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Dynamic Credit Constraints: Theory and Evidence from Credit Lines*

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Abstract

We use a comprehensive Swedish credit register to document that firms throughout the size distribution have access to fairly large and reasonably priced credit lines, but borrow relatively little from them. We rationalize this using a theoretical framework in which the expected cost of financial distress increases with current borrowing and lower credit-line utilization reflects tighter 'dynamic' credit constraints. Consistently with the predictions of the model, the data shows that there is a negative relation between firm-level uncertainty and credit-line utilization. We also find that firms increase borrowing in response to credit-limit increases, even when their current debt is far from the limit.

Keywords: Credit constraints; banks; uncertainty; credit lines; precautionary behavior.

JEL: D22; E44; G21; G32.

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1 Introduction

Credit constraints are a widespread impediment to firms' ability to develop and grow, according to a large literature in economics and finance (see, for example, Campello, Graham and Harvey, 2010; Banerjee and Duflo, 2014; and Besley, Roland and Van Reenen, 2020). The view is, broadly speaking, that firms have investment opportunities in high-return projects, but cannot take advantage of them because they are unable to raise sufficient external funds or because the cost of doing so is excessively high. Credit constraints are, moreover, commonly viewed as especially important for smaller firms because their access to external funds is thought to be more restricted (see, for example, Gertler and Gilchrist, 1994; Chodorow-Reich, 2014; Duygan-Bump, Levkov and Montoriol-Garriga, 2015).

In this paper, we present a set of stylized facts that at first sight seem inconsistent with the notion that tight credit constraints are widespread in the economy. More specifically, we use a rich dataset that combines annual financial-accounts data for the universe of Swedish corporate firms with an administrative credit register that comprises the near-universe of corporate loans extended by Swedish banks to document the following five facts:

1. *Credit lines are widespread and sizable.* Almost half of all non-financial firms in Sweden have at least one credit line from a bank. Conditional on having one, the committed amount on average equals 16 percent of the firm's net assets, or more than five times its monthly labor costs. Credit lines are thus not only common, but also provide firms with an economically significant amount of borrowing capacity. In fact, credit lines are the most common type of corporate loan across all sectors and account for the majority of banks' loan commitments to non-financial firms outside of the real-estate sector.

2. *Credit lines are not heavily used.* The average utilization rate on credit lines—defined as the ratio of drawn to committed amount—is only 26 percent, and the undrawn amount on average equals more than 10 percent of the firm's assets, or almost three times its monthly labor costs. The average firm could thus significantly expand its operations simply by using its available credit up to the limit.

3. *Credit lines are not prohibitively expensive.* The average interest rate paid on the drawn amount of credit lines is three percent during our sample period. The rate decreases monotonically over the size distribution, going from 4.5 percent in the bottom decile to 2.2 percent in the top percentile. Hence, firms that have credit lines face relatively low marginal costs of borrowing.

4. *The prevalence and size of credit lines do not vary greatly over the size distribution.* The share of firms having at least one credit line hovers between 40 and 50 percent throughout the size distribution. The average size of credit lines—measured by the ratio of committed amounts to net assets among firms that have at least one credit line—declines mildly over most of the size distribution, going from 17 percent in the bottom decile to 14 percent in the second largest size bin. The exception is the top percentile, where it is markedly lower at nine percent. Firms throughout the size distribution thus have access to economically meaningful amounts of borrowing capacity via credit lines.

5. *Credit-line utilization rates increase with firm size.* The utilization rate on credit lines is strongly increasing over the size distribution, going from 20 percent in the bottom to over 40 percent in the top. Conversely, the average ratio of undrawn amounts to assets decreases strongly over the distribution, going from 13 percent in the bottom to four percent in the top. The smallest firms thus have almost twice as much unused credit-line borrowing capacity as large firms (measured relative to assets and conditional on having a credit line).

Taken together, these stylized facts show that non-financial firms throughout the size distribution—from micro-sized enterprises to the largest firms in the economy—have access to fairly large amounts of reasonably priced borrowing capacity through credit lines. This seems to suggest that a majority of firms are financially unconstrained, because they have the ability to borrow at a relatively low cost but choose not to do so. However, once we move from a static concept of credit constraints (according to which the the ability to borrow more now at a reasonable cost implies that a firm is unconstrained) to a more general and dynamic concept, the empirical findings can in fact be reconciled with the view that credit constraints are widespread and important.

To show this point, we present a theoretical model where lower utilization of credit can be a consequence of tighter (dynamic) constraints rather than an indicator that credit constraints are slack. Firms face uncertainty in future productivity as well as in future access to external funding. Due to these two sources of uncertainty, firms face a costly liquidity risk. This creates a trade-off in which firms weigh the benefits of borrowing more today against a higher expected cost of illiquidity tomorrow. Since the expected cost of illiquidity increases with uncertainty (both in future productivity and future credit access), firms that face higher uncertainty choose optimally to borrow less.

The dynamic concept of credit constraints is important not only for understanding the financial structure of firms—that is, how much they borrow today—but also for understanding real decisions, which in our model is in the form of hiring. In a static framework, an increase in a firm's borrowing capacity would affect hiring and investment decisions today only for firms that face binding borrowing constraints. In our model, on the contrary, an increase in a firm's borrowing capacity leads to more hiring even if the firm has not exhausted its credit capacity before the increase in capacity. In a static sense this firm would be unconstrained, but the increase in credit capacity would still affect real decisions. The reason is that higher borrowing capacity that persists in the future lowers the expected cost of financial distress for any given level of debt. Thus it makes it optimal for the firm to increase borrowing and hiring today irrespective of whether the borrowing constraint was binding prior to the increase in the credit limit.

One limitation of adopting a static view of credit constraints is that, based on this view, firms are classified as unconstrained if they do not borrow up to the limit and do not face a steeply increasing current marginal cost of borrowing. A more sophisticated way of classifying firms would be to instead consider the distance between credit capacity and actual borrowing, where a firm with a smaller distance is interpreted as facing tighter constraints. However, once we consider a dynamic interpretation of credit constraints, we end up with the opposite classification: firms with tighter 'dynamic' credit constraints are characterized, in the current period, by a larger distance between credit capacity and actual borrowing. In our model this arises because, in the presence of credit frictions, firms risk incurring future financial costs that increase with the debt chosen in current period.

A measure of 'dynamic' credit constraints that is consistent with our model is the *expected* marginal cost of borrowing. This includes not only the marginal cost faced in the current period, but also the possible increases in future financial costs caused by higher borrowing today. The possibility of higher future financial costs is the primary mechanism embedded in our model. However, a similar mechanism would operate if higher borrowing could prevent the firm from taking investment opportunities that may arise in the future. In this case the expected marginal cost of borrowing incorporates the opportunity cost of giving up future investment opportunities. Conceptually, this leads to the same mechanism: firms that face greater uncertainty in investment opportunities will choose to stay away from utilizing their current credit capacity.

Although a dynamic concept of credit constraints can be easily defined theoretically, its empirical measurement is challenging. This is because in the data we mainly have measures of current variables, while expectations of future variables are more difficult to capture. To derive testable implications from the model we need to use current variables that, according to the model, are affected by expectations of future financial costs of borrowing. In our context, this is primarily the utilization rate of credit lines or, similarly, the undrawn amount on credit lines as a share of assets. Thus, in the empirical analysis we consider two testable predictions. First, firms facing higher uncertainty about future productivity or future access to credit draw less on their credit lines. Second, firms increase borrowing and real activities in response to increases in their credit-line limits, irrespective of whether they are currently using their full credit capacity.

We begin by testing the prediction that higher financial uncertainty—i.e., uncertainty about future access to credit—is associated with lower credit-line utilization. To do so we use the average maturity of a firm's credit lines as a proxy for financial uncertainty. The idea is that, once a credit line approaches the renewal date, the quantity and utilization price will be renegotiated, which creates uncertainty. Based on this, we interpret the maturity of the credit line as inversely related to financial risk. In line with the predictions of the model, we document that firms with long-maturity credit lines draw substantially more than firms with shorter maturities. Depending on specification, the difference is between 31 and 42 percentage points. These are economically large numbers given the average utilization rate of 27 percent in the sample. Importantly, the difference persists when we control for unobservable firm characteristics by means of tight sets of fixed effects.

We then investigate the role of productivity uncertainty, which we measure with the within-firm standard deviation in the ratio of cash-flow to assets over the past ten years. We find that the difference in the average utilization rate between firms in the top and bottom of the cash-flow volatility distribution is 10 percent. For the ratio of undrawn amount to assets, the difference is three percent. These differences are economically significant given that the sample averages of the two variables are, respectively, 27 and 10 percent. Our results thus demonstrate that firms facing higher uncertainty about productivity or access to credit use their credit lines less.

The final empirical exercise assesses how firms respond to changes in their credit limits. We identify limit changes that are largely supply-driven by imposing tight sets of borrower fixed effects (following Degryse et al., 2019). We find that borrowing responds to limit changes irrespective of whether a firm is at the limit or not. However, the response is stronger the closer the firm is to the limit. More specifically, following an increase in the committed amount on a firm's credit lines of one SEK, borrowing increases by 0.71 SEK for firms nearest the limit, by 0.25 SEK in the middle of the distribution, and by 0.14 SEK for firms furthest from the limit. That borrowing responds significantly to limit changes even for firms facing slack borrowing constraints may appear surprising when we use a static concept of credit constraints but follows naturally from the dynamic interpretation of credit constraints.

Related literature. This paper proposes an intuitive dynamic concept of credit constraints and demonstrates its importance for rationalizing a set of empirical facts about credit lines that we document using a comprehensive Swedish credit register. In doing so, the paper contributes to three branches of the literature.

The first contribution is to the corporate-finance literature on firms' access to and use of credit lines. Our finding is that firms throughout the size distribution have access to large and reasonably priced credit lines but choose to use them sparingly, which shows that strictly binding borrowing constraints are relatively uncommon, even among SMEs. This finding is to our knowledge mostly new to the literature and is made possible by the comprehensive coverage of our data. The previous literature on credit lines has, in contrast, relied predominantly on data covering only publicly listed or very large firms (see, e.g., Sufi, 2009, Acharya et al., 2020, and Chodorow-Reich and Falato, 2021).

Two recent exceptions are Greenwald, Krainer and Paul (2020) and Chodorow-Reich et al. (2020), who use the Y-14 dataset from the Federal Reserve to study how firms' access to and use of credit lines vary over the size distribution.[1] The main finding of Chodorow-Reich et al. (2020) is that small firms are subject to more lender discretion than large firms and, therefore, may be unable to tap their credit lines in adverse states of the world. Greenwald, Krainer and Paul (2020), on the other hand, show that large firms often draw down their credit lines following adverse macroeconomic shocks and that this crowds out term lending to smaller firms. The key message is that this distributional effect of credit-line drawdowns by large firms amplifies the decline in aggregate investment following adverse shocks. Our goal, instead, is to investigate the importance of uncertainty for understanding credit-line utilization.

It should also be noted that while the Y-14 dataset covers a more representative set of firms than the datasets typically used in the literature, it only includes loan facilities with a committed amount of at least $1 million, which effectively excludes many SMEs from the sample—imposing the same size threshold in our sample reduces the number of firms by 93

[1] Other exceptions include Berger and Udell (1995), who use data from the Survey of Small Business Finance, and Jiménez, Lopez and Saurina (2009), who use data from the credit register of the Spanish central bank. These papers focus mostly on different aspects of credit lines, however.

percent. This turns out to matter because while most of our stylized facts are consistent with those documented by Greenwald, Krainer and Paul (2020) and Chodorow-Reich et al. (2020), a few important findings differ because of the different sample compositions. In particular, we show that the utilization rate on credit lines is increasing over the full size distribution, but is flat or decreasing in size in the restricted sample obtained when imposing the Y-14 size threshold, as in Greenwald, Krainer and Paul (2020) and Chodorow-Reich et al. (2020).

