0.138*
	(5.29)	(2.38)
Size	-3.285	-1.176**
	(-0.80)	(-5.00)
Constant	1166.447**	1083.366**
	(27.51)	(31.44)
Rating dummies	No	Yes
Trend	Yes	Yes
No of observations	4537	4537
R^2	0.18	0.64

White-Hubar estimator corrects for heteroskedasticity and clustering. The t-statistics are reported in parenthesis. **, and * indicate significance at 1%, and 5% level respectively.

The interest rate/policy rate enters the regression with a positive coefficient. This positive coefficient implies that a corporate bond's yield is more sensitive to the interest rate increase than the yield of a risk-free bond. An increase in the overnight rate can increase the interest rate banks charge for commercial loans. Hence, it becomes difficult for firms to finance their investment through bank loans. Again, the opportunity cost for investors to invest in a bond also increases. Intuitively, this high nominal interest rate increases the risk premium of holding a corporate debt which widens the spreads. Again, the positive relationship can also stem from the correlation between the interest rate and the firm value (Collin-Dufresne and Goldstein 2001). If they are negatively correlated, then an increase in the interest rate decreases the value of the underlying assets for the firm, thereby widens the spreads.

There is a positive and significant relationship between inflation and corporate credit spreads; higher inflation leads to higher spreads. Higher inflation leads to lower expected cash flow in real terms from bond investment. Again, higher inflation also increases the nominal liabilities for firms by increasing wages and interest rates. Higher liabilities paired with low real cash flow increases the default risk by firms. This inflation risk induces issuers to increase the yield to compensate for the additional risk faced by investors.

The coefficient on the stock return is negative and significant. This finding is also consistent with the literature studying other bond markets that argues that a higher stock market index sends a positive signal to investors about the lower risk of default by firms due to rising stock prices. This positive signal leads to a reduction in the price of default risk, thereby shrinking the spread.

Bond maturity has a small and negative effect on credit spreads in the fixed-effect regressions. The interaction term that accounts for the non-linearity between bond maturity and the firm's debt structure enters with a positive coefficient in the fixed-effect regressions. This result is consistent with the rightly skewed debt distribution in the sample. As the majority of the firms in the sample are highly leveraged, thus, increased maturity gives the firms more time to pay back debt which eventually reduces default risk. Again, this reduction in risk is slightly smaller for firms with more debt, as reflected by the positive interaction term. In contrast, coefficients associated with bond maturity along with the interaction term enter with opposite signs in the pooled regressions.

Most of the coefficients are similar in their signs for firm-specific variables but vary in statistical significance across the two specifications. When I control for bond-specific fixed-effects, more leverage results in a lower compensation offered by firms, and this reduction in spreads is smaller for bonds with longer maturity. Although higher debt levels should increase the risk of default, one possible reason for the negative relationship can be attributed to the mean-reverting leverage ratio and investors' expectations about future firm leverage. Collin-Dufresne and Goldstein (2001) find that if the firms adjust their debt levels according to their firm value, then this generates a mean-reverting debt structure which can give rise to larger spreads for firms with low leverage. Again, expectations about a firm's future leverage have a significant role to play in determining the riskiness of investing in a bond (Flannery et al. (2012)). Hence, high leverage in the past quarter can influence investors' expectations to anticipate a reduction in firms' future debt holding, thereby expecting a lower compensation for risk in the current quarter. The coefficient of liquidity is positive and significant in both specifications. Finally, profitability and firm size do not have any statistically significant impact on the spreads. However, the signs of the coefficients are both consistent with theory. In the pooled regression, the coefficients associated with most firm-specific variables enter the model with similar signs as the FE regression with the exception of firm profitability.

Table 3.6 presents the results of the baseline regression estimated for different rating categories. All macroeconomic variables enter the regressions with the same sign as in the full sample. Except for the inflation rate, the coefficients for other macroeconomic variables are relatively larger in magnitude for bonds rated BBB. Hence, changes in the GDP growth, interest rate, the exchange rate, and the stock market return have a greater impact on bonds that rate between BBB- to BBB+. Although the coefficient associated with the stock index return is not statistically significant effect for AA rated bonds, it enters with the same sign as the other sub-samples. Bond maturity reduces spreads by a small amount only for A rated bonds.

The magnitude, sign, and statistical significance of coefficients for firm-specific control variables vary substantially across sub-samples of bonds with different ratings. EBIT/Asset ratio, which measures a firm's profitability, has no significant effect on the spreads of bonds rated BBB but surprisingly increases the spreads for A and AA rated bonds. Firm leverage has a statistically significant negative effect on the spreads of BBB rated bonds. Liquidity increases the spreads for AA and BBB rated bonds but has no significant effect on the spreads of A rated bonds. An increase in the firm size increases the spreads for AA rated bonds. The coefficient for firm size is not statistically significant at a 5% level for the other bonds.

Table 3.6: Determinants of OAS by rating category

Dependent Variable	AA rated bonds	A rated bonds	BBB rated bonds
OAS			
Macroeconomic factors			
GDP growth rate	-9.463**	-10.009**	-16.252**
	(-2.98)	(-20.28)	(-15.43)
Policy rate	16.837**	25.411**	27.076**
	(4.05)	(22.56)	(10.51)
CAD-USD Exchange rate	232.743**	286.884**	394.702**
	(11.06)	(35.57)	(22.91)
Inflation rate	22.293**	5.618**	12.710**
	(3.95)	(8.87)	(9.24)
Return	-0.155	-0.676**	-1.113**
	(-1.48)	(-22.17)	(-15.98)
Bond specific			
Time to maturity	-2.912	-0.614*	-0.981
	(-1.14)	(-1.88)	(-1.32)
Time to maturity x Debt/Asset	0.034	0.006	0.031*
	(0.71)	(1.52)	(1.70)
Firm specific			
EBIT/Asset	3.992**	1.953**	-0.449
	(2.86)	(3.14)	(-0.81)
Debt/Asset	0.402	-0.092	-1.125**
	(0.47)	(-0.54)	(-2.97)
Working capital/Asset	-0.199	0.532**	0.549**
	(-0.37)	(4.92)	(2.10)
Size	40.086	13.105**	-12.604*
	(1.62)	(4.00)	(-1.97)
Constant	508.782	855.231**	1450.162**
	(1.63)	(27.69)	(24.79)
R^2	0.05	0.08	0.28
Trend	Yes	Yes	Yes
No of observations	67	2239	2231

This table presents the OLS-FE estimation results of the baseline model for bonds under different rating category. White-Hubar robust standard error corrects for heteroskedasticity and clustering. The t-statistics are reported in parenthesis. **, and * indicate significance at 1%, and 5% level respectively. AA represent AA-, AA, and AA+ rated bonds. A represent A-, A, and A+ rated bonds. BBB represent BBB-, BBB, BBB+ rated bonds.

To analyze the relative contribution of different types of determinants, I perform a variance decomposition of OAS spread.[10] Figure 3.1 shows the variance contributions of only the time-variant determinants. The firm- and bond-specific determinants have very negligible contributions towards variation in the aggregate spread. However, the contribution of macroeconomic determinants on the aggregate spread is about 7%. The rating-wise decomposition shows that macroeconomic determinants contribute relatively more towards the variation in spreads of AA rated bonds compared to the riskier (A and BBB rated) ones. This implies that while economic theory applies better on the higher rated less risky bonds, idiosyncratic factors contribute more towards the more risky bonds.

In Figure B.4 I also include the contribution of the time trend and the bond-specific FE. The joint contributions of time-varying and time-invariant bond-specific factors amount to more than 22% of the total variation. The time trend is the second largest contributor in explaining variation in spreads for these bonds. One thing to note here is that the number of AA rated bonds is very small, and this creates a possibility of less reliable econometric inference for these bonds. For A and BBB rated bonds, unobserved heterogeneity across bonds explains a large amount of the variation in the spreads.

Since unobserved heterogeneity associated with bonds account for a lot of the variation in spreads, similar to findings in the previous literature, a large portion of

[10] I use an ANOVA model to analyze the relative contributions. The contribution of each determinant X_i on the variance of Y is calculated as $\frac{PSS_{X_i}}{TSS_Y}$ where PSS is the partial sum of squares, and TSS is the total sum of squares. I use the marginal sum of squares to calculate the partial sum of squares, so the order in which the variables enter the model does not affect the variation they generate on the dependent variable.

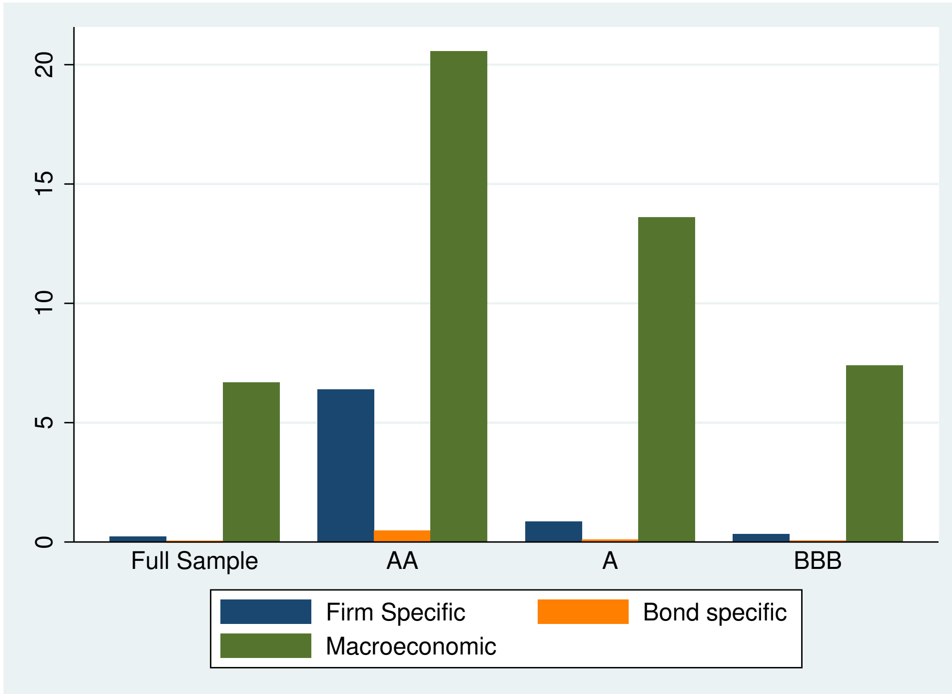


Figure 3.1: Variance decomposition of OAS spread

the variation in spreads remains unaccounted for. Besides, the relative importance of the determinants in explaining spreads variation also depends on the riskiness of the bonds. As far as the macroeconomic determinants are concerned, they account for a small share of variance in the spreads of bonds (of any rating) issued by Canadian non-financial corporations. Consistent with previous empirical evidence on large and developed U.S. bond market (Collin-Dufresn et al. (2001); Duffie et al. (2007)), macroeconomic determinants do have a significant role in explaining the credit spreads in the context of a small market like Canada as well. Cavallo and Valenzuela (2010) apply a similar econometric analysis followed in this chapter on a smaller set of emerging market bonds and find firm-level fundamentals as the most prominent source of variation in the spreads.

The variance decomposition analysis also points towards the existence of a 'credit spread puzzle' in a different way in the context of the Canadian corporate bond market. The finding that unobserved time-invariant bond FE explains most of the variations in the spreads creates an avenue for further research on exploring specific bond- or firm-specific characteristics that risk models can include. In this respect, the most closely relatable existing explanation for the Canadian bond market is concentration risk. As Amato and Remolona (2003) highlight, the returns distribution in the bond market is highly negatively skewed. The investors, therefore, need to have massively large portfolios in order to achieve full diversification, which is unattainable in the bond market. In the absence of such diversification, unexpected losses will be priced into credit spreads. The problem of diversification is more pronounced in the Canadian bond market. The bond and equity markets in Canada are very small compared to the respective global markets' sizes. Moreover, the majority of the investment-grade bonds are issued by large utility companies (more than 67% in my sample) in Canada. The lack of diversification opportunities in the portfolio of investors in Canadian bonds increases the concentration and correlation risk. These risks feed into the pricing of bonds, which reflects in higher spreads. The bond FE included in the regressions captures this high concentration of utility firms in the sample. Findings in this chapter also indicate that the nature of the bond market and the economy may explain some variations in the borrowing cost.

3.5 Robustness check

I perform a variety of robustness checks to account for potential model misspecification or endogeneity arising from firm-specific variables. In the first specification, I control for firm-specific endogeneity and estimate the baseline regression by two-step dynamic panel GMM proposed by Arellano and Bond (1991). In this specification, I also include lagged spread as an explanatory variable to control for any missing information it might contain. In another specification, I replace the overnight rate with the risk-free interest rate and include term spread (the slope of the yield curve) as an additional explanatory variable to re-estimate the regressions. Finally, I re-estimate the baseline equation 3.3.1 for monthly frequency, including only the macroeconomic controls. In all of these specifications, I control for bond-level fixed effects.

