A Win-Win Loan Contract in Profit Uncertainty

John C. Chu* Zhanbing Xiao†

Updated on: December 2, 2025

Abstract

This study identifies a wedge of profit uncertainty in entrepreneurial projects. The wedge breaks the deterministic causality from innovations to monopolistic profits. Profit uncertainty changes the decisions that underlie the management of entrepreneurial liquidity and the origination of bank loans. We develop a win-win loan contract in which the borrower maximizes its interest without sacrificing that of the lender. Active credit screening is essential for achieving a win-win agreement, although ex ante agreements differ from win-win outcomes. Empirical evidence challenges the traditional classification of financially constrained companies. The drawdown analysis has discovered weak loan demand during economic recessions.

Keywords: win-win contract, active credit screening, profits and growth, bank capital, borrower side story.
JEL Codes: G21, G30.

*Corresponding author, Monash Business School, Monash University. Email: john.chu@monash.edu. Tel: +61-3-9903-4546.

†City University of Hong Kong. Email:zhanbing.xiao@cityu.edu.hk.

1 Introduction

This study presents a new framework for evaluating the decisions of entrepreneurs, banks, and households. These decisions revolve around the management of entrepreneurial liquidity and the decisions of the bank loan business. The new framework is named Achieving a Win-Win Loan Business (AWWLB), introducing a dynamic growth process with two key operations.

The first step involves establishing a pair of loan and deposit contracts with the expectation of achieving a win-win outcome. This study covers the first step, and the bank's active credit screening prior to loan origination is the key to success. The second operation involves maintaining loan portfolios. Loan maintenance leads to different outcomes Chu (2025).

Holmström and Tirole (1998) suggests an "active role" of intermediaries, on page 39, as a direction of future research. This study addresses three questions on why, how, and what. Why should a bank be active? How should a bank play its active role? What could change in the bank loan business when the bank is active?

The analytical foundation for why a bank must be active is the uncertainty of profit. This study identifies an overlooked wedge in the causality of endogenous growth theory in Romer (1990). The wedge is profit uncertainty, which lies between innovations and monopolistic profits. Due to uncertainties, an innovative technology may not automatically guarantee profit. 23andMe is a recent empirical observation of profit uncertainty.

The traditional method to solve profit maximization problems has lost its dominance in a world of uncertainty. The most profitable project chosen by the Lagrange multiplier method disappoints entrepreneurs earlier than expected. Market supply and demand change because the world is no longer static. Furthermore, the choice of project replacements cannot be addressed by re-running the Lagrange multiplier. This is due to another reason: the path dependence. Choosing a project with the highest immediate profits can limit an entrepreneur's future options when the former flagship project loses its momentum. The growth divergence between Compaq and Apple from 1980 to 2010 shows the path dependence.

In a world of uncertainties, new talent is needed to regain profits in project replacements. The guiding spirit can identify a project of tomorrow's star, whereas others don't. Steve Jobs demonstrates the ability to transform Apple from a company experiencing declining profits in computer manufacturing to a global innovator in high-margin consumer electronics.

Why do entrepreneurs continue to try new projects when the previous one has lost steam? The question is especially interesting because most entrepreneurs have more wealth than they could consume. Following the mechanism of endogenous bank growth in Chu (2025), this study identifies project profits as the main source of happiness for entrepreneurs.

Permanent interest is usually attributed to Lord Palmerston's speech. This study defines profit accumulation through project replacements in a world of uncertainty as the permanent interest of all entrepreneurs. Project profits increase an entrepreneur's wealth, which satisfies utility (happiness) in multiple dimensions beyond consumption. Invested wealth can grow an entrepreneur's future wealth. More wealth conveys the image of being smarter and more successful among peers, indicating a higher status in the socioeconomic pyramid.

Project replacement can fail due to strategic uncertainties. Wealth is reduced when a project fails to succeed. When a series of failures has depleted an entrepreneur's wealth, bankruptcy becomes a likely outcome. Observing loan defaults after bankruptcy announcements, banks are vigilant for bad loans due to imperfect diversification identified in Chu (2025).

Imperfect diversification arises when profits from good loans are not enough to cover losses from bad loans. Bank insolvency and bank runs are the worst results. Charging higher coupon rates is not helpful because doing so increases the default probability of the borrowers. The only way to maintain a sustainable loan business is to strike a pair of win-win contracts for loans and deposits. In a win-win relationship, entrepreneurs, banks, and households can maximize their own permanent interests without encroaching on the interests of others.

After signing a loan contract, a bank either lends to the borrower or converts the loan commitment into an entry on its balance sheet. In the latter case, a bank can honor drawdown requests at any time before the maturity date. The borrower has achieved a win.