The second contribution of our paper relates to the theoretical literature on credit constraints. Our goal is not to elaborate new theories, but to synthesize mechanisms that are present in more complex models. Our model, despite being fully dynamic, is relatively parsimonious and allows us to illustrate the basic mechanism in a transparent and straightforward matter. The dynamic feature of credit constraints are the result of uncertainty in future collateral constraints which could lead to future financial distress costs.

A similar precautionary behavior on the household side is present in consumption and saving models where agents face uninsurable idiosyncratic risks (e.g., Bewley, 1977, Deaton, 1991, Huggett, 1993, Aiyagari, 1994, Carroll, 1997, and Guerrieri and Lorenzoni, 2017). It is also present in many corporate-finance models, such as Riddick and Whited (2009) and Rampini and Viswanathan (2010).[2] While our dynamic concept of credit constraints is closely related to the precautionary mechanism in these papers, our formulation is useful because it allows us to contrast the static and dynamic concepts of credit constraints in a clear and intuitive manner. It also allows us to derive precise testable implications for empirical analysis.

The third and final contribution of our paper is to the growing literature on the real and financial effects of uncertainty. A closely related recent paper is Alfaro, Bloom and Lin (2022), who study the effect of uncertainty on firms' decisions and how this depends on real and financial frictions. We view our contribution as complementary to theirs, in that we study the universe of firms rather than publicly listed firms and that we provide more granular evidence on firms' borrowing decisions.

Overview of the paper. Section 2 describes the data that we use in the empirical analysis. Section 3 presents the stylized facts on firms' access and utilization of credit lines. Section 4 describes the theoretical framework and Section 5 conducts the empirical analysis using the

[2] Gross and Souleles (2002) and Aydin (2022), among others, provide empirical evidence on the importance of the precautionary motive among households based on consumption responses to credit expansions. On the firm side, the precautionary motive has mainly been documented in the context of corporate cash holdings, for example by Almeida, Campello and Weisbach (2004), Riddick and Whited (2009), and Acharya and Steffen (2020). We complement these papers by showing the importance of uncertainty and precautionary behavior for understanding firms' credit-line borrowing decisions.

main testable predictions of the model. Section 6 concludes.

2 Data

2.1 Data sources

The empirical analysis is based on two main data sets, which we merge using the unique identifier (*organisationsnummer*) belonging to every Swedish firm. The first is the credit registry KRITA, collected and maintained by Statistics Sweden on behalf of Sveriges Riksbank, the central bank of Sweden. KRITA is the Swedish part of ESCB's pan-European credit registry AnaCredit, which it follows closely in terms of data structure and variable definitions. The database contains detailed monthly data on the universe of loans extended by around 20 Swedish monetary financial institutions to Swedish companies from 2019 and onwards. The reporting institutions account, jointly, for 95 percent of the outstanding volume of bank loans to Swedish companies, which makes KRITA close to a census of corporate loans in Sweden. The missing loans are mainly from very small banks, such as local savings banks.[3] Since large firms rarely, if ever, borrow from small banks, the loans that we fail to observe will predominantly be loans to small firms. Hence, to the extent that missing loans bias our analysis, it will primarily be by understating the prevalence and importance of credit lines among small firms. For each loan reported in KRITA, we observe a broad set of information, such as outstanding amount, committed amount, loan type, maturity, as well as information about the borrowing firm, including its size, industry, location, legal form, and group affiliation.

The second data set comprises annual financial-accounts data, as well as demographic and other corporate data, for the universe of Swedish corporate firms (*aktiebolag*). The data set is provided by the leading Swedish credit bureau, UC AB, and is based primarily on the financial statements that Swedish corporate firms are required to submit to the Swedish Companies Registration Office every year in accordance with EU standards. Since Swedish firms are largely free to choose when their fiscal year starts and ends, many observations in the data do not correspond to calendar years. We deal with this by interpolating the financial statements so that each observation corresponds to a calendar year (see Amberg et al., 2021, for details on the interpolation procedure).[4] For each firm and year, we observe a wide range of

[3]This is because KRITA's reporting requirement for monetary financial institutions is determined by ranking lenders in terms of size, from largest to smallest, and then moving down the list until the included lenders jointly account for 95 percent of the total volume of corporate loans.

[4]The length of the fiscal year is 12 months in the great majority of cases, but it may occasionally be shorter or longer. This mainly happens when a firm enters or exits, or when it changes the timing of its fiscal year. Ob-

balance-sheet and income-statement variables. We also have data on each firm's registration date, industry, and probability of default as estimated by the leading Swedish credit bureau, UC AB.

2.2 Sample composition

The main strength of our data set is that it covers the universe of non-financial corporate firms, including small and micro-size enterprises. We nevertheless impose a minimum size threshold to ensure that we only have active and economically meaningful enterprises in our sample. More specifically, we retain only firms that have at least five employees as well as net assets and annual sales amounting to at least five million SEK (approximately 500,000 USD). This leaves around 40,000 firms per time period in the sample. The lower size threshold does not alter the fact that there is substantial size dispersion in the sample: for example, average net assets is around five million SEK in the bottom percentile but over 26,000 million SEK (approximately 2.6 billion USD) in the top percentile. Firms in the top percentile are thus on average 5,200 times as large as the firms in the bottom percentile.

2.3 Variable construction and definitions

Throughout the empirical analysis, we work with a firm-month panel data set, constructed by aggregating the loan-level data to the firm-month level. For variables measuring loan amounts, we aggregate by summing over all relevant loans held by a firm in a given month. When we construct ratios based on loan-amount variables, like the credit-line utilization rate, we do so on the basis of the summed firm-month values; for example, we measure a firm's utilization rate in a given month as the ratio of the drawn amount summed over all credit lines held by the firm to the committed amount summed over the same lines. For other variables, like interest rate and maturity, we compute the firm-month value as the weighted average of the variable across all relevant loans in a given month, with the committed amount on each loan as weight.

The focus of the empirical analysis is on credit lines, which we define as loans satisfying the following four conditions: (i) the borrower is allowed to use funds up to a pre-agreed limit (the committed amount) without notifying the lender in advance, (ii) the available credit (the undrawn amount) decreases and increases as the borrower draws and repays funds, re-

servations corresponding to fiscal periods longer or shorter than 12 months are straightforwardly handled by our interpolation approach.

spectively, (iii) the loan can be used multiple times, and (iv) the borrower pays a fee for the maintenance of the facility as a whole but interest only on the amount that it actually uses at a given point in time (the drawn amount). Two loan types in KRITA/AnaCredit satisfy these conditions and are therefore included in our analysis: overdrafts and revolving credit other than overdrafts and credit card debt.

3 Facts about Firms' Access to and Utilization of Credit Lines

This section documents five stylized facts about credit lines which, taken together, demonstrate that firms throughout the size distribution have access to fairly large amounts of unused and reasonably priced borrowing capacity via credit lines. We interpret this as showing that static credit constraints is not a widespread phenomenon in the corporate sector. The main empirical evidence underlying the facts is reported in Table 1 and Figures 1-3.

3.1 Five stylized facts

Fact 1 *Credit lines are widespread and sizable*

Almost half of all non-financial firms in Sweden have at least one credit line from a bank (Table 1, Panel A). Hence, a substantial share of the non-financial firms in the economy are able to draw bank credit on demand and without notifying the bank in advance. Conditional on a firm having at least one credit line from a bank, the committed amount on average equals 16 percent of the firm's net assets, or more than five times its monthly labor costs (Table 1, Panel B). Credit lines are thus not only common, but also provide firms with an economically significant amount of borrowing capacity.

In fact, credit lines are the most common type of bank loan extended to non-financial firms, held by 46 percent of firms, compared to 36 and 34 percent for financial leases and term loans, respectively. In terms of the aggregate committed amount of loans to non-financial firms, credit lines are second to term loans, accounting for 45 percent compared to 51 percent for term loans. Outside of the real-estate sector, however, credit lines are the quantitatively most important loan type, accounting for 56 percent of the aggregate committed loan volume compared to 38 percent for term loans. Credit lines are thus a key source of external finance for non-financial firms.

Fact 2 *Credit lines are not heavily used*

Table 1: Firms' access to and utilization of credit lines

	Mean	25th pct.	Median	75th pct.	Number of firms	Number of observations
A. All firms						
Has at least one credit line	0.464	0.000	0.000	1.000	40,247	456,265
Has at least one term loan	0.337	0.000	0.000	1.000	40,247	456,265
Has at least one financial lease	0.362	0.000	0.000	1.000	40,247	456,265
B. Firms with at least one credit line						
Committed amount/Net assets	0.155	0.052	0.115	0.214	19,918	211,594
Committed amount/Labor costs	5.494	1.021	2.342	5.051	18,797	200,076
Utilization rate	0.266	0.000	0.000	0.563	19,918	211,594
Undrawn amount/Net assets	0.104	0.027	0.073	0.145	19,918	211,594
Undrawn amount/Labor costs	2.704	0.610	1.496	3.211	18,797	200,076
Interest rate	0.036	0.024	0.033	0.043	19,755	206,886

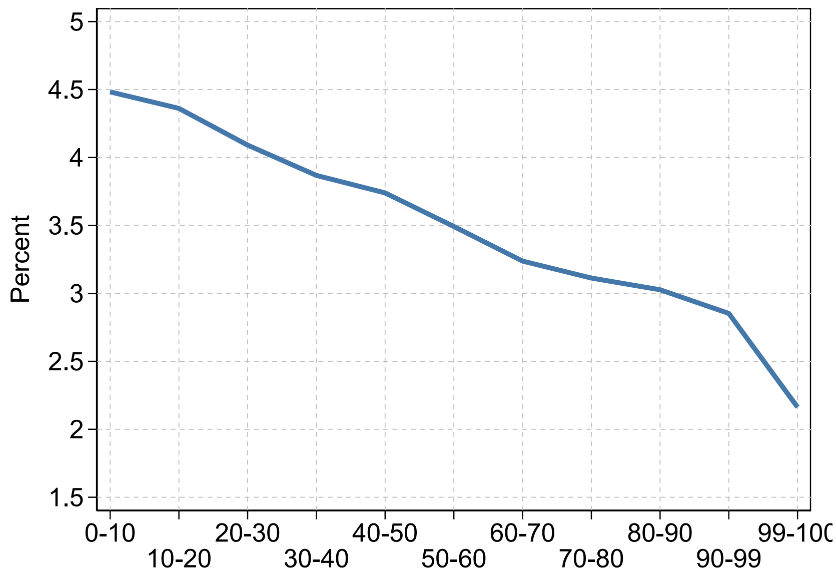
This table shows descriptive statistics for variables measuring firms' access to and utilization of credit lines. The sample spans the period December 2019 to December 2020 and comprises all non-financial firms in Sweden with at least five employees and five million SEK in sales and net assets. Net assets are total assets net of cash holdings and labor costs the average monthly labor cost during the year covered by the latest available financial statement.

The average utilization rate on credit lines—defined as the ratio of drawn to committed amount—is only 26 percent (Table 1, Panel B). Credit lines are thus not very heavily used. That committed amounts are large while utilization rates are low implies that firms have access to large amounts of unused borrowing capacity via credit lines. More precisely, conditional on a firm having at least one credit line from a bank, the undrawn amount on average equals over 10 percent of the firm's net assets, or almost three times its monthly labor costs (Panel B). The average firm with a credit line could thus substantially expand its operations by using the credit it already has been granted.

Fact 3 *Credit-line interest rates are not prohibitively high*

The price of a credit line has two parts: a fixed fee for the maintenance of the facility as a whole and an interest rate charged on the actual amount of borrowing at any given point in time (the drawn amount). The latter determines the marginal cost of borrowing from a credit line and is typically not dependent on how much the firm draws; hence, firms face a flat marginal cost of borrowing up to their credit-line limits.