3.5.1 Endogeneity

If there is any persistence in the spreads, then the baseline specification might give biased results due to endogeneity arising from the autocorrelation of spreads. To address this concern, I re-estimate the baseline regression using two-step dynamic panel GMM proposed by Arellano and Bond (1991). In this specification, I also include lagged spreads as an additional explanatory variable. Inclusion of lagged spreads allows controlling for any missing information that the lagged value of spreads might contain and reduce the possibility of an omitted variable bias. I also instrument all firm-specific variables with GMM-style instruments (all lags of the endogenous variables). Table 3.7 presents the results for GMM estimation.

The coefficients associated with the macroeconomic variables remain statistically significant with the same signs as the baseline results. The magnitude of these coefficients, however, slightly differs from those reported by the OLS estimation. Interestingly, the coefficients associated with the bond- and firm-specific determinants no longer remain statistically significant after controlling for endogeneity. This implies that the OLS estimates associated with firm-specific variables did suffer from endogeneity and likely produce biased estimates for firm-level variables in the OLS estimations.

Table 3.7: Determinants of OAS, 2012 Q1 - 2019 Q3 (GMM estimation)

Macroeconomic factors	
Lagged OAS	0.352**
	(6.14)
GDP growth rate	-15.415**
	(-7.83)
Policy rate	18.095**
	(4.04)
CAD-USD Exchange rate	242.069**
	(6.76)
Inflation rate	21.151**
	(11.74)
Return	-0.311**
	(-3.74)
Bond specific	
Time to maturity	0.577
	(0.49)
Time to maturity x Debt/Asset	-0.019
	(-1.07)
Firm specific	
EBIT/Asset	-0.553
	(-1.24)
Debt/Asset	-0.067
	(-0.16)
Working capital/Asset	0.383
	(1.60)
Size	-11.974
	(-1.21)
No of observations	4068
Sargan statistic of over identifying restrictions	335.28**

Windmeijer bias-corrected (WC) robust standard errors are used to construct the t statistics (reported in parenthesis). Instrumented EBIT/Asset, Debt/Asset, Working capital/Asset and Size. **, and * represent significance at 1%, and 5% level respectively.

3.5.2 Level and slope of the yield curve

As an additional robustness exercise, I replace the overnight rate with the risk-free interest rate (the 10-year benchmark bond yield) as a proxy for interest rate and include the slope of the yield curve or the term spread as an additional explanatory variable. The slope of the yield curve provides information about the financial market's expectation about the direction of future short-term interest rates. The level and slope of the yield curve are important determinants of the dynamics of the term structure of interest rate (Merton (1974)). A negative slope signals a weakening economy and reduction in firms' asset value, which, in turn, widens the spread. I construct the proxy for the term spread from the yield difference between 10- and 2-year benchmark bonds (Boss and Scheicher (2002)).

Table 3.8 shows the results with the above specifications included. For brevity, I only report the results from OLS-FE regressions for the full sample and the different rating categories. The results show a negative relationship between the slope of the yield curve and bond spreads. The negative relationship between the term spread and the bond spreads holds in the full sample and across different rating categories. A reduction in term spread signals weakening of the economy in the future and hence increases credit spreads. The positive association between the risk-free rate and the spreads implies that an increase in the 10-year benchmark bond yield induces a more than proportionate increase in the yields of corporate bonds compared to risk-free bonds. This finding is in contrast to the usual negative relationship between the risk-free rate and credit spreads, as found by notable theoretical studies like Merton (1974), Longstaff and Schwartz (1995), and Duffee (1998). This positive association can be attributed to the correlation coefficient between the risk-free interest rate and the firm value stated above. Morris et al. (1998) and Bevan and Garzarelli (2000) also find corporate spreads to be positively correlated to the risk-free rate.

The results also show a slightly more significant effect of GDP growth rate on the

Table 3.8: Determinants of OAS, 2012 Q1 - 2019 Q3

Dependent variable OAS	**Full Sample**	**AA**	**A**	**BBB**
Macroeconomic factors				
GDP growth rate	-17.493**	-11.488**	-14.567**	-19.749**
	(-28.44)	(-4.12)	(-25.99)	(-19.07)
Term spread	-16.663**	-27.847*	-79.36**	-29.168**
	(-5.37)	(-2.30)	(-3.65)	(-5.10)
Risk free interest rate	8.50**	16.079*	5.164**	12.281**
	(5.68)	(2.38)	(3.98)	(4.43)
CAD-USD Exchange rate	275.112**	270.374**	203.214**	35712.82**
	(23.79)	(5.81)	(24.87)	(18.49)
Inflation rate	9.112**	15.982**	6.80**	11.79**
	(11.12)	(3.78)	(11.27)	(7.91)
Return	-0.884**	-0.037	-0.709**	-0.996**
	(-20.34)	(-0.31)	(-17.08)	(-12.49)
Bond specific				
Time to maturity	-0.797**	-2.231	-0.546	-1.199
	(-2.52)	(-1.27)	(-1.56)	(-1.64)
Time to maturity x Debt/Asset	0.013**	0.012	0.005	0.038*
	(2.99)	(0.36)	(1.11)	(2.09)
Firm specific				
EBIT/Asset	0.055	3.434	2.226**	-0.329
	(0.13)	(1.68)	(3.95)	(-0.67)
Debt/Asset	-0.474**	1.236	0.038	-1.255**
	(-2.75)	(2.18)	(0.21)	(-3.27)
Working capital/Asset	0.598**	0.575	0.406**	0.522*
	(4.21)	(0.89)	(3.39)	(2.01)
Size	-2.65	23.404	13.701**	-10.136
	(-0.64)	(0.75)	(4.11)	(-1.57)
Constant	1122.474**	495.479	709.017**	1547.259**
	(18.56)	(1.32)	(18.44)	(16.10)

White-Hubar estimator is used to correct for heteroskedasticity and clustering. The t-scores are reported in parenthesis. **, and * indicate significance at 1%, and 5% level respectively.

spreads. Compared to the baseline estimates, the coefficients associated with the other macroeconomic variables are smaller in magnitude for the entire sample and different rating categories. Most bond- and firm-specific variables enter the regression with similar signs and statistical significance with similar or relatively smaller magnitudes than the baseline regressions.

3.5.3 Data frequency

All the above exercises use data in quarterly frequency for a short sample period (2012 - 2019). Due to the short time length, there is a possibility that the baseline model does not have enough variations in the time series. To allow for more variations in the time series of the determinants, I use monthly data for the same time duration and run the baseline model without firm-specific and bond-specific controls. However, I include the bond-specific fixed effects to control the bonds' and their issuers' time-invariant characteristics. It should be safe to assume that the loss of the model's explanatory power due to not including firm-specific and bond-specific controls is limited because of the negligible contribution of the firm-specific and bond-specific determinants found from the GMM and the variance decomposition exercises presented above. I include one additional macroeconomic control, oil price growth, in this model. As most bond issuing firms in the sample belong to the energy sector, they are likely to be significantly affected by oil price movements. As a proxy for oil price growth, I use the monthly growth rate of the seasonally adjusted data on West Texas Intermediate crude oil price. Table B.2 shows that all macroeconomic determinants except the stock market return retain their expected signs. Spreads reduce when oil price grows because, with the increased oil price, investors feel confident about future earnings of the bond issuing firms due to lower default risk. However, stock market return enters the regression with a positive sign, unlike the findings with quarterly data. One probable reason for this can be the perception of the bond investors. If the average stock returns are persistently higher in the past quarter, the investors feel more confident to substitute away from bonds and invest in the stock market. However, a higher return in the past month may not convince investors to buy more stocks by selling bonds.[11]

I also perform the variance decomposition analysis using the monthly data. Figure B.5 presents the visual illustration of the variance decomposition for monthly OAS. Similar to quarterly data, bond-specific FE dominates in explaining much of the variations in the spreads. Macroeconomic determinants continue to contribute more towards explaining variations in the spreads for higher rated bonds.

In addition to the above findings, using the monthly data, I find that predicted credit spreads significantly improve the prediction of future GDP growth. Towards this, I include the predicted spreads estimated from equation (3.3.1) without the bond- and firm-specific variables in a simple model of GDP growth regressed on its lags and two monetary policy variables, real overnight interest rate, and the term spread. I find that the adjusted R^2 improves to 0.25 for a model with predicted spreads from 0.13 for a model with spreads obtained from data. B.2 provides the details of the forecasting exercise.

3.6 Macroeconomic uncertainty

In addition to looking into the level effects of macroeconomic determinants on credit spreads, I also examine how the volatilities of some of these determinants affect the spreads. Higher volatility implies higher uncertainty, and higher uncertainty is expected to increase firms' default risk, thereby widening the spreads. In this specification, I include the second moments of macroeconomic variables (a proxy for uncertainty) as an additional explanatory variable to examine how the volatilities of

[11] Adding more lags of the stock return shows that the negative relationship between the credit spreads and stock return shows up in the third lag.

the macroeconomic variables affect the spreads besides their level effects. I apply a Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model to construct the proxies for macroeconomic uncertainty. Previous literature (Byrne and Davis (2005); Driver et al. (2005);Baum et al. (2006)) apply this method of obtaining proxy of uncertainty from the conditional variance of macroeconomic variable. Baum and Wan (2010) follows the same methodology to show the impact of macroeconomic uncertainty on CDS spreads using U.S firm-level data.

I construct three measures of macroeconomic uncertainty. The first proxy construction uses the conditional variance of GDP, representing the overall uncertainty of the economy. The second measure captures the financial market uncertainty from the conditional variance of the quarterly index of S&P/TSX return. The third measure is a proxy for external uncertainty, for which I use the conditional volatility of the CAD/U.S exchange rate. I construct all proxies of uncertainty by fitting a lower order (1,1) GARCH model. Table B.3 provides the details of the GARCH specifications. Finally, I include a measure of policy uncertainty to examine how corporate bond spreads respond to uncertainty around economic policy. I use the national economic policy uncertainty (EPU) index for Canada by Baker et al. (2016) as a measure of policy uncertainty.[12]

Table 3.9 reports the results for the baseline regression with macroeconomic uncertainty entering as an additional determinant. All regressions for four different

[12]For Canada, Baker et al. (2016) construct an index based on newspaper articles regarding policy uncertainty. The newspapers included in the index calculation are The Gazette, The Vancouver Sun, The Toronto Star, The Ottawa Citizen, and The Globe and Mail, including articles from the Canadian Newswire. The authors search for terms like ‘uncertainty’, ‘economy’ along with policy-relevant terms such as ‘policy’, ‘tax’, ‘spending’, ‘regulation’, ‘central bank’, ‘budget’, and ‘deficit’.

Table 3.9: Determinants of OAS, 2012 Q1 - 2019 Q3

Dependent variable	**Macroeconomic Uncertainty**			
OAS (in basis points)	**GDP growth**	**Stock market return**	**Exchange rate**	**Policy**
Macroeconomic factors				
GDP growth rate	-14.789**	-14.046**	-12.468**	-13.953**
	(-12.80)	(-11.93)	(-12.36)	(-12.86)
Policy rate	25.722**	7.955**	25.203**	24.127**
	(-10.42)	(2.11)	(10.09)	(9.33)
CAD-USD Exchange rate	314.777**	249.583**	311.927**	313.948**
	(15.10)	(13.18)	(14.71)	(16.25)
Inflation rate	12.534**	9.506**	9.203**	9.257**
	(9.03)	(6.94)	(7.98)	(7.73)
Return	-0.840**	-1.509**	-0.767**	-1.042**
	(-15.24)	(-9.07)	(-17.10)	(-14.97)
Uncertainty	367211.900**	4616.354 **	4325.525 **	-0.064**
	(15.76)	(4.51)	(13.00)	(-6.97)
η	0.07**	0.10**	0.04**	-0.09**
	(0.004)	(0.023)	(0.003)	(0.014)
Bond specific				
Time to maturity	-0.819**	-0.753**	-0.787**	-0.752**
	(-2.38)	(-2.32)	(-2.27)	(-2.07)
Time to maturity x Debt/Asset	0.014**	0.014**	0.015**	0.014**
	(2.53)	(2.57)	(2.58)	(2.44)
Firm specific				
EBIT/Asset	-0.241	-0.003	0.130	-0.211
	(-0.24)	(0.00)	(0.13)	(-0.21)
Debt/Asset	-0.540**	-0.549**	-0.517**	-0.495**
	(-2.48)	(-2.36)	(-2.35)	(-2.39)
Working capital/Asset	0.667**	0.714**	0.589**	0.702**
	(2.72)	(2.75)	(2.29)	(2.97)
Size	-2.187	-2.732	-2.910	-3.396
	(-0.23)	(-0.28)	(-0.30)	(-0.36)

White-Hubar estimator corrects for heteroskedasticity and clustering. The t-scores are reported in parenthesis. **, and * indicate significance at 1%, and 5% level respectively. η is the elasticity of spreads with respect to changes in uncertainty and its standard error is reported in the parenthesis below.

uncertainty proxies generate similar results. The original relationship between the spreads and the macroeconomic variables in their level forms continues to hold. The coefficients associated with the bond- and firm-specific controls also retain similar signs and magnitudes. An increase in any form of uncertainty except policy uncertainty increases the spreads. η reports the elasticity of spreads with respect to each uncertainty proxy. A 10% increase in the conditional volatility of the macroeconomic variables brings about a 0.4% - 1% increase in the corporate credit spreads depending on the choice of proxy for uncertainty. Stock market volatility affects the spreads more than all other types of uncertainty. One standard deviation (0.002) increase in the stock market volatility increases the spreads by about 8 basis points. The second largest effect comes from the overall macroeconomic uncertainty measured by the conditional volatility of GDP growth. One standard deviation increase in the overall uncertainty increases the spreads by 5 basis points. The external sector uncertainty, on the other hand, increases the spreads by the least amount. Unlike other types of uncertainty, policy uncertainty, with an elasticity of 0.09% reduces spreads in the next quarter. One possible explanation for this finding is the lag between the declaration of policies and their implementation. Policies typically take a long time to take effect, which can influence investors' perceptions. Again, more uncertainty about the policy may not necessarily mean policies detrimental to investment. Including multiple lags of policy uncertainty shows, higher policy uncertainty increases spreads after about three quarters.