Figure 1: Credit-line interest rates over the firm-size distribution



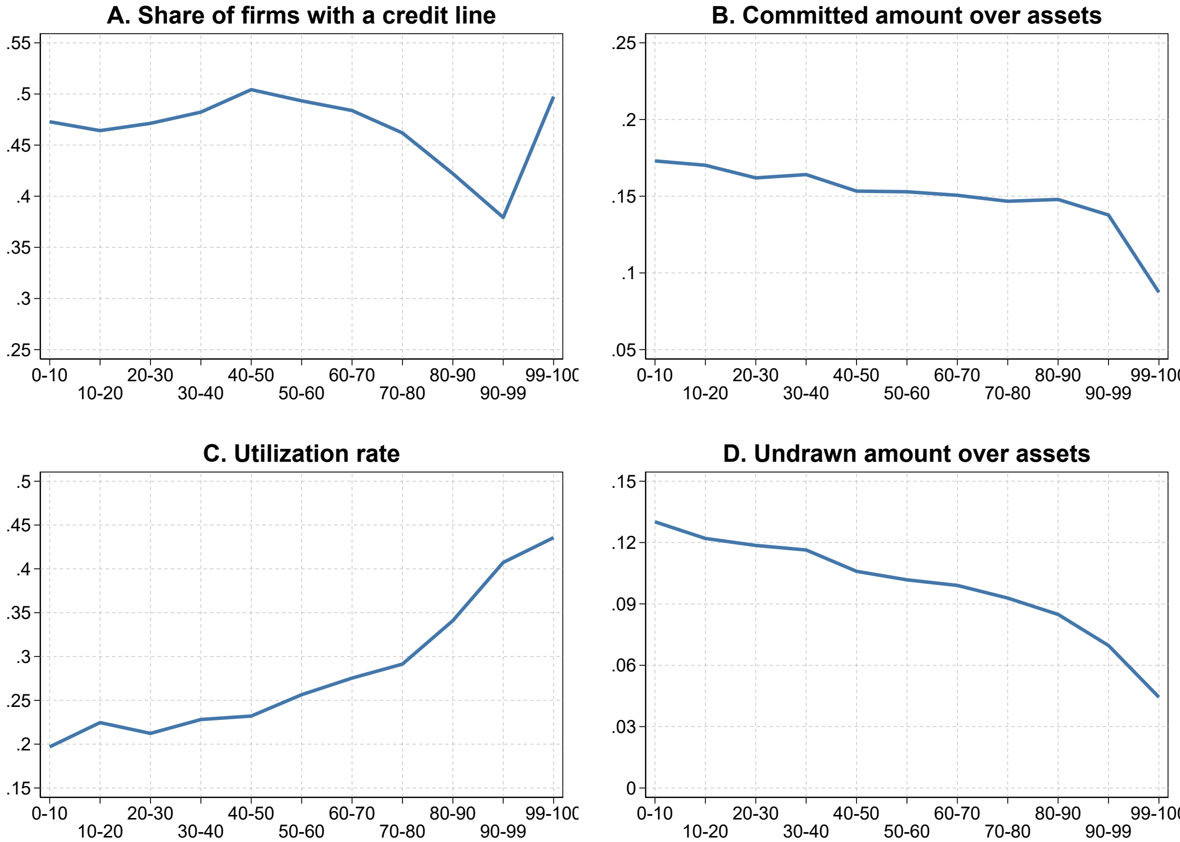
This figure plots the average interest rate on the drawn amounts on credit lines within each bin of the net-asset distribution. In case the interest rate is missing for a firm-month observation, we impute it as the average interest rate on credit lines among firms in the same industry-size-rating-month cell, where the industries are two-digit SNI/NACE codes, the size classes are the eleven bins of the net-assets distribution, and the rating classes are five bins of the distribution of probabilities of default, as estimated by the credit bureau UC AB.

The average interest rate on the drawn amount on credit lines is 3.6 percent in our sample (Table 1, Panel B) and decreases monotonically over the size distribution, going from 4.5 percent in the bottom decile to 2.2 percent in the top percentile (Figure 1). These interest rates—which are quite similar to those reported by Greenwald, Krainer and Paul (2020) and Chodorow-Reich et al. (2020) in terms of level as well as size gradient—imply that firms that have credit lines face non-increasing and relatively low marginal costs of borrowing.

Fact 4 *The prevalence and size of credit lines do not vary greatly over the size distribution.*

How do firms' access to and utilization of credit lines vary over the size distribution? To answer this question, we compute the mean of four credit-line characteristics—an indicator for whether the firm has at least one credit line, the committed amount over net assets, the utilization rate, and the undrawn amount over net assets—within eleven size bins. The size bins correspond to deciles of the net-assets distribution, except when it comes to the top decile, which we split in two: 90th to 99th and above the 99th percentile, respectively. The results are plotted in Figure 2.

Figure 2: Firms' access to and utilization of credit lines over the size distribution

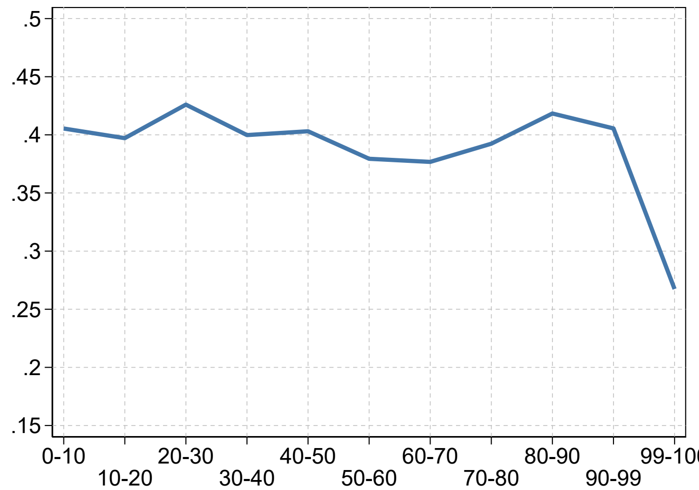


This figure plots the averages of various credit-line characteristics within each bin of the net-asset distribution. Panel A is based on all firms in the sample, whereas Panels B-D concern firms that have at least one credit line from a bank. The sample spans the period December 2019 to December 2020.

To begin with, the share of firms having at least one credit line from a bank is fairly stable across the size distribution (Panel A), being between 40 and 50 percent in all but one size bin—the 90th-99th percentile bin, where it is just below 40 percent. This demonstrates that firms throughout the size distribution have access to bank loans via credit lines.

The size of credit lines—measured by the ratio of committed amounts to net assets among firms that have at least one credit line—does not vary greatly over the size distribution either. The average ratio lies between 14 and 17 percent in all size bins except the top percentile, where it is markedly lower at nine percent; the ratio of committed amount to net assets is thus, if anything, declining in firm size (Panel B). Hence, the fact that the aggregate volume of committed amounts is heavily concentrated in large firms, as documented by Greenwald, Krainer and Paul (2020), is mostly a reflection of the skewness of the firm-size distribution—

Figure 3: Utilization rates over the size distribution for the restricted sample



This figure plots the average utilization rate on credit lines within each percentile of the firm-size distribution when implementing the same sample restriction as in the Federal Reserve's Y-14 data set, namely, only including loans with at least 10 million SEK (roughly $1 million) in committed amount.

i.e., once the committed amounts are scaled by the firms' assets, there is no economically meaningful difference in the size of the credit lines held by firms of different sizes (again, with the exception of the top percentile).

Fact 5 *Credit-line utilization rates increase with firm size*

Utilization rates on credit lines are, on the contrary, strongly increasing over the firm-size distribution: the average utilization rate is 20 percent in the bottom of the distribution, 25 percent in the middle, and over 40 percent in the top (Figure 2, Panel C). The largest firms thus draw more than twice as much on their credit lines as the smallest firms. That the average size of credit lines (relative to firms' assets) is mildly decreasing over the size distribution while the average utilization rate is increasing implies that undrawn amounts are decreasing in firm size. More specifically, the average ratio of undrawn amount to net assets goes from 13 percent in the bottom decile to four percent in the top percentile (Panel D). Hence, relative to assets, small firms have access to more unused borrowing capacity via credit lines than large firms.

The finding that utilization rates increase over the size distribution stands in contradiction to Greenwald, Krainer and Paul (2020), who use the Federal Reserve's Y-14 data set to document that the average utilization rate among U.S. firms hovers between 40 and 50 percent throughout most of the size distribution and then *declines* sharply in the top deciles. This difference is, however, explained mainly by the difference in sample compositions: when we impose the same sample restriction as in the Y-14 data—namely, only including loans with at least 10 million SEK (roughly $1 million) in committed amount—we find that the average utilization rate hovers around 40 percent throughout most of the size distribution and then declines markedly in the top percentile (Figure 3). Our respective data sets thus yield broadly consistent conclusions once the difference in sample compositions is accounted for.

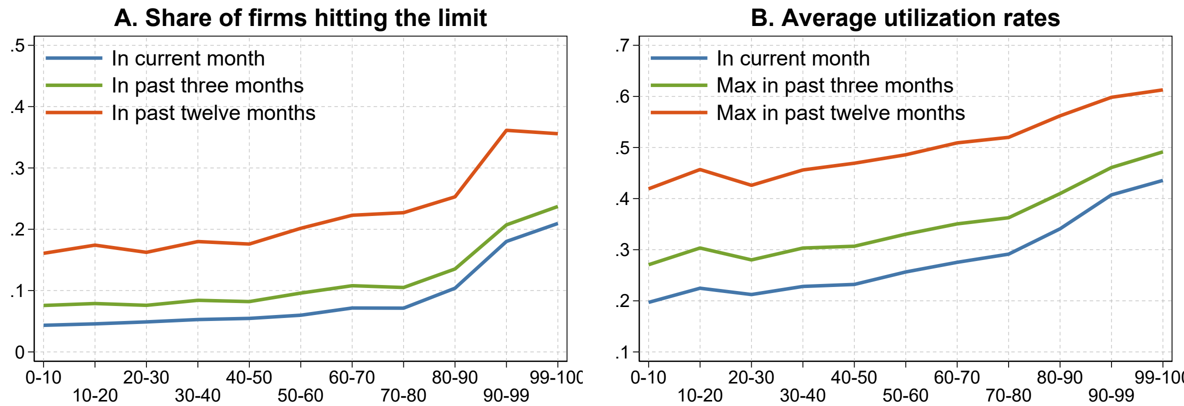
3.2 Robustness and alternative specifications

Measuring utilization rates over time. Firms' funding needs often vary over time due to seasonal factors. One may therefore argue that the relevant measure for determining whether a firm is borrowing constrained is not the average but the maximum utilization rate over some longer period of time. Suppose, for example, that a firm has a credit line as its only source of external finance. Furthermore, suppose that the firm exhausts the credit line one month per quarter due to predictable seasonal variation in demand, but does not need to use it at all during the other two months. One can plausibly argue that such a firm faces a binding borrowing constraint because it frequently and predictably hits its borrowing limit even though it is below the limit most of the time (in this example the average utilization rate over time is only one-third).

Figure 4 shows, however, that the overall message doesn't change fundamentally when we consider measures of firms' maximum utilization rates over longer time periods. In Panel A, we plot the shares of firms that have exhausted their credit lines in a given month, at any point in the past three months, and at any point in the past twelve months, respectively.[5] The share of firms hitting the limit of their credit lines is low for all time spans considered; for example, only 22 percent of firms ever hit the limit during a given twelve-month period. A similar picture emerges in Panel B, where we plot the average maximum utilization rate in each size bin for the same time spans: the average maximum over a year is 50 percent in the sample as a whole, which implies that most firms are never close to exhausting their credit lines. Note also that the share of firms hitting the limit, as well as the average maximum utilization rate, is strongly increasing over the size distribution, which corroborates the conclusion that small firms use their credit lines less than large firms.

[5] For practical purposes, we classify a firm as having exhausted its credit lines if it has used more than 95 percent of the committed amount summed over all of its credit lines.

Figure 4: Measuring firms' maximum utilization rates over time



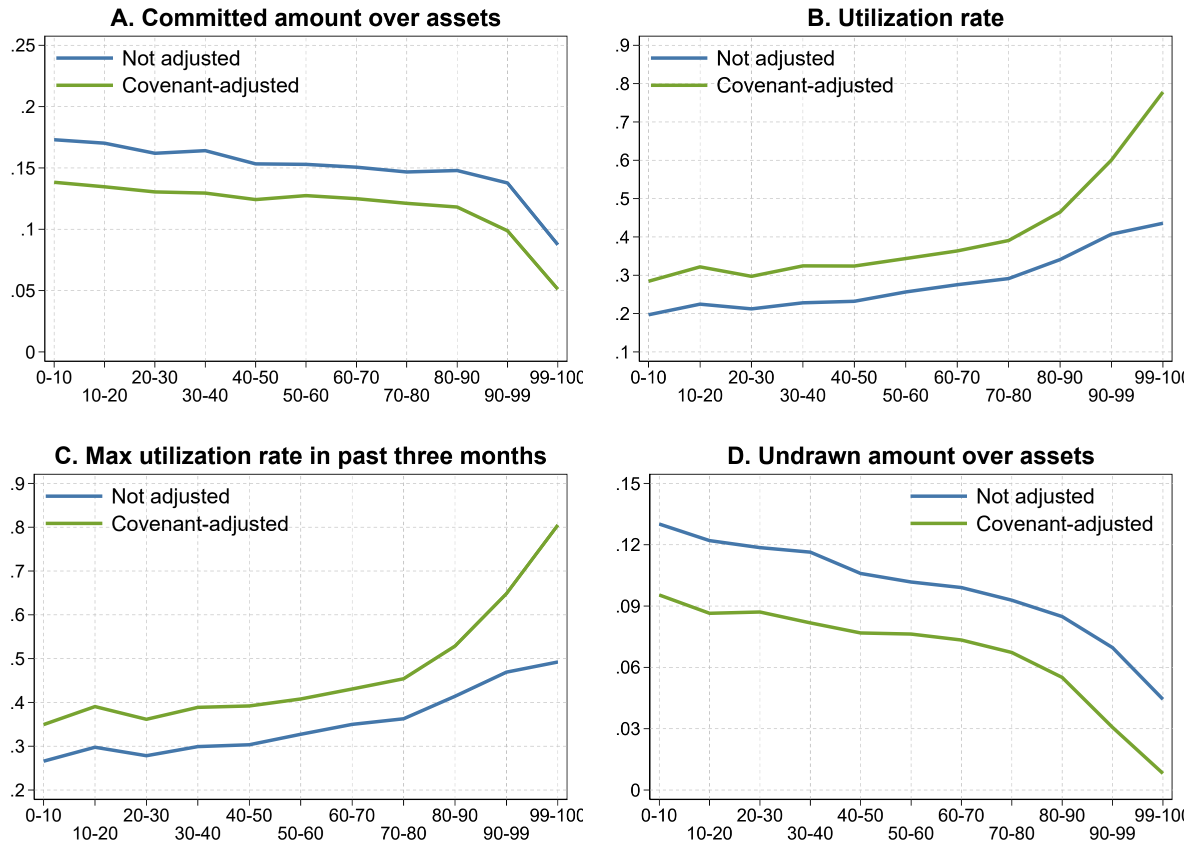
Panel A plots the share of firms in each size bin that exhaust their credit lines in a given month (blue line) as well as at any point in the past three and twelve months (green and red lines, respectively). We define a firm as having exhausted its credit lines if it has drawn more than 95 percent of the committed amounts summed over all of its credit lines. Panel B shows the average utilization rate (blue line) as well as the average maximum utilization rate over the past three and twelve months (green and red lines, respectively) in each size bin.

Covenant-adjusted measures. A common feature of credit-line contracts are covenants, which specify conditions that the borrower has to satisfy in order to avoid having the loan renegotiated or revoked prior to its maturity date. Covenants frequently prevent borrowers from using their credit lines in full, because in doing so the borrower would violate one or several covenants. In such cases, the committed amount on a credit line overstates the actual borrowing capacity available to the firm.

To get a better sense of the actual amount of unused borrowing capacity that firms have access to, we recompute our main measures of the size and utilization of credit lines after covenant-adjusting the committed amounts. The idea is to adjust the committed amount downwards until the undrawn amount equals the increase in borrowing that the firm can undertake without breaking any covenant. We do not observe covenants in the data and therefore follow Greenwald, Krainer and Paul's (2020) approach to covenant-adjust the committed amounts. This involves assuming (i) that all firms are subject to two of the most common covenants in debt contracts—a minimum interest coverage ratio and a maximum debt-to-earnings ratio—and (ii) that the requirements on these ratios equal the average requirements in the sample of debt contracts studied by Greenwald (2019).[6]

[6]See Appendix A1 for details on the construction of the covenant-adjusted measures.

Figure 5: Covenant-adjusted credit-line characteristics across the firm-size distribution



This figure plots the averages of various credit-line characteristics within bins of the firm-size distribution, where firms are sorted according to their net assets. We plot both the non adjusted (blue line) and the covenant-adjusted (green line) measures. We describe the covenant-adjustment approach in general terms in Section 3.2 and in more detail in Appendix A1.

The covenant-adjusted measures of the size and utilization of credit lines are reported in Figure 5 along with the respective non-adjusted measures. The covenant-adjustment has some impact on the measures we consider, but not large enough to overturn any of our conclusions. More specifically, the average ratio of committed amount to net assets falls from 15 to 12 percent; the average utilization rate increases from 28 to 41 percent; the average maximum utilization rate in the past three months increases from 35 to 47 percent; while the ratio of undrawn amount to net assets declines from ten to seven percent. The respective size gradients, meanwhile, are hardly altered at all. Hence, the finding that firms throughout the size distribution have access to large amounts of unused borrowing capacity via credit lines survives the covenant-adjustment of the committed amounts.[7]

4 A Model of Dynamic Credit Constraints

This section presents a model of a firm's borrowing and hiring decisions under uncertainty, a cash-flow based borrowing constraint, and costly financial distress. The model allows us to contrast the static and dynamic concepts of credit constraints in a clear and intiutive manner, as well as to derive testable predictions that we take to the data in Section 5.

4.1 Firm's constraints

Consider a firm with production technology $y_t = z_t N_t$, where z_t is an idiosyncratic productivity shock and N_t is employment.

Hiring is costly. A firm with current employment N_t and new employment N_{t+1} incurs the cost $\Upsilon\left(N_{t+1}/N_t\right) N_t$, where the function $\Upsilon(.)$ is strictly increasing and convex. This cost insures that the optimal size of an individual firm is determined at each point in time.

The firm starts period t with debt B_t issued in the previous period $t-1$. After the realization of revenues, the firm issues new debt B_{t+1} at price q_t. The price of the debt is the inverse of the gross interest rate.

The new debt is subject to the collateral constraint

$$B_{t+1} \leq \bar{\xi}_{t+1} \bar{z}_{t+1} N_{t+1}, \tag{1}$$

where $\bar{z}_{t+1} = \mathbb{E}_t z_{t+1}$ is the expectation of next period productivity and $\bar{\xi}_{t+1} = \mathbb{E}_t \xi_{t+1}$ is the expectation of a stochastic variable that determines the financial tightness for the firm. The constraint links the borrowing capacity of the firm to the expected cash flow in the next period, $\bar{z}_{t+1} N_{t+1}$. Effectively, the cash flow acts as a collateral. However, only a fraction $\bar{\xi}_{t+1}$ of the expected cash flow can be used to enforce the debt.

[7] The exercise in this section builds on the assumption that all credit lines are restricted by covenants. This is not the case in practice, particularly not when it comes to small borrowers; a common alternative is to issue credit lines with short maturities that are routinely rolled over, which gives the lender frequent opportunities to revoke or renegotiate the line in case the borrower's financial health deteriorates. We think, however, that the covenant-adjusted measures are informative about how much firms can actually draw on covenant-free but short-maturity credit lines, because it is likely that banks impose informal restrictions on borrowers with such contracts and that these restrictions are similar to the explicit restrictions in contracts with covenants.

The budget constraint of the firm is

$$B_t + D_t + \Upsilon\left(\frac{N_{t+1}}{N_t}\right)N_t = z_t N_t - w_t N_t + q_t B_{t+1}, \tag{2}$$

where D_t is the equity payout (dividends) and w_t is the wage rate. All the other variables have been defined above.

4.2 Firm's policies

The problem of the firm can be written recursively as

$$V_t(B_t, N_t) \quad = \quad \max_{B_{t+1},N_{t+1}} \left\{ D_t + \beta\, \mathbb{E}_t V_{t+1}(B_{t+1}, N_{t+1}) \right\}$$

subject to (1) and (2).

The function $V_t(B_t, N_t)$ is the equity value which depends on two endogenous states, debt B_t and employment N_t, in addition to the exogenous states z_t and ξ_t. To simplify the notation, the dependence on the exogenous states is not shown explicitly but is captured by the time subscript t.

We now take advantage of the linearity of the model and normalize the problem of the firm by N_t so that all variables will be expressed in per unit of employment,

$$v_t(b_t) \quad = \quad \max_{b_{t+1},g_{t+1}} \left\{ d_t + \beta g_{t+1} \mathbb{E}_t v_{t+1}(b_{t+1}) \right\} \tag{3}$$

subject to:

$$d_t = z_t - w_t - \Upsilon(g_{t+1}) + q_t g_{t+1} b_{t+1} - b_t$$

$$\bar{\xi}_{t+1} \bar{z}_{t+1} \geq b_{t+1}.$$

The function $v_t(b_t) = V_t(B_t, N_t)/N_t$ is the per-employee value of the firm, $d_t = D_t/N_t$ is the per-employee dividend paid to shareholders, $b_t = B_t/N_t$ is the per-employee liabilities, and $g_{t+1} = N_{t+1}/N_t$ is the gross growth rate of employment.

To characterize the policies of the firm, we derive the first order conditions with respect to b_{t+1} and g_{t+1}. Let $\mu_t g_{t+1}$ be the Lagrange multiplier for the enforcement constraint, the first order conditions read

$$q_t + \beta \mathbb{E}_t \frac{\partial v_{t+1}(b_{t+1})}{\partial b_{t+1}} = \mu_t,$$
$$q_t b_{t+1} + \beta \mathbb{E}_t v_{t+1}(b_{t+1}) = \Upsilon'(g_{t+1}).$$

The envelope condition provides the derivative of the firm value, which is equal to $\partial v_t(b_t)/\partial b_t = -1$. This shows that the normalized value of the firm is linear in normalized debt b_t. The linearity property allows us to rewrite the value of the firm as

$$v_t(b_t) = \hat{v}_t - b_t, \tag{4}$$

where $\hat{v}_t$ depends only on the exogenous states (shocks). The first order conditions can then be rewritten as

$$q_t = \beta + \mu_t, \tag{5}$$
$$(q_t - \beta)b_{t+1} + \beta \mathbb{E}_t \hat{v}_{t+1} = \Upsilon'(g_{t+1}). \tag{6}$$

The first condition determines the optimal choice of debt. The left-hand-side is the marginal benefit of borrowing: by increasing b_{t+1} by one unit the firm increases the dividend by q_t. The first term on the right-hand-side is the marginal cost of borrowing: if the firm increases b_{t+1} by one unit, it has to repay that unit in the next period. However, since the repayment is in the next period, the present value is β. If $q_t > \beta$, the marginal benefit is always bigger than the cost. Therefore, the firm borrows as much as possible until it reaches the limit. This implies that the borrowing constraint is binding and, therefore, the multiplier μ_t is positive.

The second condition determines the optimal employment growth, g_{t+1}. The left-hand-side is the marginal benefit resulting from the sum of two terms. The first term captures the fact that higher employment allows the firm to increase its debt by b_{t+1}, with a net benefit of $(q_t - \beta)b_{t+1}$. The second term captures the fact that higher employment increases the value of the firm by $\beta \mathbb{E}_t \hat{v}_{t+1}$. Remember that $\hat{v}_{t+1}$ is the value for the firm from one employee. The right-hand-side is the marginal cost of employment growth, captured by the derivative of the adjustment cost $\Upsilon'(g_{t+1})$.