Table 3.10 shows the effect of different macroeconomic uncertainty on the spreads of bonds with different rating categories. The higher rated bonds are mostly responsive to policy uncertainty. A 10% increase in the policy uncertainty reduces the spreads for these bonds by about 0.8%. The second most dominating factor for these bonds is the overall economic uncertainty. On the other hand, for lower rated bonds, uncertainty associated with the stock market has the largest effect. A 10% increase in the stock market uncertainty increases the spreads for these bonds by 1.8%. The effect of exchange rate uncertainty is the same across bonds with different ratings. These findings imply that bonds with higher ratings are more affected by changes in the overall economy, while bonds with lower ratings (riskier) are more affected by stock market activities.

Table 3.10: Determinants of OAS by Rating, 2012 Q1 - 2019 Q3

Dependent variable OAS (in basis points)	**Macroeconomic uncertainty**			
A and above	**GDP growth**	**Stock market return**	**Exchange rate**	**Policy**
Uncertainty	335164.200**	1688.070	4448.501**	-0.048**
	(12.87)	(1.89)	(10.87)	(-9.45)
η	0.07**	0.05*	0.05**	-0.08**
	(0.006)	(0.024)	(0.004)	(0.018)
BBB	**GDP growth**	**Stock market return**	**Exchange rate**	**Policy**
	378224.800**	9193.143**	6922.307**	-0.0700**
	(10.72)	(5.41)	(11.89)	(-3.09)
η	0.06**	0.18**	0.05**	-0.087**
	(0.006)	(0.034)	(0.004)	(0.028)

White-Hubar estimator is used to correct for heteroskedasticity and clustering. The t-scores are reported in parenthesis. **, and * indicate significance at 1%,and 5% level respectively. η is the elasticity of spreads with respect to changes in uncertainty and its standard error is reported in the parenthesis below.

3.7 Conclusion

Previous studies have identified the importance of corporate credit spreads in predicting future changes in real economic activity for the Canadian economy. On the other hand, the corporate sector faces various risks that are affected by the macroeconomic condition of the economy. Therefore, to fully understand the feedback effect, it is crucial to identify how the macroeconomic variables affect the credit spreads. This chapter attempts to determine the importance of various macro and financial factors in explaining credit spreads for bonds issued by non-financial Canadian corporations. The results show that macroeconomic variables significantly affect the spreads across all rating categories, and the effects of bond- and firm-specific determinants vary across ratings. Variance decomposition analysis shows that unobserved heterogeneity associated with bonds accounts for the bulk of the total variation in spreads, and only a small percentage of the total variation in spreads is attributable to macroeconomic factors. The relative importance of different determinants in explaining the variation of spreads also varies across different rating classes. The effects of macro determinants are robust to different specifications of the model. Besides the level effects, the volatilities of different macroeconomic variables affect the spreads by a small percentage. The overall findings of this chapter reinforce the existence of 'the credit spread puzzle' in the context of the Canadian corporate sector.

Chapter 4

Transmission of Monetary Policy through Asset Durability Channel

4.1 Introduction

In this chapter, I explore the role of asset durability in the differential response of firms to monetary policy. I find that firms that invest in more durable assets are more responsive to monetary policy than the less durable assets using firms. For financially constrained firms, this difference is more prominent. The findings highlight the critical role asset durability plays in the financial propagation of monetary shocks on aggregate activity.

The role of credit market frictions in the propagation of business cycles and also in the transmission of monetary policy is well established in the literature. A large body of literature finds that firms' cyclical behavior and response to monetary policy depend on their respective access to the credit market. Again, a borrower firm's access to finance depends on the value of the collateral the firm places. This chapter explores if monetary policy shock has differential impacts on firm fundamentals through collateral assets' durability. During monetary contraction, an increase in the interest rate decreases the collateral values for firms and increases the real value of their debts. Thus increasing interest rates can negatively affect the production of these firms. Again, the more durable the assets are, the more expensive they are. Thus increased durability of new investments that firms also place as collateral increases firms' overall financing needs. In Chapter 2, I presented empirical evidence that increased asset durability increases the external financing costs for financially constrained firms. Therefore, more durable collateral further limits firms' ability to obtain external financing during a monetary contraction. Hence, the adverse effects of monetary contraction should substantially affect firms that place more durable assets as collateral.

Using data on the publicly listed U.S. manufacturing firms, I find that more durable assets using firms respond stronger than the less durable assets using firms to a monetary contraction. For my empirical analysis, I construct a firm-level proxy of asset durability and split the sample into groups of more and less durable assets using firms. Then by applying a VAR model, I analyze the impact of monetary policy on the time series of growth rates of sales, inventory, short-term debt, and investment for the two classes of firms. In the baseline scenario, the impulse response functions show that monetary shocks have a stronger effect on firms using relatively more durable assets. These firms face a somewhat larger decline in the growth rates due to increased interest rates. For the pre-financial crisis sub-sample, the contrast in the response between these two classes of firms is more interesting. In the pre-financial crisis sub-sample, a rate increase reduces physical capital investment and debt growths for more durable assets using firms. However, it induces less durable assets using firms to borrow more. Additionally, if the firms are financially constrained, the heterogeneous response of firms with different asset durability to monetary policy is also more prominent than the baseline scenario. Overall, the findings suggest that firms that invest in more durable physical capital are more adversely affected by a monetary contraction than those that invest in relatively less durable assets. Finally, I find that the less durable assets using firms contribute more towards aggregate sales decline. In contrast, the more durable assets using firms lead the inventory decline after a monetary contraction.

The remainder of the chapter is organized as follows: Section 4.2 documents the background literature, Section 4.3 discusses sample selection and methodology, Section 4.4 includes some descriptive analysis of the data, Section 4.5 discusses the key findings, and Section 4.6 concludes.

4.2 Background Literature

Monetary policy transmission can occur via two different channels - the interest rate channel and the credit channel. The monetary policy directly impacts firms' investment through the interest rate channel through its effects on the user cost of capital. On the other hand, monetary policy works through the credit channel by affecting the external financing premium that firms need to pay due to information asymmetry between borrowers and lenders. The existence of a credit channel or a balance sheet channel of monetary policy transmission has gained a lot of attention since the influential work of Bernanke and Gertler (1989). They identify that borrowers have to pay an external financing premium to raise funds for investment using external financing due to the agency costs associated with the asymmetric information between lenders and borrowers. Thus during a time of monetary tightening, firms with weak financial positions face a higher external financing premium, which further curbs investment and accelerates the effect of an initial shock. The chain of events responsible for this amplification of an initial shock is termed the financial accelerator mechanism. Kiyotaki and Moore (1997) offer an alternative perspective on the financial accelerator mechanism by introducing collateral constraints on firm borrowing. In this view, firms can borrow only up to a fraction of the collateral they place. Therefore, the value of their collateral restricts the amount of external financing they can obtain. The value of collateral and borrowers' access to funds can also magnify the effects of monetary policy in the economy (Iacoviello (2005)). Thus, when a firm opts for asset-based financing, the collateral plays an essential role in determining how much external financing premium the firm has to pay and the total amount of funding the firm will obtain through external financing. Rampini (2019) shows that collateral asset's durability affects the collateral constraints faced by firms and more durable assets increase a firm's overall financing needs, for which financially constrained firms tend to invest in less durable assets. In Chapter 2 I use data on the U.S. publicly traded manufacturing firms to show that asset durability increases external financing premium. Therefore, collateral assets' durability can affect the strength of the financial accelerator mechanism in the transmission of monetary policy shocks.

Previous literature finds the differential impact of monetary policy on firm fundamentals between financially constrained and unconstrained firms. A large body of empirical literature associate financial constraints with various firm-level proxies such as cash flows (Fazzari et al. 1988), size (Gertler and Gilchrist 1994), firm age (Cloyne et al. 2018), paying dividends (Fazzari et al. 1988), leverage (Ottonello and Winberry 2018) etc. A recent paper by Crouzet and Mehrotra (2020) revisits the findings of Gertler and Gilchrist (1994) and find that while smaller firms are more cyclically sensitive than large firms, this difference may not necessarily be attributed only to financial frictions. The authors argue that the heterogeneity in monetary policy response is also present for firms with similar cyclicality due to the extremely skewed sales distribution. This chapter emphasizes the link between collateral assets' durability and financial constraints, where ex-ante heterogeneity stems from the durability of collateral assets that firms purchase using financing. The external financing premium associated with investing in durable assets reflects the financial constraints faced by firms. Moreover, Lian and Ma (2018) report that cash-flow based debts constitute 80% of the total debt in the COMPUSTAT firms, with only 20% belonging to asset/collateral based loans. The paper also finds that more than 54% of the total borrowing by smaller firms are collateral based loans. In light of these findings, the analysis in this chapter is particularly useful for smaller firms (which are typically considered financially constrained) that heavily rely on collateral value for external financing.

The literature does not explore whether asset durability through its effects on collateral constraints can explain differential cyclical behavior of firms and the differential response of firms to monetary policy. The findings of this chapter contribute to the literature by exploring the critical role asset durability, and capital structure plays in the transmission of monetary shocks on aggregate activity.

4.3 Data and Methodology

In this section, I present the data sources, variable construction, and the strategy to identify monetary policy shocks I follow for my analysis.

4.3.1 Sample construction

For my empirical analysis, I consider a sample of manufacturing firms (SIC 2000-3999) over 1985 $Q1$ - 2020 $Q3$. The sample consists of quarterly data on firm fundamentals, total assets, capital stock, cash flow, sales, and capital expenditures from COMPUSTAT. I follow specific steps to prepare the data for my analysis. First, I eliminate firm-quarter observations for which total assets (item AT), physical capital (item PPEGT), and sales (item SALE) are either zero or negative. I also eliminate observations for which capital stock (item PPENT) is less than $5 million. This strategy removes firms that are too small. Next, I eliminate observations for which real asset or sales growth exceeds 100% as these large increases are likely due to mergers and acquisitions. I deflate all series to 2015 dollars using CPI data retrieved from the Bureau of Labor Statistics. To mitigate the effects of outliers present in the data, I winsorize the dataset from both ends at 5% cut-off. I use the Federal Funds Rate as the monetary policy indicator. I obtain the quarterly data on Effective Federal Funds Rate from the Federal Reserve Bank of St.Louis.

To explore how firms' response to monetary policy depends on their physical capital's durability, I split the sample into more durable asset firms and less durable asset firms. I use firm-level implied depreciation rates of physical capital to measure durability in this splitting process. Following Chen (2014) I compute the implied depreciation rate using the expression below:

$$\delta_{i,t} = \left[\frac{i_{i,t-1}}{k_{i,t-1}} + \frac{k_{i,t-1}}{k_{i,t}} - 1 \right] \tag{4.3.1}$$

where $k_{i,t}$ is the book value of physical assets (item #7 PPEGT) and $i_{i,t}$ is calculated as capital expenditures (item #128 CAPX) minus sale of property, plant, and equipment (item #107 SPPE). I drop observations for which the annual depreciation rate is negative, zero, or greater than 1. In each quarter, I rank firms according to the depreciation rate of their capital and classify those firms as high (low) durable assets using firms that are at the bottom (top) three deciles of the durability distribution. The sample separation using the durability of the past period would capture the effects of placing the existing assets as collateral. As I aim to bring out the heterogeneous response by firms that endogenously choose the durability of new investments depending on their financial constraints, I split the sample according to the firms' contemporaneous durability distribution.[1]

An essential first step is to look at how firm-level durability is correlated with

[1] One potential weakness of Compustat data is that the database includes only the listed firms that are not entirely dependent on debt financing. However, other available data sources like the Quarterly Financial Report for Manufacturing Corporations (QFR) do not provide firm-level data on assets and depreciation rates. Compustat data allows to construct a proxy variable for firm-level asset durability, which aids in the ex-ante separation of the sample of firms according to their asset durability every quarter.

other traditional financial constraints indicators like firm age and size. Firm size is the natural logarithm of total assets (Compustat item atq) of a firm. To determine the age of a firm, I follow Hadlock and Pierce (2010). The age of the firm is the number of years the firm is listed in Compustat with a non-missing stock price. The younger and the smaller firms have lower asset durability compared to their older and larger counterparts. However, the cross-sectional dependence between firm-level asset durability and firm age or size is low.[2] The small correlation between firm-level asset durability and their age or size allows for a less biased analysis of the financial constraints operating through the asset durability channel. Table 4.1 provides the descriptive statistics of some key variables:

Table 4.1: Descriptive statistics of key variables

	More Durable				Less Durable			
	Mean	Median	S.D	N	Mean	Median	S.D	N
Size	4.01	4.05	2.56	38,130	3.77	3.75	2.28	26,582
Age	26.35	25	14.3	38,137	19.21	17	12.14	26,582
Sales	0.34	0.27	7.20	38,037	0.24	0.21	0.53	26,463
Inventory	0.20	0.18	0.15	38,061	0.15	0.12	0.14	26,505
Short-term Debt	0.58	0.02	10.40	37,289	0.31	0.01	7.50	26,066
Long-term Debt	0.25	0.11	2.39	37,885	0.26	0.03	6.01	26,300

This table gives summary statistics for key firm financials for more and less durable asset using firms. Durability is measured as $1 - \delta_i$ where δ_i is the depreciation rate of physical assets used by firm i. The sample includes manufacturing firms only (SICs 2000-3999) and the sample period is 1985 $Q1$ - 2020 $Q3$. Sales (Compustat item saleq), Inventory (Compustat item invtq), Short- and Long-term Debt (Compustat items dlcq and dlttq respectively) are scaled by total assets (Compustat item atq).

The descriptive statistics show that more durable assets using firms are relatively bigger in size and older compared to the less durable assets using firms. Average sales, inventory, and short-term debt are also higher for firms using more durable

[2] The sample correlation coefficient between durability and firm size is 0.03 and between durability and firm age is 0.19. Both correlation coefficients are statistically significant at 1% level of significance.

assets. All firm financials have a rightly skewed distribution for both types of firms. However, the variances are much higher for firms using more durable assets.[3]

To gain further insight into the cyclical behavior of the two classes of firms, I construct the time series of growth rates of some key variables for both types of firms. I use the same set of variables as in Gertler and Gilchrist (1994) with one addition, investment growth rate. To construct the growth rates I compute total real sales, inventories, short-term debt, investment for every quarter by aggregating over the cross section of firms in each group.[4] For $i \in (d_h, d_l)$ where d_h denotes the group of firms with more durability (top 30% of the durability distribution) and d_l denotes the group of firms with less durability (bottom 30% of the durability distribution) let $s_{i,j,t}$ denote the sales of firm j at quarter t in group i. The cumulative sales by all firms in a group can be calculated as,

$$S_{i,t} = \sum_{j}^{N_i} s_{i,j,t} \tag{4.3.2}$$

Where $N_i \in (N_h, N_l)$ and N_h and N_l are the numbers of firms in groups d_h and d_l respectively. Then I calculate the quarterly growth rate of $S_{i,t}$ as follows,

$$g_{i,t} = \frac{(S_{i,t+1} - S_{i,t})}{S_{i,t}} \tag{4.3.3}$$

[3] The firms are sorted according to the distribution of durability every year. Although firms are divided in deciles, the less durable asset using group has a smaller number of firms than the more durable asset using group. However, the ranking appropriately captures the durability distribution as the maximum durability of less durable assets using firms (0.93) is smaller than the minimum durability of the more durable using firms (0.95).

[4] I construct the investment variable following the equation, $Investment = \frac{\textit{capital expenditures}\text{ (Compustat item (capxy))}}{\textit{lagged net property, plant and equipment}\text{ (Compustat item (ppentq))}}$.

I follow the same procedure to obtain the growth rates of other variables.

4.3.2 Monetary policy identification

I use a standard vector autoregression framework to analyze the dynamic responses to a monetary policy shock of the behavior of the two sets of firms classified according to their asset durability. The VAR consists of macroeconomic variables and financial variables. I use the federal funds rate as an indicator of monetary policy. The structure of the VAR model is as follows: Let Y_t be the vector of endogenous variables that contain both macroeconomic and financial variables. Then the general structural form of VAR in consideration is given by the following equation,

$$AY_t = c + \sum_{j=1}^{p} B_j Y_{t-j} + \varepsilon_t \tag{4.3.4}$$

where,

$$Y_t = \begin{bmatrix} \text{GNP growth} \\ \text{CPI inflation} \\ \text{More durable firms' variable} \\ \text{Less durable firms' variable} \\ \text{Federal Funds rate} \end{bmatrix},$$

A is a vector of coefficients, B_j with $j \geq 1$ is a vector of coefficients of the lagged values of Y_t, c is a vector of constants, and ε_t is a vector of structural white noise shocks. More and less durable firms' variables include sales growth, inventory growth, short-term debt growth, and investment growth computed using equations 4.3.2 and 4.3.3. I include 4 lags of each variable in the VAR using the information criteria given by Akike information criteria (AIC) and Bayesian information criteria (BIC).

To estimate equation (4.3.4) using OLS, I pre-multiply the equation with A^{-1} to obtain the reduced form VAR,

$$Y_t = d + \sum_{j=1}^{p} F_j Y_{t-j} + u_t \tag{4.3.5}$$

where, $d = A^{-1}c$, $F_j = A^{-1}B_j$, and $u_t = A^{-1}\varepsilon_t$ is the reduced form shock. The variance-covariance matrix of the reduced form shock is given by,

$$\Sigma = E[u_t u_t^{'}] = E[A^{-1}\varepsilon_t \varepsilon_t^{'}(A^{-1})^{'}] = A^{-1}(A^{-1})^{'} \tag{4.3.6}$$

If $i_t^p \in Y_t$ is the monetary policy indicator then exogenous variation to monetary policy indicator is contained in the policy shock ε_t^p. Now let a denote the column in matrix A^{-1} that corresponds to the impact of shock ε_t^p on each element of the vector of reduced form shocks u_t. The impulse response to a monetary policy shock to each vector can then be computed using

$$Y_t = d + \sum_{j=1}^{p} F_j Y_{t-j} + a\varepsilon_t^p \tag{4.3.7}$$

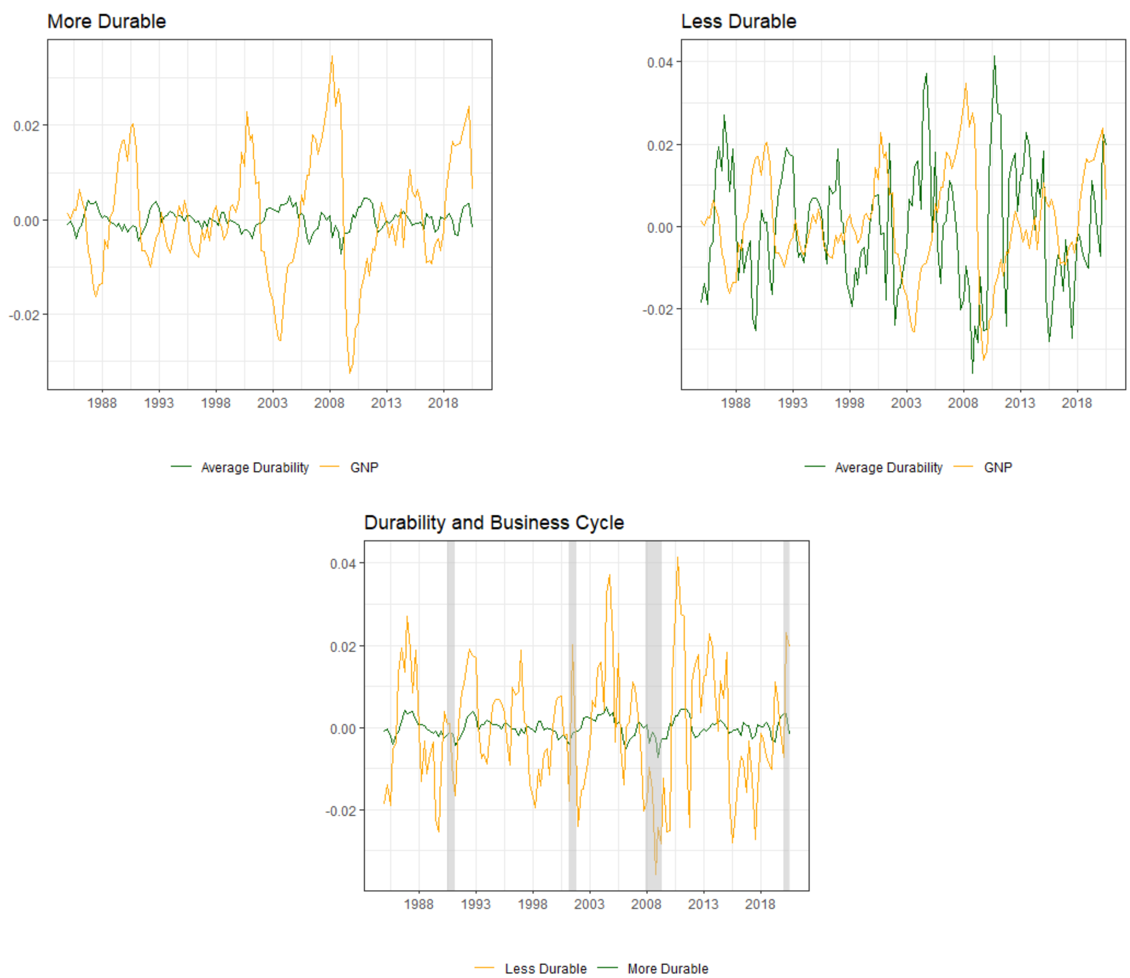
The impulse response functions will show the dynamic response of each endogenous variable included in the VAR to an external shock on the monetary policy indicator. Since each residual in the reduced form VAR is a linear combination of structural errors, meaningful impulse response functions that result from orthogonal policy shock requires imposition of additional restrictions. By imposing restrictions necessary to identify the coefficients in a, I can use the ordinary least squares estimation to estimate the coefficients in F_j and obtain the impulse response functions.

I use the Cholesky decomposition to identify the monetary policy shock using a recursive ordering following Sims (1980). Cholesky decomposition decomposes Σ into a product of a lower triangular matrix P and its transpose P'. This implies that $\Sigma = PP' = A^{-1}(A^{-1})'$ and thus that A^{-1} is lower triangular. The Cholesky decomposition implies that a shock to the variable placed first in the VAR specification has a contemporaneous effect on all other variables that come after it, but has no contemporaneous impact to a shock on the other variables that are placed before it. In other words, Cholesky decomposition places a high significance on the ordering of the variables, and macroeconomic intuition plays a key role in the ordering of the variables included in a VAR specification. In my model, I order the variables as defined by the vector Y_t by placing the macroeconomic variables on top with GNP growth followed by CPI inflation. The next in order are financial variables that include more durable and less durable firms' variable. Finally, the monetary policy indicator is placed at the bottom. The estimates of the model are not sensitive to the ordering between more durable firms' variable and less durable firms' variable.

4.4 Asset durability and firm behavior in business cycle

In this section, I provide a visual illustration of the cyclical pattern of firm-level asset durability for the two classes of firms. Figure 4.1 shows similar cyclical patterns of firm-level asset durability for more and less durable asset using firms.

Figure 4.1: Asset durability over business cycle



The figure shows the cyclical pattern of firm-level asset durability (hp filtered cyclical component) for more and less durable asset using firms plotted along with hp filtered cyclical component of the logarithm of GNP. The sample period is 1985 $Q1$ - 2020 $Q3$. The shaded columns represent NBER recession dates.

The figure illustrates a negative correlation between asset durability for both types of firms and GNP. This negative correlation stems from the procyclical nature of the price of durable assets. But the cyclicality of asset durability is different for more and less durable assets using firms during business cycles. The counter cyclicality of average asset durability of more durable assets using firms is stronger during expansions than recessions. On the contrary, the counter cyclicality of average asset durability of less durable assets using firms is stronger during recessions than expansions.[5] During good times, durable assets are relatively more expensive, due to which the firms reduce investment in more durable assets. This reduction in asset durability is more pronounced for more durable assets using firms relative to their counterparts. Alternatively, during recessions, durable assets trade cheaper, due to which firms tend to invest more in those assets. But, the less durable assets using firms tend to respond to this price decline by increasing asset durability more than those with more durable assets. Hence, more durable assets using firms reduce investment in more durable assets only when those assets are very expensive.