The following proposition characterizes the firm's policy.

Proposition 4.1 *If $q_t > \beta$ the borrowing constraint binds and the growth of the firm increases* *in $\bar{\xi}_{t+1}$ and $\bar{z}_{t+1}$. If $q_t = \beta$, the debt is indeterminate and the growth of the firm increases only in $\bar{z}_{t+1}$.*

Proof 1 *The borrowing constraint is binding if the multiplier μ_t is positive. Condition (5) shows that this is the case only if $q_t > \beta$. Since $\Upsilon'(g_{t+1})$ is increasing in g_{t+1} due to the convexity of the adjustment cost, condition (6) shows that $\Upsilon'(g_{t+1})$ must increase in b_{t+1} and in $\mathbb{E}_t\hat{v}_{t+1}$. The latter depends positively on $\bar{z}_{t+1}$. Since an increase in $\bar{\xi}_{t+1}$ or $\bar{z}_{t+1}$ increases the debt, g_{t+1} must also increase. However, if $q_t = \beta$, b_{t+1} no longer enters condition (6). The growth of the firm then depends only on $\mathbb{E}_t\hat{v}_{t+1}$, which is only a function of $\bar{z}_{t+1}$.* ■

The model described so far has two frictions: the adjustment cost in hiring and the borrowing limit. The proposition establishes that, if the debt is cheaper than equity, that is, $q_t > \beta$, the firm always borrows up to the limit. This implies that the firm always utilizes the whole borrowing capacity. The fact that hiring is risky or the borrowing limit is stochastic is irrelevant for the choice of credit utilization. In the next section we introduce an additional friction that reduces the incentive of the firm to borrow. In particular, we assume that higher debt increases the likelihood of costly financial distress. This could lead to occasionally binding constraints. We will interpret the 'unused' borrowing capacity as 'unused' lines of credit.

4.3 Financial distress

To introduce the risk of financial distress we make the following assumption: if the liabilities of the firm at the beginning of the period, b_t, are bigger than $\xi_t z_t$, the firm needs to raise emergency funds to cover the difference.

The firm enters the period with (per-employee) debt b_t chosen in the previous period. Given the realization of ξ_t and z_t at time t, the enforcement constraint might no longer be satisfied, that is, $b_t > \xi_t z_t$. In this case the firm needs to raise $b_t - \xi_t z_t$ with alternative sources that are costly. In particular, we assume that the cost incurred to access the alternative funds is $\kappa(b_t - \xi_t z_t)^\eta$. This is a 'financial distress cost' since it is paid to raise emergency funds and could also include, in the extreme, the cost of bankruptcy. The cost can be expressed more generally as

$$\varphi_t(b_t) = \kappa \cdot \Big(\max\{b_t - \xi_t z_t, 0\}\Big)^\eta, \tag{7}$$

where $\eta > 1$ so that it is convex in b_t.

With financial distress, the normalized problem of the firm becomes

$$v_t(b_t) \quad = \quad \max_{b_{t+1}, g_{t+1}} \Big\{ d_t + \beta g_{t+1} \mathbb{E}_t v_{t+1}(b_{t+1}) \Big\} \tag{8}$$

subject to:

$$d_t = z_t - w_t - \Upsilon(g_{t+1}) + q_t g_{t+1} b_{t+1} - b_t - \varphi_t(b_t)$$

$$\bar{\xi}_{t+1} \bar{z}_{t+1} \geq b_{t+1}.$$

The new problem is similar to the previous problem (3). The only difference is that the budget constraint also includes the distress cost $\varphi_t(b_t)$. Notice that the value function $v_t(b_t)$ is net of the distress cost. If $\varphi_t(b_t) = 0$ for all b_t, we go back to the previous problem. Although this may seem a minor modification, it has important implications for the optimal decisions of firms. As we will see, it generates a precautionary motive in the choice of b_{t+1} and, as a result, the borrowing constraint might not be binding.

To characterize the optimal policies chosen by the firm, we derive the first order conditions from problem (8). Differentiating with respect to b_{t+1} and g_{t+1}, respectively, we obtain

$$q_t + \beta \mathbb{E}_t \frac{\partial v_{t+1}(b_{t+1})}{\partial b_{t+1}} = \mu_t,$$

$$q_t b_{t+1} + \beta \mathbb{E}_t v_{t+1}(b_{t+1}) = \Upsilon'(g_{t+1}), .$$

The envelope condition returns $\partial v_t(b_t)/\partial b_t = -1 - \varphi_t'(b_t)$, which allows us to write the value function, net of the distress cost, as

$$v_t(b_t) = \hat{v}_t - b_t - \varphi_t(b_t). \tag{9}$$

Now the value of the firm is no longer linear in b_t but becomes concave. Since $\varphi_t(.)$ is convex, the negative value is concave. This is key to introduce precautionary considerations in the choice of debt.

Using the envelope condition, we can rewrite the first order conditions as

$$q_t = \beta \Big[1 + \mathbb{E}_t \varphi_{t+1}'(b_{t+1}) \Big] + \mu_t, \tag{10}$$

$$(q_t - \beta) b_{t+1} + \beta \mathbb{E}_t \Big[\hat{v}_{t+1} - \varphi_{t+1}(b_{t+1}) \Big] = \Upsilon'(g_{t+1}). \tag{11}$$

The first condition determines the optimal choice of debt. The left-hand-side is the marginal benefit of borrowing: by increasing b_{t+1} by one unit the firm pay q_t more dividends. The first term on the right-hand-side is the marginal cost of borrowing: if the firm increases b_{t+1} by one unit, in the next period it has to pay back that unit. In addition—and this is what differentiates the optimal choice of debt from the previous problem—higher borrowing may increase the expected distress cost faced by the firm in the next period. The expected increase in distress cost is $\mathbb{E}_t \varphi'_{t+1}(b_{t+1})$. If the optimal debt is constrained, however, the marginal benefit is lower than the marginal cost. The difference is captured by the multiplier μ_t.

The second condition determines the optimal employment growth, g_{t+1}. The left-hand-side is the marginal benefit resulting from the sum of two terms. The first term derives from the fact that higher employment allows the firm to increase its debt by b_{t+1}, which has a net benefit of $(q_t - \beta)b_{t+1}$. The second is that higher employment increases the value of the firm, net of the distress cost, which is given by $\beta \mathbb{E}_t[\hat{v}_{t+1} - \varphi_{t+1}(b_{t+1})]$. The right-hand-side is the marginal cost of employment growth, captured by the derivative of the adjustment cost $\Upsilon(g_{t+1})$.

As in the model without financial distress, the variable $\hat{v}_t$ depends only on the exogenous shocks. The value function, however, is no longer linear in b_t. The convexity of the distress cost makes the surplus function concave, introducing a precautionary motive that discourages excessive borrowing. Effectively, the firm may choose not to borrow up to the limit and the borrowing constraint $\bar{\xi}_{t+1}\bar{z}_{t+1} \geq b_{t+1}$ could be only occasionally binding.

Proposition 4.2 *If $q_t > \beta$ and κ is sufficiently large, the borrowing constraint is not binding. The growth of the firm increases in $\bar{\xi}_{t+1}$ and $\bar{z}_{t+1}$, independently of whether the borrowing constraint is binding or not. If $q_t = \beta$ the debt is indeterminate and the growth of the firm depends only on $\bar{z}_{t+1}$.*

Proof 2 *See Appendix A1.*

Having non-binding borrowing constraints allows us to capture limited credit utilization or unused lines of credit. We interpret the difference between the credit limit and the actual borrowing as unused credit, that is,

$$\text{Unused Credit} = b_{t+1} - \bar{\xi}_{t+1}\bar{z}_{t+1}.$$

Another important point highlighted in the proposition is that, even if the borrowing constraint is not binding, still higher utilization could have a positive impact on employment.

The next proposition establishes the importance of uncertainty or risk. Let's first introduce some preliminary definitions.

Define $x = \xi z$ the product of the two shocks, ξ and z. The cumulative distribution function is denoted by $\Gamma(x)$. Now consider two distributions with the same mean $\bar{x}$ but different cumulative functions $\Gamma_A(x)$ and $\Gamma_B(x)$. Suppose that $\Gamma_A(x) < \Gamma_B(x)$ for all $x < \bar{x}$. What this implies is that, even if the two distributions have the same mean $\bar{x}$, values below the mean are less likely with distribution A than with distribution B. Since in our model financial distress arises for values below the mean, distribution B can be interpreted as characterized by greater uncertainty. For example, if the distributions are log-normal, the condition is satisfied if A has a lower standard deviation than B (but the same mean). We then have the following proposition.

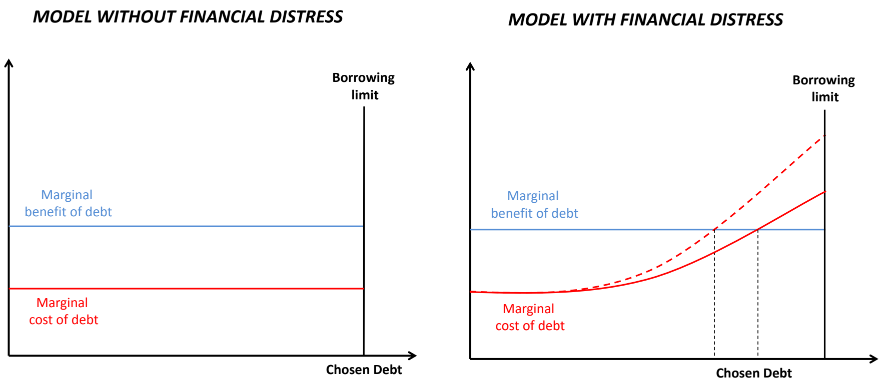
Proposition 4.3 *If $q_t > \beta$ and κ is sufficiently large, credit utilization and employment growth decline when the distribution of $x_{t+1} = \xi_{t+1} z_{t+1}$ changes from Γ_A to Γ_B. If $q_t = \beta$, credit utilization and employment are not affected by the change in distribution.*

Proof 3 *We have shown in the previous proposition that, if $q_t > \beta$ and κ is sufficiently large, the borrowing limit is not binding. Equations (B1) and (B2) in the proof of Proposition 4.2 imply that a change in the distribution of x_{t+1} from Γ_A to Γ_B increases $\mathbb{E}_t \varphi_{t+1}(b_{t+1})$ and $\mathbb{E}_t \varphi'_{t+1}(b_{t+1})$. This is because lower values of x_{t+1}, which are associated with higher distress costs, are more likely when the cumulative distribution is Γ_B. Condition (10) then implies that b_{t+1} falls (lower credit utilization) and condition (11) implies that g_{t+1} declines (lower employment growth).* ■

The change in the distribution captures higher uncertainty or risk. Therefore, the model predicts that risk—both productivity and financial—affects the utilization of credit. Even if the credit constraint is slack, the higher risk induces the firm to use less credit and to choose lower employment growth.

Figure 6 provides a graphical illustration of the optimal borrowing chosen by the firm. The graph plots the marginal benefit and cost of debt. As discussed above, the marginal benefit of borrowing is indicated in the left-hand-side of condition (10): by increasing b_{t+1} by one unit, the firm increases the dividends (consumption) by q_t. The marginal cost of borrowing is the first term on the right-hand-side: if the firm increases b_{t+1} by one unit, in the next period it has to pay back that unit, plus the increase in distress cost induced by higher borrowing. In the proof of Proposition 4.2 we have shown that $\varphi'_{t+1}(b_{t+1})$ increases in b_{t+1}. Thus, the expected marginal cost $\mathbb{E}_t[1 + \varphi'_{t+1}(b_{t+1})]$ increases in b_{t+1}.

Figure 6: Optimal debt policy



The first panel depicts the model without financial distress. In this case, if $q_t > \beta$, the marginal benefit of borrowing is always bigger than the marginal cost. Therefore, the firm always borrows up to the limit, which is indicated in the graph by the vertical line.