The bottom panel plots the cyclical components of asset durability for more and less durable assets using firms with NBER recession bars. The firms with less durable assets show large fluctuations in asset durability around the trend than the more durable assets using firms through business cycles. During recessions, borrowing constraints are stronger, but at the same time, durable assets are cheaper. Again during

[5] During good times, the correlation coefficient between the cyclical component of log GNP and asset durability is -0.52 for firms that invest in more durable assets, while for firms that invest in relatively less durable assets, the correlation coefficient is -0.25. During recessions, the correlation is very small and statistically not significant (correlation coefficient is -0.18) for more durable assets using firms, but for less durable assets using firms, there is a moderate but statistically significant correlation (correlation coefficient -0.52).

recovery, borrowing constraints relax, but durable assets are also more expensive. Moreover, in Chapter 2 I show that less durable assets using firms are typically those firms that are financially constrained. The large fluctuations of asset durability by less durable assets using firms likely stem from their financially constrained situation. During recessions, these firms tend to alter their investments by taking advantage of relatively cheaper durable assets, while during recovery, they take advantage of easier access to cash flow.

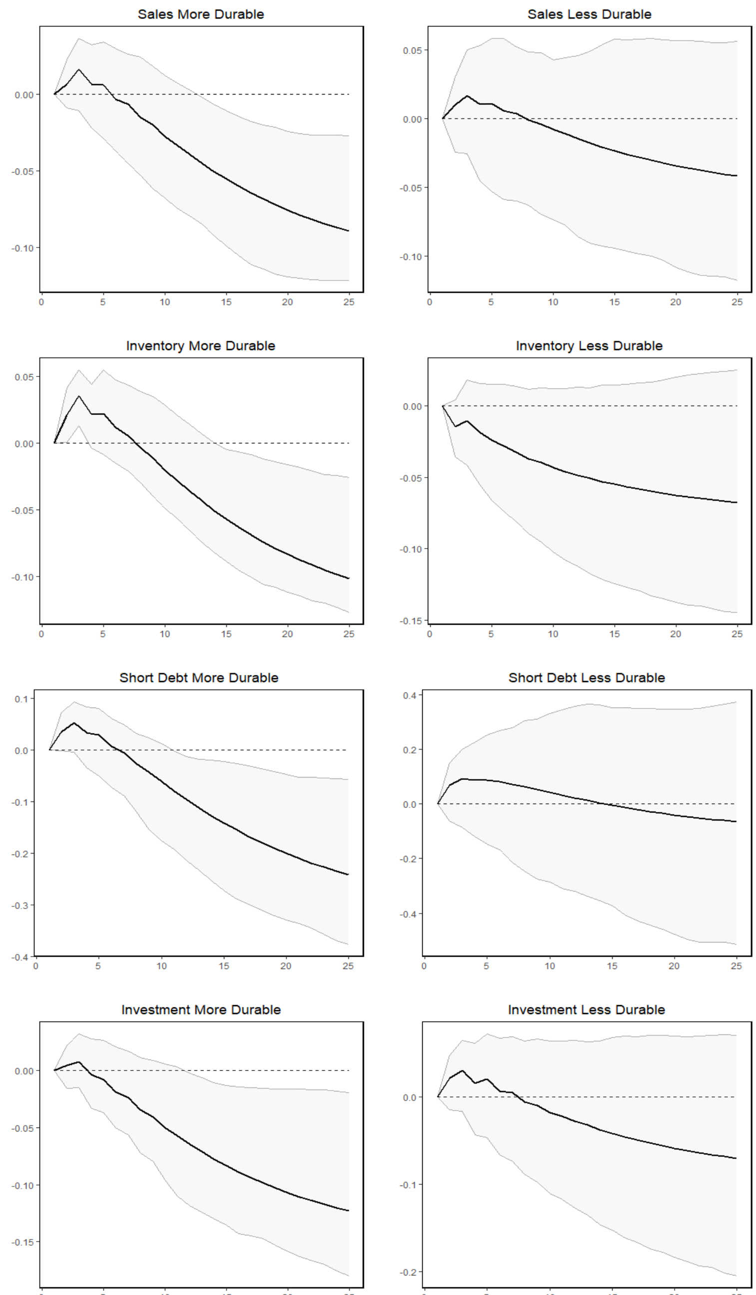
4.5 The response of more and less durable asset firms to monetary policy

The visual illustration provided above shows the heterogeneous response of more and less durable assets using firms to business cycle fluctuations. I now look at how the growth rates of the two types of firms respond to monetary policy. As a baseline model, I follow Gertler and Gilchrist (1994) and use a simple multivariate VAR model to look at how the growth rates react to a shock to the federal funds rate. Figure 4.2 presents the impulse responses due to one standard deviation shock to the federal funds rate. The sales growth for more durable assets using firms initially increases after the federal funds rate shock but declines after about three quarters. Firms using less durable assets show a similar but less steep increase in sales growth, and then about three quarters out, the sales growth starts to decline. However, the decline in sales growth of the less durable assets using firms is relatively smaller than their more durable asset using counterparts. While more durable assets using firms' sales growth becomes negative six quarters after the shock, for the less durable assets using firms, sales growth becomes negative after about eight quarters. Additionally, the decline in sales growth for more durable assets using firms becomes statistically significant, about ten quarters out.

Inventory growth follows a similar pattern as sales growth for the more durable assets using firms. Following a contractionary monetary policy, more durable assets using firms accumulate inventory at an increasing rate in the initial few quarters. Three quarters out, the inventory accumulations slow down, and eventually, these firms start shedding inventories eight quarters out. There is an instant decline in inventory growth for firms using less durable assets following a contractionary monetary policy. Similar to the sales growth, inventory growth of these firms decline at a slower rate compared to their more durable assets using counterparts.

Short-term debt initially grows for both types of firms about three-quarters out, but after that, debt growth falls more rapidly for firms using more durable assets. For less durable assets using firms, both the increase and the decline in short-term debt growth are smaller than those using more durable assets. Finally, investment growth of more durable assets using firms is also more negatively impacted following a federal funds rate shock. The more durable assets using firms start to reduce investment about a year after the shock. In contrast, the less durable assets using firms start reducing investments about eight quarters (two years) after the shock. All the findings from the impulse response figures show an increased sensitivity of more durable assets using firms to a contractionary monetary policy shock.

Figure 4.2: Impulse response to a Federal Funds Rate shock



Impulse response to Funds rate for the sample period 1985 $Q1$ - 2020 $Q3$. Each column represents a separate VAR that includes growth in GNP, Inflation, More durable firms' variable, Less Durable firms' variable, and Federal Funds rate. All figures report the cumulative response of the growth rates to a one standard deviation shock to Federal Funds rate. The figures also include one standard deviation bootstrapped error bands with 100 iterations.

The above analysis uses the data over the entire sample period of 1985 $Q1$ to 2020 $Q3$. The whole sample contains the post-financial crisis period during which the federal funds rate remained at the zero lower bound. During this time and afterward, the Fed relied heavily on unconventional monetary policy in the form of forward guidance to further stimulate the economy. Thus, for a significant amount of time in my sample, the federal funds rate has not been used as a target instrument to implement monetary policy. As a robustness check, I re-estimate the VAR models for a subset of the sample containing data for the period of 1985 $Q1$ to 2007 $Q4$. Figure C.1 presents the response of the key variables to a funds rate shock for this sub-sample. Overall, the figures show the effects of contractionary monetary policy are relatively larger for more durable assets using firms in this sub-sample relative to the entire sample. However, the more durable assets using firms continue to respond stronger to monetary contraction than the relatively less durable assets using firms. The sales and inventory growth rates of less durable assets using firms reach a minimum, respectively, six and five quarters after the shock and before increasing afterward. Interestingly, the short-term debt growth of these firms continues to increase after the shock before tapering off about eight quarters out.

The less durable assets using firms also demonstrate an increase in the investment growth rate following the shock. The investment growth rate seems to follow a similar movement as the short-term debt growth. One possible explanation of this similarity can be that the firms find it easier to finance less durable investments with rising interest rates. Increased investment in less durable assets accompanied by rising interest rates increase the amount of liability on a firm's balance sheet. For the more durable assets using firms, the response of investment growth continues to be small. As more durable assets using firms suffer a larger decline in sales growth and find it more expensive to invest in more durable assets, these firms face a decline in more durable investment due to the weak financial positions of these firms.

4.5.1 The contribution of more and less durable asset firms

I construct the following table to analyze how the two types of firms contribute to total sales and inventory movements. Table 4.2 shows the percentage change in log sales and inventories four, eight, and twelve quarters after monetary policy contraction for all firms and more and less durable assets using firms. Panel A shows the change in growth rate[6] and panel B shows the contribution of the two types of firms on total manufacturing decline following a monetary contraction.[7] Four quarters out, the less durable asset using firms are the dominant driver of the total sales decline. Twelve quarters after the shock, less durable assets using firms still contribute about 73% of total sales decline. On the inventory side, however, the scenario is different. Although the less durable assets using firms start accumulating inventories eight quarters after the shock, the reduction in inventories in the whole sample is driven primarily by the firms using more durable assets. Eight quarters after the shock, the reduction in inventories in the whole sample is about 95% of the inventory reduction in more

[6] Numbers in panel A contains change in log-levels for both types of firms obtained from the impulse responses to a Federal funds rate shock from a VAR that includes four lags of more durable and less durable firms variable, GNP growth, inflation and the funds rate.

[7] To obtain the change in all firms, I estimate a similar VAR by replacing more durable firms variable with all firms. Total contribution for less durable firms equals $w_t \times$ (change in log-level at t). Total contribution for more durable firms is computed as $(1 - w_t) \times$ (change in log-level at t), where w_t is the weight that satisfies the equation $w_t \times$ (less durable firms' change at t) + $(1 - w_t) \times$ (more durable firms' change at t) = Change in all firms at t.

durable assets using firms. Thus, firms using more durable assets face greater costs of maintaining inventories than those that use less durable assets. These higher costs faced by the more durable assets using firms eventually contribute to overall inventory decline.

Table 4.2: Contribution of more and less durable asset firms

		Panel A Change in log-level			**Panel B** Total contribution		
Quarter		4	8	12	4	8	12
Sales	Less Durable	-0.0536	-0.1753	-0.2716	-0.0253	-0.0800	-0.1457
	More Durable	0.0004	-0.0512	-0.1158	0.0002	-0.0278	-0.0536
	Total	-0.0250	-0.1078	-0.1994	-0.0250	-0.1078	-0.1994
Inventory	Less Durable	-0.0097	0.0009	0.0027	-0.0091	0.0012	0.0031
	More Durable	0.0629	0.0855	0.0784	0.0036	-0.0237	-0.0112
	Total	-0.0055	-0.0226	-0.0081	-0.0055	-0.0226	-0.0081

This table gives the relative contribution of more and less durable asset using firms in the total manufacturing sales and inventory change. The sample includes manufacturing firms only (SICs 2000-3999) and the sample period is 1985 $Q1$ - 2020 $Q3$. The change in log-level is computed from the impulse response to a funds rate shock from a VAR that includes four lags of more durable and less durable firms variable, GNP growth, inflation and the funds rate.

4.5.2 The heterogeneous response of financially constrained firms with different asset durability to monetary policy

Until now, I presented how firms can respond differently to monetary policy shocks due to differences in their collateral assets' durability. Gertler and Gilchrist (1994) find that small firms are more responsive to monetary policy shocks because smaller firms are more financially constrained. Thus increased durability can impose additional constraints on the smaller (financially constrained) firms that rely on debt to finance assets. This section presents how financially constrained firms with different asset durabilities respond to a monetary policy shock. To classify firms as financially constrained, I rank them according to their total asset size every quarter. Those firms that belong to the bottom (top) 30% of the asset distribution are classified as financially constrained (unconstrained). Then I again split the subsample of these constrained firms according to their asset durability distribution. Finally, I run the multi-variate VAR model described above for the subsamples of constrained firms with different asset durabilities. For consistency, I run the model for the sample period between 1985 Q1 - 2007 Q4.

Figure C.2 shows that the effect of a monetary contraction is much stronger for financially constrained subsamples than the samples that include all firms. Consistent with previous findings, constrained firms that use relatively more durable assets are more responsive to a contractionary monetary policy shock than those that use relatively less durable assets. On impact, these firms' sales, inventory, and short-term debt growth decline significantly while the growth rate of physical capital investment declines slightly.

Constrained firms with less durable assets face a relatively smaller sales and inventory growth decline. The short-term debt growth rises for an initial couple of quarters before dropping. Finally, investment growth also declines for these firms in response to a monetary contraction. As smaller firms are already financially more constrained, they find it even more difficult to obtain short-term debt to finance their current liabilities with rising interest rates. As a result, these firms end up reducing their investments in physical capital. Thus, the increase in the short-term debt growth and investment growth of less durable assets using firms seen in Figure C.1, is likely driven by the larger firms (with better financial position) in that sub-sample.