The case with financial distress is depicted in the second panel of Figure 6. In this case the marginal cost (continuous line) is initially below the marginal benefit. However, as the debt increases, the expected cost of financial distress rises, inducing an increase in the marginal cost of debt. As a result, the firm does not borrow up to the limit (provided that κ is sufficiently large).

The dashed line in the second panel captures two changes. The first is an increase the distress cost captured by the parameter κ: the higher the value of κ is, the bigger the difference between the borrowing limit and the actual debt chosen by the firm. The second captures an increase in the volatility or dispersion of the idiosyncratic shocks z_{t+1} and ξ_{t+1}: higher volatility of the shocks increases the expected marginal cost associated to financial distress, for any level of debt. This is captured in the graph by the upward shift in the marginal cost of debt (dashed line). As a result, the optimal debt chosen by the firm is lower (lower utilization of credit). This property, formalized in Proposition 4.3, will be the focus of our empirical analysis.

4.4 Numerical example

To further illustrate the properties of the model, we consider a numerical example. We need to specify first the functional forms for the adjustment cost of employment and the distribution of the shocks. The employment adjustment cost takes the form

$$\Upsilon(g) = \lambda(g - 0.9)^{\nu}.$$

The parameter λ determines the magnitude of the cost while ν determines its curvature. Notice that the cost is zero if $g = 0.9$, that is, if employment drops by 10 percent. We can think of 10 percent as capturing the employment drop if the firm does not make any effort in hiring (natural quits). The shocks z and ξ are both iid. Their distributions are uniform over the domains $\bar{z}(1 \pm \Delta_z)$ and $\bar{\xi}(1 \pm \Delta_\xi)$.

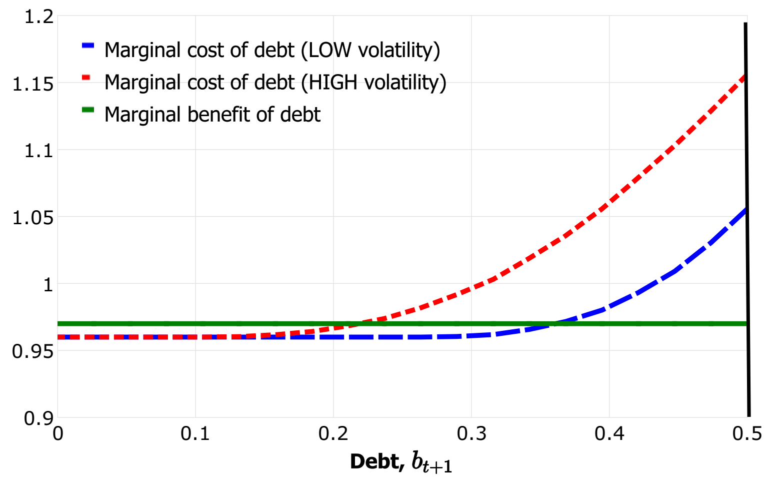
The parameter values are listed in Table 2. Since the numerical example is only meant to illustrate the qualitative properties of the model, rather than its quantitative performance, the particular parameter values are not important.

Table 2: Parameter values.

Description	*Parameter*	*Value*
Discount factor	β	0.96
Price of risk-free debt	q	0.97
Adjustment cost in employment	λ	1.50
Curvature of adjustment cost in employment	ν	2.00
Distress cost	κ	1.00
Curvature of distress cost	η	2.00
Mean productivity	$\bar{z}$	1.00
Productivity deviation from mean (proportional)	Δ_z	0.25
Mean borrowing limit	$\bar{\xi}$	2.00
Borrowing limit deviation from mean (proportional)	Δ_ξ	0.25

Figure 7 plots the marginal benefit and marginal cost of borrowing for the parameterized model under two levels of uncertainty. In the first case the proportional deviation from the mean is $\Delta = 0.25$ for both shocks (low volatility). In the second case the proportional deviation from the mean is $\Delta = 0.5$ (high volatility). As can be seen, the marginal cost of borrowing rises with volatility. In both cases the borrowing limit is $b_{t+1} \leq 0.5$. Therefore, the marginal cost intersects the marginal benefit before hitting the borrowing limit. The firm then chooses not to utilize the whole borrowing capacity. When volatility is low, utilization is about 72 percent. When volatility is high, utilization is about 44 percent. Although not shown in the graph, employment growth drops from 5.2 percent to 4.9 percent.

Figure 7: Optimal debt policy with low and high uncertainty



4.5 Dynamic credit constraints

The concept of credit constraints is often used in the literature to describe a condition in which firms are either unable to raise external funds or the cost of external funds is abnormally high. From a theoretical point of view, the precise definition of credit constraints depends on the structure of the model used in the analysis.

In general, models can be divided in two categories. The first category includes models that specify well defined limits to the amount that a firm can borrow. In these models a firm faces tight credit conditions if it borrows up to the limit. The degree of tightness is then captured by the Lagrange multiplier associated with the borrowing limit: a higher value of the multiplier indicates that relaxing the borrowing limit brings higher value to the firm. The second category of models does not have a strict borrowing limit. However, the cost of borrowing increases as the firm takes more debt. This could reflect, for instance, the higher probability of default that increases the interest rate charged by the lender. In this case credit constraints are captured by the marginal cost of borrowing.

While these theoretical concepts of credit constraints are well defined within the specific types of models, mapping them to the data is more complicated. For example, if we think of a world in which firms face well defined borrowing limits, it is not obvious how to measure the Lagrange multiplier in the data. If we are in a world where firms do not face a strict borrowing limit but the cost of borrowing increases with leverage, credit constraints could be measured by the interest rate paid by the firm. Still, this is not a perfect measure of credit constraints because the data, typically, provides the average interest rate paid by the firm while we would need the marginal cost of borrowing.

Setting aside the issues related to the empirical measurement, the definition of credit constraints using either the Lagrange multiplier or the current cost of borrowing is not useful in our framework because most firms do not borrow up to the limit. This means that, even if firms face financial frictions, for most of them the Lagrange multiplier is zero and the marginal cost of borrowing is not abnormally high. Therefore, if we apply the typical definitions of credit constraints used in the literature, we would conclude that most firms do not face tight credit constraints. But in our framework firms do face financial frictions that affect their operational decisions today, even if today they have access to external funds without incurring increasing costs. At least when they do not borrow to the limit, which is the case for most of them.

The main limitation associated with the typical definitions of credit constraints is that these definitions are based on a static concept of constraints. Even if the marginal cost of borrowing is not increasing in the current period, higher borrowing today may increase the financial cost in the future. This is exactly what happens in our model: if a firm is not borrowing up to the limit today (which we interpret as unused line of credit), increasing the current debt does not change the current marginal cost of borrowing. However, it may increase the risk that the firm will incur higher financial costs in the future. So the measure of credit constraints in our model should be the 'expected' marginal financial cost that the firm would incur in the future. This is the term $\mathbb{E}_t\varphi'_{t+1}(b_{t+1})$ in equation (10). A definition of credit constraints that focuses on the impact of current borrowing on the future is a dynamic concept of credit constraints because it is based on the anticipation of future events (financial distress) that are not reflected in current prices (no increase in interest rate spreads today).

Unfortunately, the data provides only measurements of current variables, not expectations of future variables. But even if we had direct measures of $\mathbb{E}_t\varphi'_{t+1}(b_{t+1})$, Figure 6 shows that firms choose b_{t+1} to equalize the marginal cost to the marginal benefit, which is the same among firms. Therefore, the only way to measure credit constraints is through the measurement of current variables that incorporate (are affected by) expectation of future financial costs. This is similar to measuring credit constraints through interest rate spreads, except that in our model the interest rate spread is zero. Instead, the variable that is affected by the structure of the future financial cost is the utilization rate of credit lines: the higher is the expected cost of financial distress (for given level of borrowing), the lower is the rate of utilization. This shows that lower utilization rates—which in the data seem more prevalent for smaller firms—are not an indicator of less tight credit conditions. On the contrary, they are the reflection of tighter constraints.

5 Taking the Testable Predictions of the Model to the Data

In this section, we take the two main testable predictions of the model to the data, namely, that higher uncertainty is associated with lower credit-line utilization rates (Proposition 4.3) and that firms increase borrowing and real activity in response to an increase in their credit limit even if they are not up against a binding borrowing constraint (Proposition 4.2).

5.1 Uncertainty and credit-line utilization

Firms face both productivity and financial uncertainty in the model, which is captured by the dispersion of the distributions of productivity (z_t) and access to finance (ξ_t). The model predicts that an increase in either type of uncertainty (or both) leads firms to utilize credit lines less. The goal of this section is to test this theoretical prediction. Section 5.1.1 tests this prediction for financial uncertainty, while section 5.1.2 does so for uncertainty about productivity.

5.1.1 Financial uncertainty

The financial uncertainty in the model is captured by the dispersion of the distribution of ξ, the parameter that determines the fraction of a firm's cash-flow that can be pledged as collateral and thus how much it is able to borrow. More specifically, the wider is the dispersion in the distribution of next-period ξ, the more uncertain is the firm about how much it can borrow today without having to raise costly emergency funds tomorrow. Hence, more dispersion in next-period ξ leads the firm to reduce borrowing for precautionary reasons, as established in Proposition 4.3.

To take the proposition to the data, we proxy the distribution of ξ with the maturity of a firm's credit lines, where shorter maturities correspond to higher levels of dispersion in ξ. Intuitively, a firm has a degree of certainty about the credit limit and loan spread it faces during the lifespan of its credit lines, but once the lines fall due both the price and quantity of loans are subject to renegotiation and thus become uncertain. Hence, the financial uncertainty faced by a firm is, all else equal, decreasing in the maturity of its credit lines.[8]

We test whether shorter maturities are associated with lower utilization rates using the following regression:

$$Y_{i,t} = \alpha_{i,j,s,c,t} + \beta \cdot \mathbb{1}\{Maturity_{i,t} \leq 1\ year\} + \varepsilon_{i,t}, \tag{12}$$

where the dependent variable is some measure of firm i's credit-line utilization rate in period t; $\mathbb{1}\{Maturity_{i,t} \leq 1\ year\}$ is an indicator variable equal to one if the weighted average maturity of firm i's credit lines in period t is less than or equal to one year; and $\alpha_{i,j,s,c,t}$ is a set of fixed effects, which varies across specifications (the subscripts i, j, s, c, and t index firms, industries, size bins, counties, and months, respectively). Under the hypothesis that shorter maturities are associated with lower utilization rates, we should observe $\beta < 0$. Note that $Maturity_{i,t}$ measures the maturity at origination—i.e., it measures the initial rather than the remaining maturity of a firm's credit lines. We cluster standard errors by firm and time, respectively.

The estimation results are reported in Table 3. Column (1) shows that the average utilization rate is 42 percentage points lower for firms with short-maturity credit lines than for firms with long-maturity lines. This difference is very large given that the average utilization rate is 27 percent in the sample. Tightening the set of fixed effects by including industry-size-county-month as well as firm fixed effects does not affect the results much—in the most restrictive specification, reported in column (3), the difference in utilization rates between firms with short- and long-maturity credit lines is 37 percentage points. Thus, firms with shorter maturities on average utilize their credit lines substantially less than firms with longer maturities.

In columns (4)-(6), we show that this finding holds also for alternative measures of the utilization rate. More specifically, continuting with the most restrictive combination of fixed effects—namely, industry-size-county-month as well as firm fixed effects—we find that the difference between firms with short- and long-maturity credit lines is 33 percentage points when the dependent variable is the maximum utilization rate over the past three months (column (4)); 36 percentage points when it is the covenant-adjusted utilization rate (column

[8] In practice, a firm is not completely certain about its access to credit even during the lifespan of its credit lines: first, because banks have the right to renegotiate credit lines prior to maturity if the contract features covenants and the firm violates one of them; and second, because firms often renegotiate favorable changes to credit lines prior to maturity (Roberts and Sufi, 2009). Firms thus face both upside and downside uncertainty in credit access during the lifespan of their credit lines. The point here, though, is simply that financial uncertainty—and in particular downside uncertainty, which is what matters in the model—is decreasing in credit-line maturity.