4.6 Conclusion

The effect of collateral constraints on the cyclical behavior of firms and the transmission of monetary policy is well established in the literature. Moreover, the durability of the assets that firms place as collateral plays a significant role in determining the collateral constraints firms face, i.e., the access of funds the firms have (Rampini (2019), Jahan (2020)). However, the literature does not explore whether asset durability, through its effects on collateral constraints, can explain the differential cyclical behavior of firms and the differential response of firms to monetary policy. This chapter conducts an empirical study to explore this issue using data on U.S. manufacturing firms. Firms that invest in more durable assets are more responsive to monetary policy than the less durable assets using firms. For financially constrained firms, this difference is more prominent. Finally, while the less durable assets using firms contribute more towards aggregate sales decline, the more durable assets using firms lead the inventory decline after a monetary contraction. The findings highlight the critical role asset durability plays in the transmission of monetary shocks on aggregate activity.

Chapter 5

Conclusion

In this thesis, I discuss factors determining the firm-level cost of borrowing and their impact on aggregate firm investment. The first essay (Chapter 2) shows that asset durability can influence firms' investment decisions by restricting their access to external financing in the presence of financial constraints. The second essay (Chapter 3) highlights that the relative influence of macroeconomic and financial factors on corporate bond credit spreads depends on the risk profiles of the issuing firms. While firms with high credit ratings respond more to changes in macroeconomic factors, risker firms are more influenced by idiosyncratic factors. In light of the first essay, the third essay (Chapter 4) discusses how asset durability affects the transmission of monetary policy and show that more durable assets using firms respond more strongly to monetary policy than firms that invest in relatively less durable assets

The findings from the three chapters have important policy implications. The results from Chapter 2 imply that durable assets may not necessarily alleviate financial constraints for extremely constrained firms despite supporting higher collateral value.

As financially constrained firms are heavily reliant on debt financing, the increase in borrowing costs due to asset durability can amplify the effects of adverse shocks for these firms. Thus, in the event of an economic downturn, firms struggling with financing their assets can choose to invest in less durable assets and increase investment in more durable assets as their financial situation improves. Consistent with findings in Chapter 2, Chapter 4 provides empirical evidence that difference in asset durability can also generate a heterogeneous response of firms to monetary policy.

Findings from Chapter 3 have great significance in managing the risk associated with fixed-income securities and preventing the negative consequences that the widening of spreads has on real activity. Moreover, credit spreads are forward-looking and thus contain important information about investors' perception of future risk. By understanding the differential sensitivity of credit spreads to macroeconomic factors for bonds with different riskiness, the investors can form their expectations more accurately in the event of uncertainty. The analysis done in this paper can also help policymakers evaluate the effectiveness of various macroeconomic policies by assessing investors' responses (from the variation in credit spreads) to those policies.

Finally, the last chapter (Chapter 4) contributes to the literature by documenting the heterogeneous response of firms with different asset durability to monetary shocks. This chapter also contributes by exploring the capital structure's role in the transmission of monetary policy through firm balance sheets from a new angle that has been unexplored in the previous literature.

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Appendix A

Appendix for Chapter 2

A.1 Rampini (2019)

Rampini (2019) develops a model with collateral constraints. The model assumes that the economy has limited enforcement and firms that default on debt obligations cannot be excluded from borrowing. Subject to collateral constraints, under complete market, firms in this economy can implement a dynamic contract one period ahead. Unlike previous models with collateral constraints (Kiyotaki and Moore (1997)), this model considers the effect of depreciation or durability of capital on the collateral constraints faced by firms. Capitals purchased by firms can either have different geometric depreciation rates or have a finite useful life. With the latter, new capital is more durable compared to used ones. For capital with geometric depreciation, the price is determined by the cost of producing the capital. In this paper, I only consider the case where capital has geometric depreciation.

The model economy is set in discrete time with infinite horizon where t=0,1,2,. . . .

The economy has a continuum of stochastic overlapping generations of entrepreneurs. The model is a stationary competitive general equilibrium model with production. The entrepreneur maximizes the value function subject to the budget constraint it faces in the current period and the next period along with a collateral constraint. There are two types of capital used for production and an output good which is a numeraire. Firms can choose between two types of capital which are perfect substitutes but have different durability (more durable and less durable). Let δ_i denote the depreciation rate of capital i each period where, $i \in I \equiv [d(durable), nd(non\text{-}durable)]$ with $\delta_i \in (0,1)$ and $\delta_d < \delta_{nd}$. Then durability of capital i is given by

$$D_i = 1 - \delta_i \tag{A.1.1}$$

Due to the presence of collateral constraints, a firm can borrow only up to a fraction $\vartheta \in [0,1)$ of the depreciated capital at interest rate R. If the price of capital i is q_i and b is total borrowing, then the collateral constraint is given by,

$$\vartheta \sum_{i \in I} q_i k_i (1 - \delta_i) \geq Rb \tag{A.1.2}$$

The collateral constraint implies that including the interest payment, the firm can borrow up to a fraction ϑ of the resale value of the depreciated capital. The model characterizes that trade-off between more or less durable capital depends on the frictionless user cost of capital and the down payment. The frictionless user cost (one period rental rate) of capital i is defined following Jorgenson (1963) as,

$$u_i \equiv R^{-1} q_i (r + \delta_i) \tag{A.1.3}$$

Where, r is the interest payment made for financing one unit of capital i. If the price of one unit of type i capital is q_i and firms can obtain only a fraction of the cost of capital $R^{-1}\vartheta q_i(1-\delta_i)$ through financing, then the difference must be put as down-payment.

If down-payment required for one unit of capital is Ψ_i then the price of capital,

$$q_i = \Psi_i + b_i \tag{A.1.4}$$

where, $b_i = R^{-1}\vartheta q_i(1-\delta_i)$ is the present value of borrowing for 1 unit of capital i.

Using the definition of user cost in (3) the model shows that down-payment is the summation of frictionless user cost of capital u_i and the present value of the resale value of non-pledgeable amount of capital. Thus,

$$\Psi_i = u_i + \eta_i \tag{A.1.5}$$

where, $\eta_i = R^{-1}(1-\vartheta)q_i(1-\delta_i)$ is the present value of the non-pledgeable resale value of the assets purchased. As the residual value of capital is only partially pledgeable, the financing need exceeds the frictionless user cost.

The model shows that when the collateral constraint binds, the discounted marginal product of capital equals the frictionless user cost plus a penalty for the down payment.[1] Thus, with the presence of collateral constraints investment is determined by the user cost as well as the down payment.

The choice of durability, therefore, depends not only on the user cost but also on the down payment of capital. In equilibrium, when the firm uses both types of capital, then neither type is dominated by the other. For capital of type i and i' with $i \neq i'$, suppose, $u_i > u_{i'}$ and $\Psi_i > \Psi_{i'}$. The first-order condition for the entrepreneur then implies that $f_k(k_i) > f_k(k_{i'})$ where, f_k is the marginal productivity of capital i.e. type i capital is dominated. Thus if type i capital has a higher user cost and if (in equilibrium) neither type of capital is dominated then it must be that $f_k(k_i) = f_k(k_{i'})$ and also, $\Psi_i < \Psi_{i'}$ i.e. type i capital must have a lower down payment.

For more durable and less durable capital respectively, suppose, $u_d > u_{nd}$; then from (3) this implies $R^{-1}q_d(r + \delta_d) > R^{-1}q_{nd}(r + \delta_{nd})$. As $\delta_d < \delta_{nd}$ then it must be that $q_d > q_{nd}$. Equation (5) thus implies $\Psi_d \equiv u_d + R^{-1}(1 - \vartheta)q_d(1 - \delta_d) > u_{nd} + R^{-1}(1 - \vartheta)q_{nd}(1 - \delta_{nd}) \equiv \Psi_{nd}$. Then it must be that the durable capital is dominated, which is a contradiction. Hence, in equilibrium, if a firm uses both more and less durable capital, then it must be that, $u_d < u_{nd}$ and $\Psi_d > \Psi_{nd}$ i.e. more durable capital has a lower user cost and a higher down payment compared to less durable capital. Thus equation (4) implies, $q_d(1 - R^{-1}\vartheta(1 - \delta_d)) > q_{nd}(1 - R^{-1}\vartheta(1 - \delta_{nd}))$. Therefore, $q_d > q_{nd}$; more durable capital is more expensive compared to less durable capital. The theoretical model leads to the following prediction:

Trade off between user cost and down-payment: If two types of capital are

[1] Rampini (2019) provides detailed proof of the entrepreneur's problem. The model shows that when $k_i > 0$, the first order conditions for capital k_i, $i \in I$ reduces to $u_i + \rho\Psi_i = \beta A f_k(k)$ where, ρ is the penalty factor, $Af_k(k)$ is the marginal product of capital and β is the discount rate.

perfect substitutes in production and have different depreciation rates $\delta_d < \delta_{nd}$, then in equilibrium more (less) durable capital has a lower (higher) user cost ($u_d < u_{nd}$). However, more (less) durable capital must require a higher (lower) down-payment ($\Psi_d > \Psi_{nd}$) due to their higher (lower) resale value. The higher down-payment of more durable capital makes them harder to finance.

The model further shows that the user cost of capital i as a function of net worth (ω) can be expressed as

$$u_i(\omega) = u_i + \beta\frac{\lambda'}{\mu}(1-\vartheta)q_i(1-\delta_i) \tag{A.1.6}$$

where, λ' is the multiplier on the collateral constraint and μ is the multiplier on the current period budget constraint. For unconstrained firms, $\lambda' = 0$ as they are unaffected by the collateral constraint. Thus, for unconstrained firms $u_i(\omega) \to u_i$, the frictionless user cost. Again, the user cost can also be expressed in the following way,

$$u_i(\omega) = \Psi_i - \beta\frac{\mu'}{\mu}(1-\vartheta)q_i(1-\delta_i) \tag{A.1.7}$$

where, μ' is the multiplier on the next period budget constraint. For severely constrained firms ω goes to 0 and so does investment. As a result, $\beta\frac{\mu'}{\mu} = 0$. Thus for severely constrained firms $u_i(\omega) \to \Psi_i$, the down-payment. Thus the composition of investment according to the financial position of a firm can be summarized as follows:

Choice of durability and the composition of investment: In equilibrium if both types of capital are used then the model shows that unconstrained firms make their optimal choice between two types of capital by comparing their frictionless user costs. Since user costs are lower for more durable capital ($u_d < u_{nd}$), unconstrained firms optimally choose more durable capital. By contrast, severely constrained firms make their optimal choice of capital based on down-payment. Hence, in equilibrium, severely constrained firms optimally choose less durable capital as they involve less financing.

A.2 Variable and Sample Construction

$$Investment\,(I) = \frac{capital\ expenditures\,(capx)}{lagged\ net\ property,\ plant\ and\ equipment\,(ppent)}$$

$$Q = \frac{total\ assets\,(at) + [closing\ price\,(prcc_f) \times common\ shares\ outstanding\,(csho)] - common\ equity\,(ceq) - deffrerd\ taxes\,(txdb)}{total\ asset\,(at)}$$

$$cash\ flow\,(cf) = \frac{income\ before\ extraordinary\ items\,(ib) + depreciation\ and\ amortization\,(dp)}{lagged\ net\ property,\ plant\ and\ equipment\,(ppent)}$$

$$Return\ on\ assets\,(ROA) = \frac{operating\ income\ before\ depreciation\,(oibdp)}{total\ assets\,(at)}$$

$$leverage = \frac{total\ long\ term\ debt\,(dltt) + debt\ in\ current\ liabilities\,(dlc)}{total\ long\ term\ debt\,(dltt) + debt\ in\ current\ liabilities\,(dlc) + stockholders\ equity\,(seq)}$$

Table A.1: **Sample construction**

Original sample	120,344
Elimination criteria	Loss of observations
Total asset(AT),physical asset (PPEGT) or sale (SALE) is zero or negative	5,801
Capital stock (PPENT) less than $5million	37,563
Cash (CHE) is zero	620
Real asset growth rate bigger than 100%	14,409
Real sales growth rate bigger than 100%	6,925
Q negative or greater than 10	5,123
Mean depreciation zero, negative or greater than 1	5,629
Missing capital stock	5,818
Firms entering for at least 3 or more consecutive years	512
Final sample	37,944

Table A.2: Estimated Physical Capital Depreciation Rate

Industry	**Mean δ_{it}**
Food	0.071
Oil	0.096
Textile	0.099
Durables	0.096
Chemicals	0.080
Consumption goods	0.069
Construction	0.100
Steel	0.064
Fabricated products	0.070
Machinery	0.085
Auto mobile	0.075
Transportation	0.082
Retail	0.084
Other	0.098

The table reports the mean of imputed depreciation rate by industry. Firms are sorted according to the 17-industry classification following Fama and French (1997). The sample includes 6,323 U.S firms for the sample period between 1983-2017.