Table 3: Financial uncertainty and utilization rates

	$Used_{i,t}$			$Used^{3m}_{i,t}$	$Used^{Cov}_{i,t}$	$Used^{3m,Cov}_{i,t}$
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$\mathbb{1}\{Maturity_{i,t} \leq 1\ year\}$	–0.416***	–0.388***	–0.370***	–0.307***	–0.362***	–0.316***
	[0.026]	[0.027]	[0.034]	[0.041]	[0.023]	[0.029]
Time FE	Yes	No	No	No	No	No
Industry × Size × County × Time FE	No	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	Yes	Yes	Yes	Yes
Number of observations	211,597	182,963	179,561	179,845	180,320	180,320
Number of firms	19,918	18,016	15,011	15,034	15,066	15,066
Adjusted R^2	0.122	0.150	0.762	0.811	0.869	0.857

This table reports estimation results for the model specified in (12). The unit of observation in the regressions is firm-month and the sample period spans December 2019 to December 2020. $Used_{i,t}$ is the ratio between the drawn and committed amounts, respectively, on the credit lines held by firm i in period t; $Used^{3m}_{i,t}$ is the maximum utilization rate over the previous three months; while $Used^{Cov}_{i,t}$ and $Used^{3m,Cov}_{i,t}$ are the covenant-adjusted versions of these ratios. Industries are defined by two-digit SNI/NACE codes and the size classes correspond to the eleven size bins defined in section 3.1. We explain the covenant-adjustment procedure in Appendix A1. Standard errors are clustered by firm and time and reported in square brackets. ***, **, and * denote statistical significance at the ten, five, and one percent levels, respectively.

(5)); and 32 percentage points when it is the maximum covenant-adjusted utilization rate over the past three months (column (6)).

In sum, the results in Table 3 demonstrate that firms facing high financial uncertainty—as measured by the maturity of their credit lines—utilize their credit lines less than firms facing low financial uncertainty.

5.1.2 Productivity uncertainty

Productivity uncertainty in the model is captured by the dispersion of z, the parameter determining how large the firm's cash-flow is and thus how much it is able to borrow. The wider is the dispersion in the distribution of next-period z, the more uncertain is the firm about how much it can borrow today without having to raise costly emergency funds tomorrow. The firm will therefore reduce borrowing for precautionary reasons when the dispersion in next-period z increases, as established in Proposition 4.3.

We proxy the productivity uncertainty facing firm i in year t as the within-firm standard deviation of the ratio of operational cash flow (EBITDA) to total assets over the preceding ten years ($t-10$ to $t-1$). We drop any firm with fewer than five cash-flow observations to ensure that a sufficient number of observations go into the computation of the standard deviation. We then test whether higher productivity uncertainty leads firms to utilize their credit lines less by means of the following regression:

$$Y_{i,t} = \alpha_{j,t} + \sum_{d=2}^{10} \beta^d \cdot \mathbb{1}\{VolatilityDecile_{i,t} = d\} + \gamma \cdot \mathbf{X_{i,t}} + \varepsilon_{i,t}, \tag{13}$$

where $Y_{i,t}$ is either firm i's credit-line utilization rate or undrawn amount over net assets in period t, and $VolatilityDecile_{i,t}$ is a categorical variable capturing the decile of the cash-flow volatility distribution to which firm i belongs in year t. The control variables consist of the vector $\alpha_{r,t}$, which comprises risk class and time fixed effects, as well as the vector $\mathbf{X_{i,t}}$, which consists of two variables: the ratio of operational cash flow to total assets in period t and working capital over total assets in period t, where working capital is defined as the sum of accounts receivable and inventories.[9] The inclusion of these control variables ensures that our results are not driven by omitted-variable bias stemming from differences in current realizations of cash-flow shocks, working-capital as a funding need, or creditworthiness.

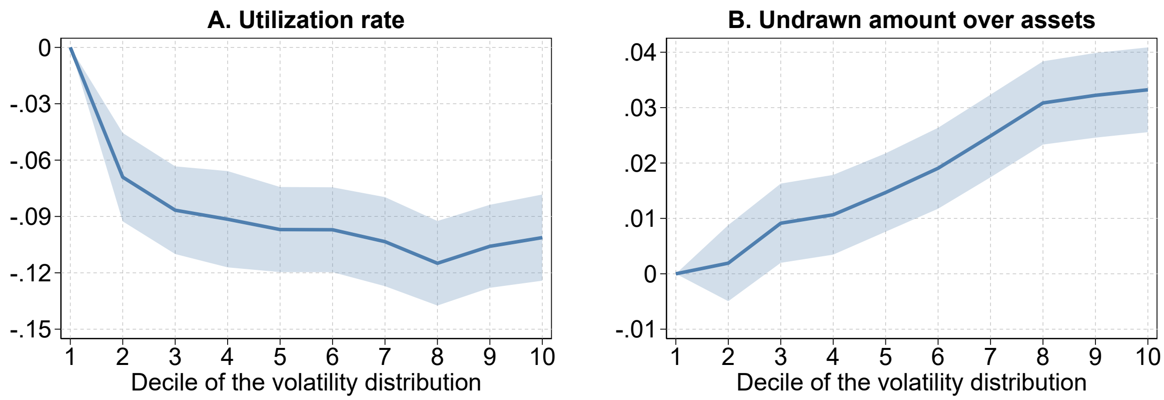
Note that the unit of observation in (13) is firm-month, but that the explanatory variables only vary at the firm-year level. This is because the main explanatory variable as well as the control variables are defined based on financial-accounts data, which we only observe at annual frequency. To account for the within-firm dependence in the error term that this gives rise to, we cluster the standard errors at the firm level as well as at the period level.

We report the results of the estimation of (13) graphically in the two panels of Figure 8. The plotted values are the estimated coefficients $\widehat{\beta}^d$ for the respective deciles d of the cash-flow volatility distribution, which capture the conditional average difference in the dependent variable between firms in decile d and firms in decile 1. The shaded areas represent 95 percent confidence intervals.

Consider first Panel A, which shows the results when the dependent variable is the utilization rate. The utilization rate is strongly decreasing in volatility, with firms in the upper half of the distribution having average utilization rates of around ten percentage points less than firms in the bottom decile. The estimated differences are statistically significant in all cases and the magnitudes are economically meaningful: the mean utilization rate in the sample is

[9]The risk classes correspond to five bins of the distribution of probabilities of default (PD), where the PDs are estimated by the leading Swedish credit bureau UC AB.

Figure 8: Cash-flow volatility and credit-line utilization



This figure plots the β^d coefficients obtained when estimating equation (13) with the utilization rate (Panel A) and the undrawn amount over net assets (Panel B), respectively, as dependent variable. The shaded areas represent 95-percent confidence intervals.

27 percent, which implies that the average difference between firms in the top-half and the bottom decile of the cash-flow volatility distribution is more than one-third of the sample mean. We reach a similar conclusion when we use the ratio of the undrawn amount on credit lines to assets as dependent variable (Panel B). The undrawn amount over assets increases monotonically over the cash-flow volatility distribution and is over three percentage points higher in the top decile than in the bottom decile. This difference amounts to one third of the sample mean of the ratio of undrawn amount to net assets and is thus clearly economically significant.

Taken together, these estimates show that when firms face higher uncertainty about future productivity—captured here by idiosyncratic cash-flow volatility—they expand their liquidity buffers by reducing their credit-line utilization and thus increasing the undrawn amounts. This confirms one of the key predictions of the model presented in Section 4, namely, that firms facing higher uncertainty stay further away from their borrowing limit in order to retain spare borrowing capacity in the eventuality of future liquidity needs.

5.2 The effects of increases in credit limits

The second main testable prediction of the model is that borrowing and real activity respond to credit-limit increases even for firms facing slack borrowing constraints. In this section, we take the financial part of this prediction to the data (section 5.2.1).[10]

5.2.1 The effect of increases in credit limits on borrowing

We use the following regression to test how a firm's credit-line borrowing responds to an increase in the committed amount (limit), and, in particular, how the response varies depending on how close the firm was to the limit before the increase:

$$\frac{\Delta Drawn_{i,t}}{NetAssets_{i,t-1}} = \alpha_{i,j,s,c,t} + \sum_{k=1}^{5} \beta^k \cdot \frac{\Delta Committed_{i,t}}{NetAssets_{i,t-1}} \cdot \mathbb{1}\left\{DTL\ Bin_{i,t-1} = k\right\} + \varepsilon_{i,t}, \qquad (14)$$

where the dependent variable is the the change in the drawn amount on firm i's credit lines between $t-1$ and t and the explanatory variable is the change in the committed amount during the same period, both normalized by the firm's net assets at $t-1$. The vector $\alpha_{i,j,s,c,t}$ contains industry-size-county-month as well as firm fixed effects—the latter absorb any time-invariant unobservable firm characteristics affecting borrowing and the former any unobservable time-variation in credit demand common to similarly sized firms operating in the same county and two-digit industry. Degryse et al. (2019) show that these interacted fixed effects are efficient in controlling for unobservable variation in credit demand, which helps us identify the effects of supply-driven changes in the committed amount. Some unobserved idiosyncratic variation in credit demand may nevertheless remain, so our model should not be interpreted as identifying purely causal estimates.

Any heterogeneity in the response of borrowing to changes in the committed amount is captured by the interaction of the main explanatory variable with indicator functions for bins of the distance-to-limit distribution in the period preceding the change in committed amount. The indicator functions are constructed as follows. First, we compute three alternative measures of a firm's distance-to-limit (DTL)—the credit-line utilization rate, the ratio of undrawn amount to net assets, and the ratio of cash holdings to net assets—in period $t-1$.[11] We then split each measure into five roughly equally-sized bins k and construct an indicator function for each, which we denote $\mathbb{1}\left\{DTL\ Bin_{i,t-1} = k\right\}$. β^k thus captures the response of credit-line borrowing to a change in the committed amount for a firm belonging to bin k of the distribution of one of the three distance-to-limit measures.

[10] We are currently working on the real part of the prediction, i.e., that hiring responds to credit-limit increases even for firms facing slack borrowing constraints.

[11] The ratio of cash holdings to net assets do strictly speaking not measure the distance to the firm's borrowing limit, but since cash holdings is a potential alternative to undrawn credit-line capacity it is nevertheless a relevant measure to consider in this context.

Table 4: Firms' propensity to borrow out of limit increases

	A. $Used_{i,t-1}$		B. $Unused/NA_{i,t-1}$		C. $Cash/NA_{i,t-1}$	
	k	β^k	k	β^k	k	β^k
	[0,0.2)	0.143*	≥ 0.15	0.155**	≥ 0.15	0.299***
		[0.078]		[0.054]		[0.086]
↑	[0.2,0.4)	0.280***	[0.1,0.15)	0.367***	[0.1,0.15)	0.408***
Further from limit		[0.079]		[0.064]		[0.115]
	[0.4,0.6)	0.251**	[0.05,0.1)	0.565***	[0.05,0.1)	0.298***
Closer to limit		[0.104]		[0.081]		[0.085]
↓	[0.6,0.8)	0.485***	[0.02,0.05)	0.612***	[0.02,0.05)	0.274**
		[0.078]		[0.099]		[0.095]
	[0.8,1]	0.706***	[0,0.02)	0.666***	[0,0.02)	0.345***
		[0.059]		[0.061]		[0.083]
Number of observations		169,363		176,040		174,829
Number of firms		14,700		14,715		14,603
Adjusted R^2		0.208		0.166		0.047

This table reports estimation results for the model specified in (14). The unit of observation in the regressions is firm-month and the sample period spans December 2019 to December 2020. All estimations include firm as well as industry-size-county-month fixed effects, where industries are defined by two-digit SNI/NACE codes and size classes correspond to the eleven size bins defined in section 3.1. The distance-to-limit measure used in the respective estimations are given in the panel headers. The columns denoted k specify the intervals defining the respective distance-to-limit bins, while the columns denoted β^k provide the estimated coefficient for bin k of a given distance-to-limit measure. Standard errors clustered by firm and month, respectively, are reported in square brackets. ***, **, and * denote statistical significance at the ten, five, and one percent levels, respectively.