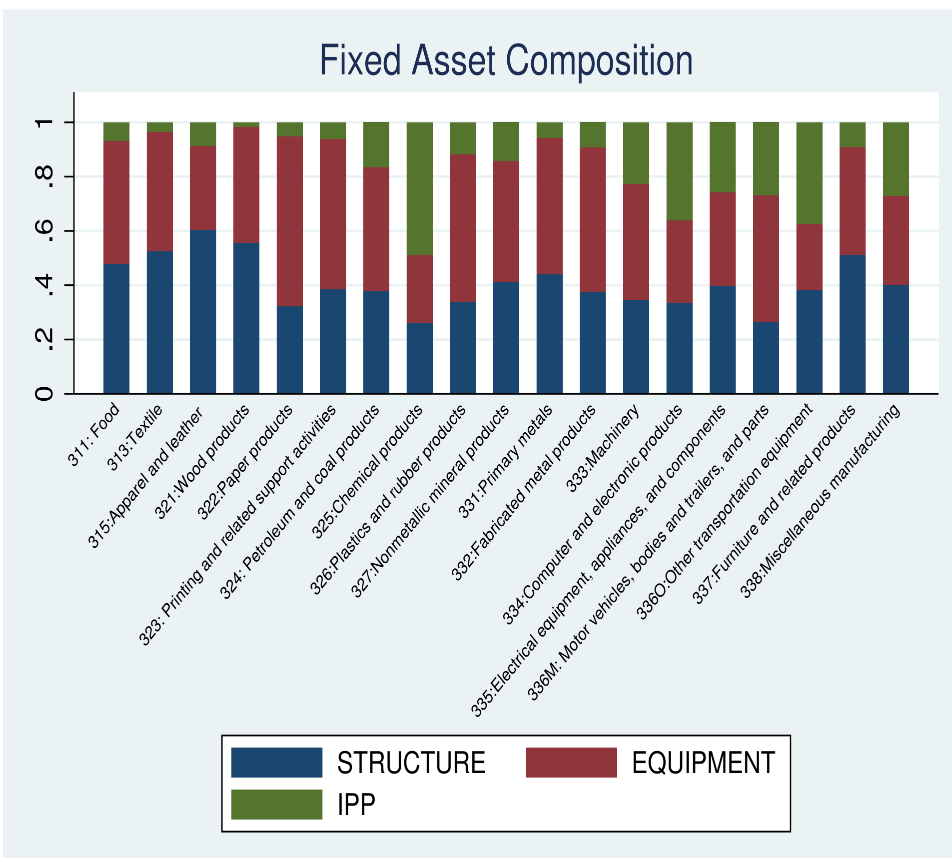


Figure A.1: Composition of fixed assets for manufacturing industry

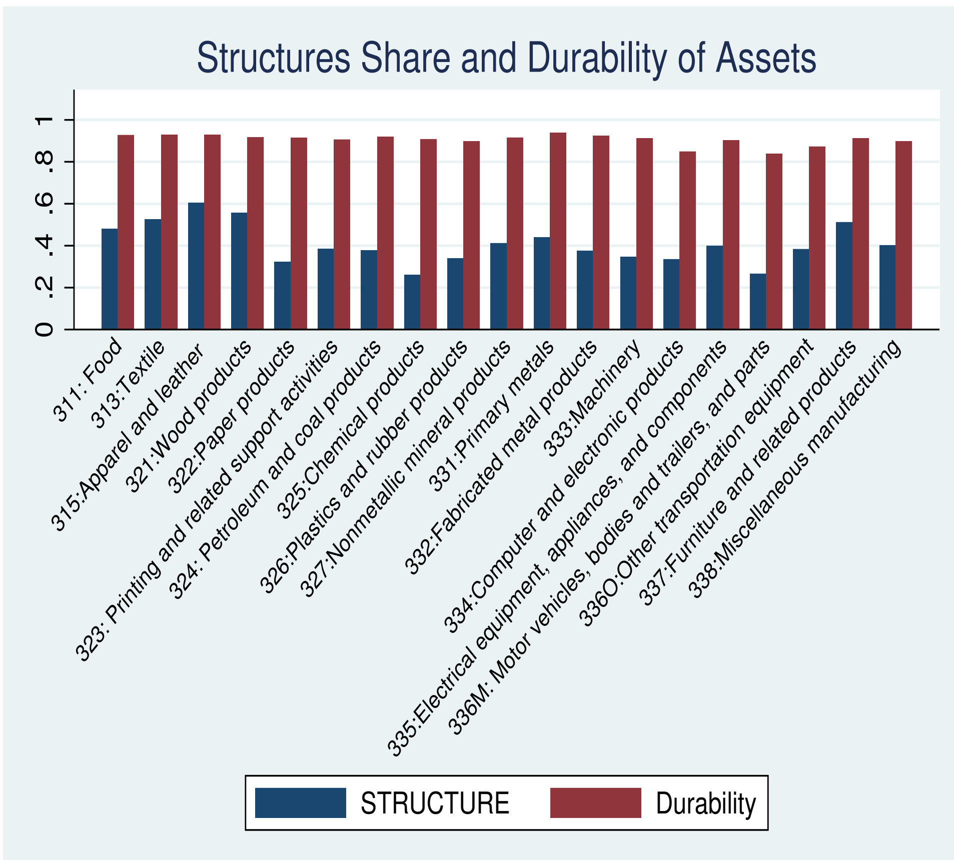


Figure A.2: Durability and share of structure in fixed asset for manufacturing industry