The results of the estimation of (14) are reported in Table 4. Consider first panel A, where the distance-to-limit measure is the utilization rate in period $t-1$. The results show that increases in committed amounts are associated with statistically significant increases in borrowing in all bins but the first (the bin comprising the firms furthest from the limit), where the point estimate is positive but statistically insignificant. The response is decreasing in distance to limit: following an increase in the committed amount of one SEK, borrowing increases by 0.71 SEK for firms nearest the limit, by 0.25 SEK in the middle of the distribution, and by 0.14 SEK for firms furthest from the limit.[12]

[12] Estimating a version of (14) in which the explanatory variable is not interacted with the distance-to-limit bins yields $\beta = 0.33^{***}$—i.e., borrowing on average increases by 0.33 SEK for every SEK increase in committed amount.

Panel B shows that the results are very similar when the distance-to-limit measure instead is the ratio of undrawn amount to net assets: the response of borrowing is here statistically significant in all bins and monotonically increasing over the distribution, going from 0.16 to 0.67 SEK for every SEK increase in committed amount as one moves from the firms furthest from the limit to those nearest to the limit. Interestingly, however, the results in panel C show that cash holdings are not a strong predictor of how borrowing responds to an increase in the committed amount on credit lines: the response is statistically significant in all bins of the distribution—ranging from 0.27 to 0.41 SEK of borrowing per SEK increase in the committed amount—but there is no clear pattern in how the response changes as one moves from firms with smaller to firms with larger cash holdings.

That borrowing responds significantly to limit changes even for firms facing slack borrowing constraints is hard rationalize based on static conceptions of credit constraints, but follows naturally from the dynamic conception developed in this paper. The results in Table 4 therefore provide importance evidence for the relevance of a dynamic conception of credit constraints.

6 Concluding Remarks

This paper has presented a set of stylized facts showing that firms, both small and large, have access to large amounts of unused and reasonably priced borrowing capacity via credit lines. These empirical facts are hard to reconcile with the notion that credit constraints are a widespread phenomenon in the corporate sector. We have, however, shown that they are still consistent with the view that credit constraints are widespread once we consider a more general concept of constraints that takes into account the dynamic properties of a firm and the uncertainty that it faces in a dynamic environment.

More specifically, we have used a theoretical model to illustrate the trade-off that firms face when taking decisions about borrowing in the presence of uncertainty. When confronted with uncertainty, firms trade off the benefit of borrowing today against the expected cost of becoming illiquid tomorrow. This leads them to optimally choose not to borrow up to the limit, but to keep some spare borrowing capacity. In such an environment, lower utilization of credit can be a consequence of tighter dynamic credit constraints rather than an indicator of slack constraints. We have taken two important implications of the model to the data.

We have first shown that when financial or productivity uncertainty increases, firms utilize their credit lines less. We have then assessed how firms respond to changes in their credit limits. We have shown that borrowing responds significantly to limit changes even for firms facing slack borrowing constraints. This result, while being puzzling from the vantage point of static conceptions of credit constraints, follows naturally from the dynamic conception developed in this paper.

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Appendix A. Details on the data and variable construction

A1 Computing covenant-adjusted measures of credit-line size and utilization

In this section, we describe the computation of the covenant-adjusted measures of the size and utilization of credit lines presented in Section 3.2 of the paper. The basic idea is to adjust the committed amount on a firm's credit lines downwards until the undrawn amount equals the increase in borrowing that the firm can undertake without breaking any covenant. We do not observe covenants in the data and therefore follow the covenant-adjustment approach of Greenwald, Krainer and Paul (2020). This involves assuming (i) that all firms are subject to two of the most common covenants in debt contracts—a minimum interest coverage ratio and a maximum debt-to-earnings ratio—and (ii) that the requirements on these ratios equal the average requirements in the sample of debt contracts studied by Greenwald (2019).

The interest-coverage (IC) covenant is defined as

$$\frac{\sum_{k=-3}^{0} EBITDA_{i,t-k}}{\sum_{k=-3}^{0} IntExp_{i,t-k}} \geq \kappa, \tag{A1}$$

where k denotes quarters and the summation reflects that the IC covenant is typically evaluated based on rolling four-quarter sums of cash flow and interest expenditures. The IC covenant thus requires that the ratio of operational cash flow (EBITDA) to interest expenditures exceeds κ. The debt-to-earnings (DE) covenant is defined as:

$$\frac{Debt_{i,t}}{\sum_{k=-3}^{0} EBITDA_{i,t-k}} \leq \tau, \tag{A2}$$

where EBITDA like before is measured as a four-quarter rolling sum and debt is the firm's total interest-bearing debt in period t. The DE covenant thus requires the ratio of debt to operational cash flow to debt to be below τ. Following Greenwald, Krainer and Paul (2020), we assume that all firms face thresholds of $\kappa = 2.75$ and $\tau = 3.75$, respectively.

The first step in the adjustment procedure is to compute the covenant-adjusted undrawn amount on a firm's credit lines. We define this as the minimum of the actual undrawn amount and the largest increase in debt that the firm can undertake without breaking any covenant:

$$Undrawn_{i,t}^{CovAdj} = \min\left\{Undrawn_{i,t}, Undrawn_{i,t}^{IC}, Undrawn_{i,t}^{DE}\right\}. \tag{A3}$$

The maximum increase in debt that the firm can undertake without breaking the respective covenants are, in turn, computed as

$$
\begin{aligned}
Undrawn_{i,t}^{IC} &= \max\left\{\frac{\sum_{k=-3}^{0} EBITDA_{i,t-k}}{2.75 \cdot i_{i,t}} - \frac{\sum_{k=-3}^{0} IntExp_{i,t-k}}{i_{i,t}}, 0\right\} \\
Undrawn_{i,t}^{DE} &= \max\left\{3.75 \cdot \sum_{k=-3}^{0} EBITDA_{i,t-k} - Debt_{i,t}, 0\right\},
\end{aligned}
\tag{A4}
$$

where $i_{i,t}$ is the weighted average interest rate on firm i's credit lines in period t. When the credit-line interest rate is missing for a firm-period observation, we impute it as the average in the industry $\times$ size decile $\times$ period$\times$ risk-class cell to which the observation belongs. We bound the covenant-adjusted undrawn amounts at zero, so that the measures reflect the maximum *additional* amount of borrowing that the firm is able to undertake.[A1]

We then define the covenant-adjusted committed amount on a firm's credit lines as the sum of the actual drawn amount and the covenant-adjusted undrawn amount:

$$
Committed_{i,t}^{CovAdj} = Drawn_{i,t} + Undrawn_{i,t}^{CovAdj}. \tag{A5}
$$

Finally, we compute the various covenant-adjusted measures of the size and utilization of credit lines based on $Committed_{i,t}^{CovAdj}$ and $Undrawn_{i,t}^{CovAdj}$; for example, we measure the covenant-adjusted utilization rate as $Used_{i,t}^{CovAdj} = Drawn_{i,t}/Committed_{i,t}^{CovAdj}$.

[A1]We are in practice forced to rely on fiscal-year figures for EBITDA and interest expenditure from the latest available annual report when computing the measures in (A4), as most firms in our data do not report quarterly financial accounts.

Appendix B. Proof of Proposition 4.2

Denote by $x = \xi z$ the product of the two shocks and $\Gamma(x)$ the joint cumulative probability density defined in the domain $[x_{Low}, x_{High}]$. Assume that the density function is strictly increasing in x. The expectations of the distress cost and its derivative can be written as

$$\mathbb{E}\varphi(b) = \kappa \cdot \int_{x_{Low}}^{b} (b-x)^2 \Gamma(\mathrm{d}x), \tag{B1}$$

$$\mathbb{E}\varphi'(b) = 2\kappa \cdot \int_{x_{Low}}^{b} (b-x) \Gamma(\mathrm{d}x). \tag{B2}$$

Both terms are strictly increasing in $b \geq x_{Low}$. A condition that is always satisfied. In fact, if $b \leq x_{Low}$, then $b_{t+1} \leq \bar{\xi}_{t+1}\bar{z}_{t+1}$, that is, the borrowing constraint is not binding and $\mu_t = 0$. Since $\mathbb{E}\varphi'(b)$ is also zero, condition (10) cannot be satisfied under the assumption $q_t > \beta$.

If the borrowing constraint is binding, then $b_{t+1} = \bar{\xi}_{t+1}\bar{z}_{t+1}$. For this to be the case we need

$$q_t > \beta \mathbb{E}_t \Big[1 + \varphi'_{t+1}(\bar{\xi}_{t+1}\bar{z}_{t+1}) \Big],$$

that is, if we set the debt equal to the borrowing limit, condition (10) implies $\mu_t > 0$. But for sufficiently high values of κ we will have

$$q_t < \beta \mathbb{E}_t \Big[1 + \varphi'_{t+1}(\bar{\xi}_{t+1}\bar{z}_{t+1}) \Big].$$

Therefore, for sufficiently high values of κ, the borrowing constraint is non-binding, that is, $b_{t+1} < \bar{\xi}_{t+1}\bar{z}_{t+1}$. On the other hand, if $q_t = \beta$, the only way condition (10) can be satisfied is to have $\mu_t = \mathbb{E}_t\varphi'_{t+1}(b_{t+1}) = 0$, which requires $b_{t+1} \leq x_{Low} < \bar{\xi}_{t+1}\bar{z}_{t+1}$. Thus, the borrowing constraint is never satisfied and the distress cost is always zero.

Next we need to show what happens if $\bar{\xi}_{t+1}$ or $\bar{z}_{t+1}$ increase. Consider an increase $\bar{\xi}_{t+1}$ or $\bar{z}_{t+1}$ that shifts the distribution to the right without changing its shape. This relaxes the borrowing constraint and reduces the values of $\mathbb{E}_t\varphi'_{t+1}(b_{t+1})$ as we can see from (B2). Therefore, condition (10) implies that b_{t+1} must increase.

We can now turn to condition (11). We want to show that the left-hand-side increases when $\bar{\xi}_{t+1}$ or $\bar{z}_{t+1}$ increase. If we can prove that, then we prove that $\Upsilon'(g_{t+1})$ on the right-hand-side must also increase and this is possible only if g_{t+1} increases.

To show that the left-hand-side of (11) increases with $\bar{\xi}_{t+1}$ or $\bar{z}_{t+1}$, let's first consider the case in which the debt b_{t+1} does not change. In this case, an increase in $\bar{\xi}_{t+1}$ reduces

$\mathbb{E}_t\varphi_{t+1}(b_{t+1})$, raising the left-hand-side of (10). If $\bar{z}_{t+1}$ increases, $\mathbb{E}_t\hat{v}_{t+1}$ rises and $\mathbb{E}_t\varphi_{t+1}(b_{t+1})$ falls. Thus, both effects raise the left-hand-side of condition (11).

We now allow the debt to change. We have seen that condition (10) implies that an increase in ξ_{t+1} or z_{t+1} raises b_{t+1}. We now show that an increase in b_{t+1} does not reduce the left-hand-side of equation (11). Taking the derivative of the left-hand-side we obtain

$$q_t - \beta - \beta\mathbb{E}_t\varphi'_{t+1}(b_{t+1}).$$

Condition (10) implies that this term is non-negative. Therefore, an increase in b_{t+1} induced by a higher value of $\bar{\xi}_{t+1}$ or $\bar{z}_{t+1}$ cannot reduce the left-hand-side of (11). Together with the direct effect characterized above (keeping the debt constant), this establishes that a higher value of $\bar{\xi}_{t+1}$ or $\bar{z}_{t+1}$ increases the left-hand-side of (11). The right-hand-side must then also rise, which requires a higher value of employment growth g_{t+1}. ■

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