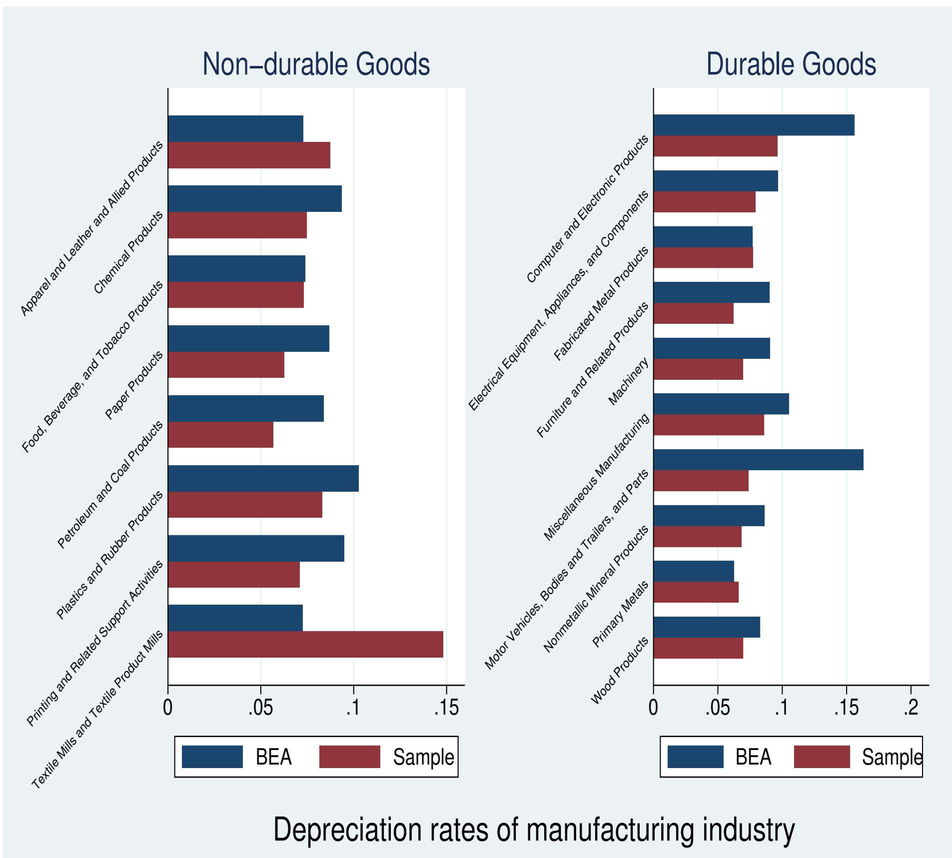


Figure A.3: Depreciation Rate of Manufacturing Industry

Appendix B

Appendix for Chapter 3

B.1

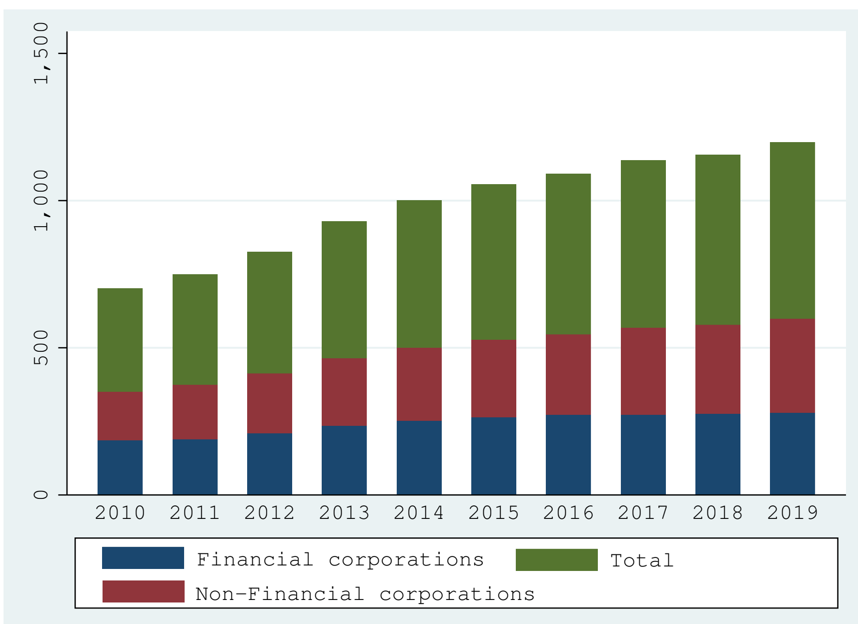


Figure B.1: Total bonds outstanding in Canadian Dollars

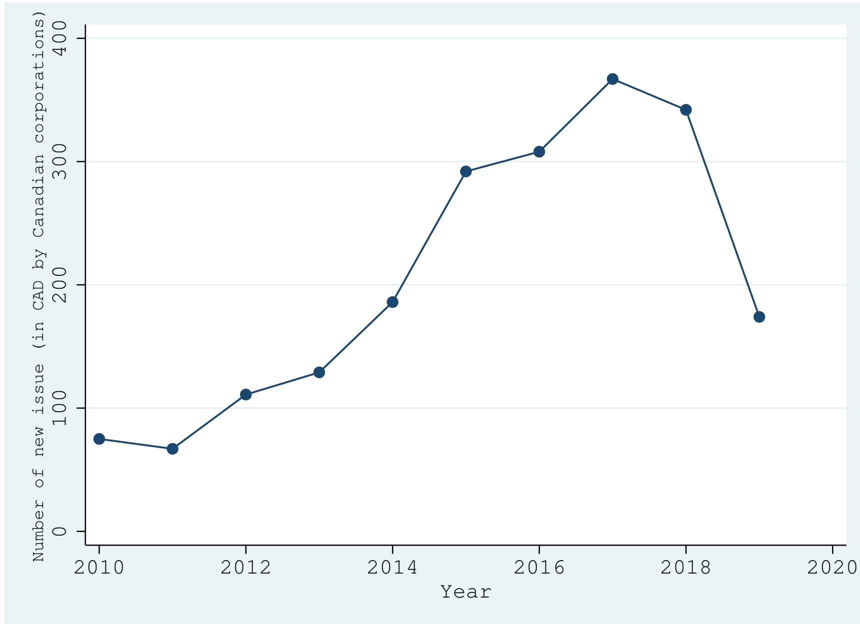


Figure B.2: Number of new issues in CAD by Canadian corporations

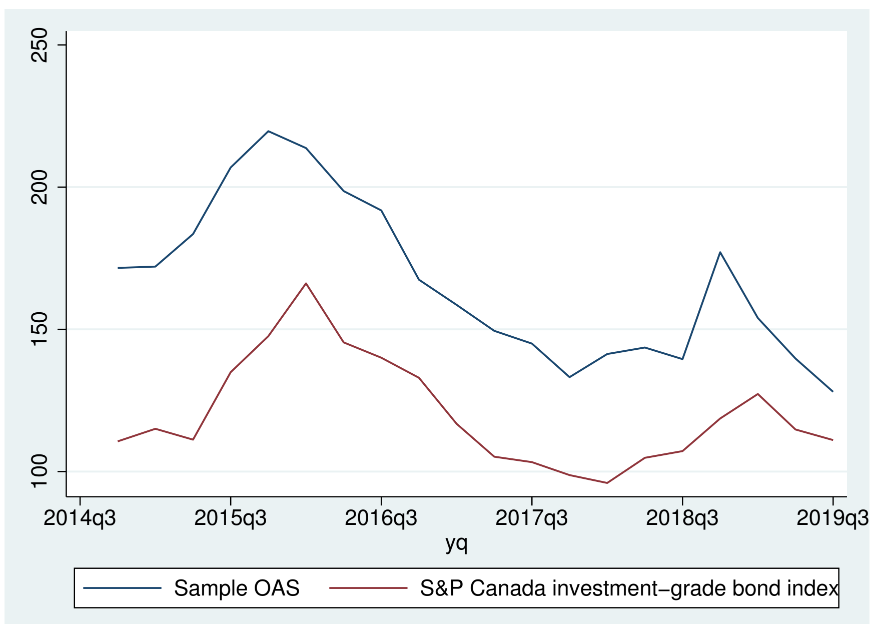


Figure B.3: Sample OAS, 2014 Q4 - 2019 Q3

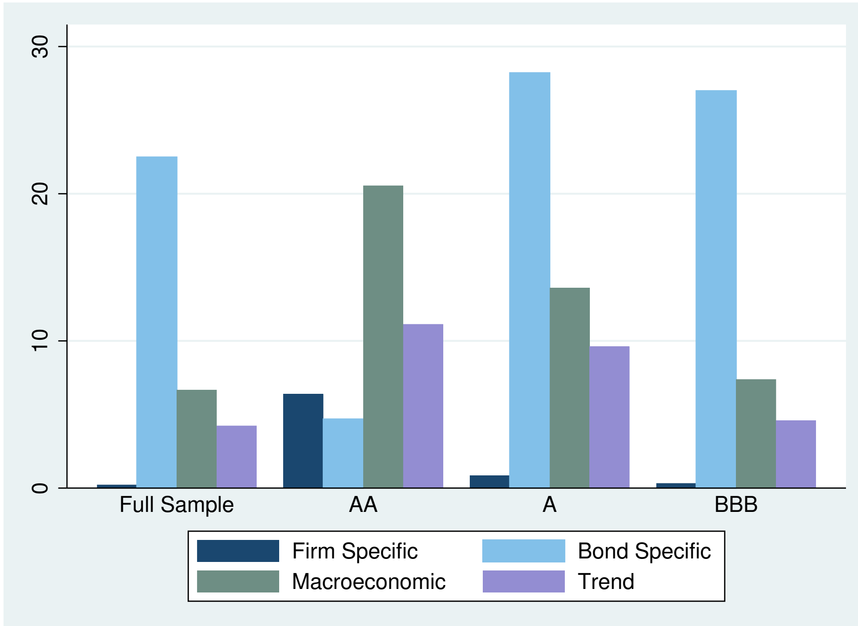


Figure B.4: Variance decomposition of OAS spread (including bond-specific FE and time trend)

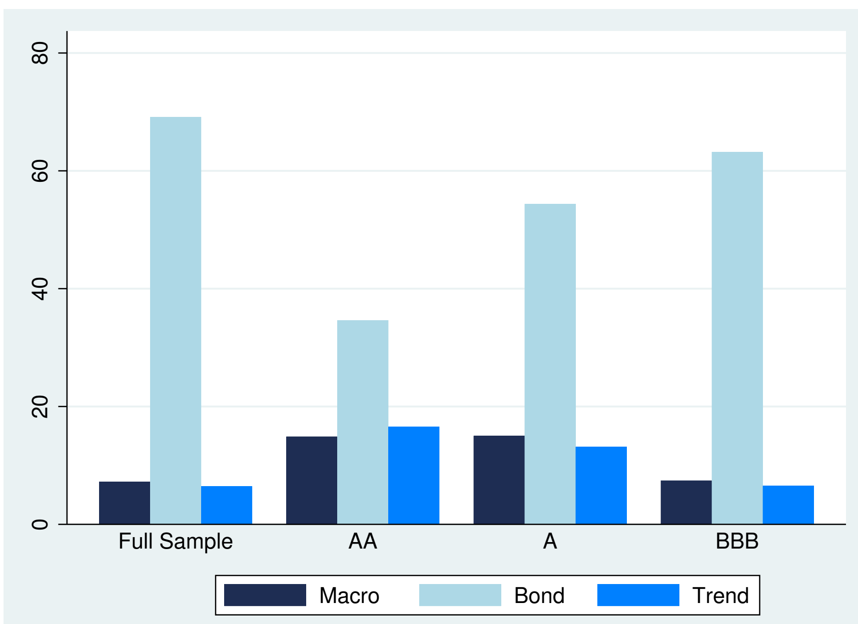


Figure B.5: Variance decomposition of OAS spread (monthly data)

Table B.1: Description of variables and sources

Variable name	Unit of measurement	Source
OAS	Basis points	Bloomberg
Macroeconomic		
GDP growth rate	Percent	Statistics Canada
GDP monthly (chained 2012 dollars)	Millions of CAD	Statistics Canada (CANSIM Table: 36100434)
Policy rate (Overnight money market financing rate)	Percent	Bank of Canada
Risk free interest rate (10 year benchmark bond yield)	Percent	Bank of Canada
Slope of the yield curve/ Term spread	Percent	Bank of Canada
CAD-USD exchange rate	Percent	FRED St. Louis
Inflation rate (CPI)	Percent	Statistics Canada
S&P/TSX return	Percent	Yahoo Finance
Oil price, West Texas Intermediate crude oil price	Dollars per barrel	FRED St. Louis
Economic policy uncertainty index (EPU)	Index	Economic Policy Uncertainty website. https://www.policyuncertainty.com/canada_monthly.html
Bond specific		
Time to maturity	Years	Bloomberg
Firm specific		
EBIT/Asset	Percent	Bloomberg
Debt/Asset	Percent	Bloomberg
Working capital/Asset	Percent	Bloomberg
Size	Millions of CAD (in natural logarithms)	Bloomberg

Table B.2: Determinants of OAS, January 2012 - October 2019 (Monthly data)

GDP growth	-1.472**
	(-3.26)
Policy rate	22.487**
	(15.30)
CAD-USD Exchange rate	392.698**
	(46.65)
Inflation rate	25.454**
	(11.88)
Return	0.162**
	(4.75)
Oil price growth	-0.046**
	(-3.86)
Constant	1101.282**
	(34.79)
No of observations	17,897
R^2	0.17

White-Hubar sandwich estimator corrects for heteroskedasticity and clustering. The t-scores are reported in parenthesis. **, and * indicate significance at 1%, and 5% level respectively.

Table B.3: GARCH proxies for macroeconomic uncertainty, 1990 Q3 - 2019 Q3

	GDP	**Stock index**	**Exchange rate**
Constant (mean)	-0.004	0.016**	1.162**
	(-1.19)	(2.33)	(2.59)
AR(1)	0.985**		0.991**
	(72.05)		(55.11)
ARCH(1)	0.384**	0.276**	0.307*
	(2.78)	(2.06)	(1.95)
ARCH(2)	0.375**		0.365**
	(2.78)		(3.47)
GARCH(1)	-0.902**	0.617**	-0.467*
	(-3.15)	(4.83)	(-2.09)
Constant(variance)	0*	0.001	0.001**
	(3.40)	(1.80)	(3.80)
Log-likelihood	441.822	141.076	221.97
No of observations	117	117	117

z- statistics are given in the parenthesis. The dependent variables are the detrended logarithms of GDP, S&P/TSX Stock returns and Exchange rate at quarterly frequency. 'mean' is conditional mean equation and 'variance' is conditional variance equation. **, and * indicate significance at 1%, and 5% level respectively.

Table B.4: Summary statistics for uncertainty proxies

	Mean	**Standard deviation**	**No of observations**
GDP	0.0000302	0.0000135	5224
Stock index	0.0039013	0.0017533	5224
Exchange rate	0.0015241	0.000969	5224
EPU	240.1616	67.68472	5224

B.2 Predictive power of the predicted spreads

Table B.5 provides the estimation results from two reduced-form regressions (equation B.2.1). For the 3-month ahead forecasting, I include three lags of GDP growth, the real overnight rate, the term spread and a measure of credit spreads. The table does not show the coefficients of the constant and the lags of GDP.

$$\Delta GDP_{t+h} = p_i \sum_i \Delta GDP_{t-i} + q_1 \text{Term Spread}_t + q_2 \text{Overnight Rate}_t + q_3 \text{Credit Spread}_t + \epsilon_t \quad \text{(B.2.1)}$$

where, for a given forecasting horizon $h \geq 0, \Delta GDP_{t-i} = \frac{1200}{h+1} ln(\frac{GDP_{t+h}}{GDP_{t-1}})$.

Table B.5: GDP growth forecast with forecast horizon 3 months

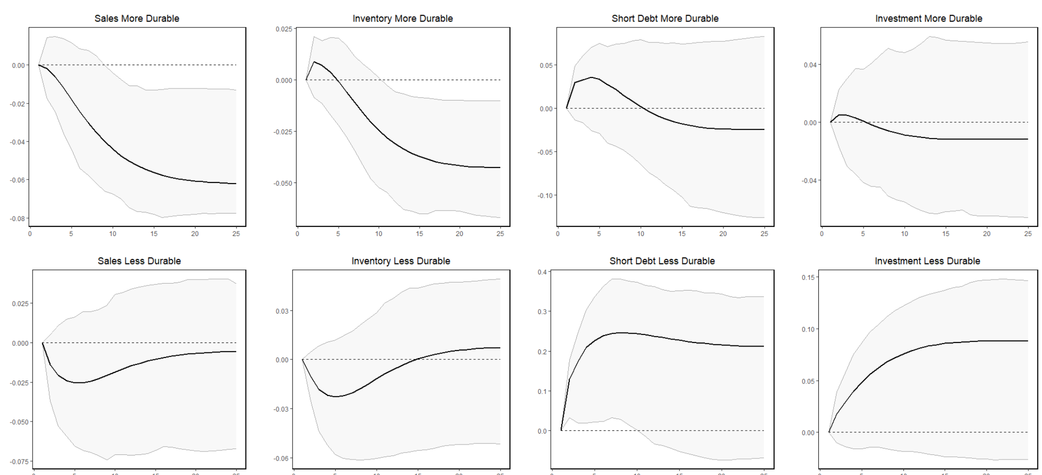
Independent Variables	**1**	**2**
Real Overnight Rate	0.695	-0.414
	(0.86)	(-0.52)
Term Spread	1.253**	1.268**
	(2.58)	(2.82)
Credit Spreads	-0.026**	
	(-2.53)	
Predicted Credit Spreads		0.052**
		(-4.52)
Adjusted R^2	0.13	0.25

t-statistics are given in parenthesis and ** indicates significance at 1% level

Appendix C

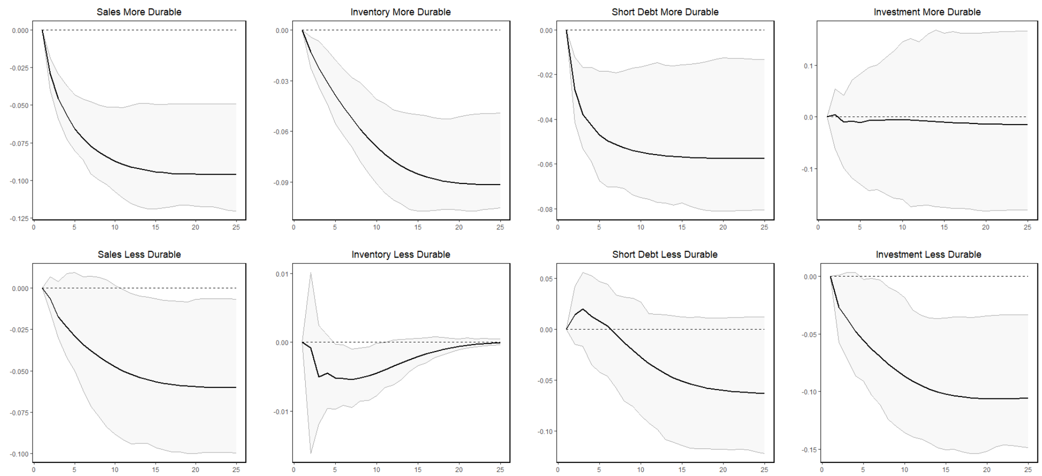
Appendix for Chapter 4

Figure C.1: Impulse response of a Federal Funds Rate shock 1985 Q1 - 2007 Q4



Impulse response to Funds rate for the sample period 1985 $Q1$ - 2007 $Q4$. Each column represents a separate VAR that includes growth in GNP, Inflation, More durable firms' variable, Less Durable firms' variable, and Federal Funds rate. All figures report the cumulative response of the growth rates to a one standard deviation shock to Federal Funds rate. The figures also include one standard deviation bootstrapped error bands with 100 iterations.

Figure C.2: Impulse response of financially constrained firms with different durability to Federal Funds Rate shock



Impulse response to Funds rate for the sample period 1985 $Q1$ - 2007 $Q4$. Each column represents a separate VAR that includes growth in GNP, Inflation, More durable firms' variable, Less Durable firms' variable, and Federal Funds rate. All figures report the cumulative response of the growth rates to a one standard deviation shock to Federal Funds rate. The figures also include one standard deviation bootstrapped error bands with 100 iterations.