However, a bank will incur losses if it does not receive debt payments as stipulated in the loan contract. To avoid a loan contract that could result in a bank's loss, credit screening exercises must thoroughly review the operational history of each loan applicant. Unlike cash holdings, operating profits ($EBIT_t$) generated by output activities are the only continuous income to pay debt. Profit uncertainty can be described as strategic or tactical. We classify heterogeneous profit uncertainties into three profiles.

Profile 1: operations report regular negative $EBIT_t$. The average of positive $EBIT_t$ is higher than the absolute average of negative $EBIT_t$. Profit uncertainty for companies in profile 1 indicates a tactical negative operating profit. Profile 2: operations report sporadic negative $EBIT_t$. The average of positive $EBIT_t$ is significantly higher than the absolute average of negative $EBIT_t$. Profile 3: operations report a regular negative $EBIT_t$. The average of positive $EBIT_t$ is significantly lower than the absolute average of negative $EBIT_t$. The uncertainty of the profit for the companies in Profile 3 indicates a negative strategic operating profit, and project replacement is the only viable option.

To establish a win-win relationship, the bank will offer a credit line contract to loan applicants in profile 1 with tactical profit uncertainty and turn down applicants in profile 3 with strategic uncertainties. The convergence process for profile 2 is complicated. The bank will offer a credit line contract to applicants in profile 2 with a premium.

Applicants in profile 2 are split. Some accept the bank's offer, while the rest decline it. Applicants in profile 2 have a strong history of generating profits. They apply for credit lines as insurance to protect against a rare liquidity disaster. However, a bank may report losses if it contracts with the applicants in profile 2 for insurance.

According to Basel II enhancements of 2006, a bank must convert its commitment of credit lines to on-balance sheet assets. For every entry of assets, a bank must pay the deposit interest rate and commit its capital. The commitment fee paid by applicants in profile 2 is insufficient to cover the costs that the bank maintains for the loan commitment.

To support the entrepreneur's win while maintaining its own win, the bank raises the all-in

loan coupon for potential borrowers in profile 2. Applicants who value the insurance protection will accept the bank's offer with a premium. Those who expect that the benefits from insurance protection are overshadowed by the costs of the loan premium will turn down the bank's offer.

Being protected from liquidity shocks in existing operations, entrepreneurs may seek term loans to expand the scope or scale of their business. Credit screening exercises still focus on operating income on debt payments. Here are two conditions for a term loan contract.

First, because a new project under construction will not generate sales revenues, the existing operating profit is the only source of coupon payments. Historical $EBIT_t$ should be stronger due to the larger principal on the term loan. Second, the accumulated profits from the sales of the new project, once completed, indicate a good or bad prospect of principal repayment. A term loan contract will be converged if the bank is satisfied with both conditions.

A young company is rejected for term loans due to a short and below-average track record. However, a bank may offer a convertible debt contract if the sales of the new project are promising. Convertible debt remains a win-win contract because cash flow rights following equity conversion will compensate for lower coupon income prior to conversion.

Active credit screening is the main contribution of this study. A bank's credit screening is necessary to achieve dynamic growth in the AWWLB framework. The AWWLB framework is build on two pillars: the wedge of profit uncertainty and the imperfect diversification of bank loans. To highlight our contribution, we first outline two characteristics of the knowledge frontier in entrepreneurial liquidity management and bank loan operations: sufficient diversification and static general equilibrium.

Diamond (1984) pioneers the concept of perfect diversification. Bad loans are not a concern. In Romer (1990), innovations guarantee monopolistic profits, and profits drive growth. Assuming effective diversification, Holmström and Tirole (1998) argues that banks play a passive role in the loan business. Diamond and his co-authors assume that bank loans are safe but illiquid. They analyze the risk of portfolios of loans from household deposits. The first and fundamental contribution is the self-fulfilling bank run model Diamond and Dybvig (1983).

Diamond and Rajan (2000) highlights the trade-off effects of bank capital. More bank capital, although improving stability, reduces liquidity creation and weakens discipline. Diamond and Rajan (2001) emphasizes why a fragile capital structure of the bank is desirable. The threat of bank runs serves as an effective discipline mechanism.

Analyzing the wave of bank failures in 2023, Chu (2025) proposes an imperfect diversification that has been overlooked in seminal papers. Imperfect diversification undermines the foundation that perfect diversification can guarantee the safety of loan portfolios. If imperfect diversification is a concern, how many bad loans are too bad? The answer lies in the relatively good-to-bad loans on a bank's balance sheet. Rapid self-healing maintenance explains the long-term growth of banks such as JPMorgan. Slow self-healing explains why a bank is acquired while another bank files for bankruptcy.

Chu (2025) has established a dynamic model for bank growth. Profits from good bank loans are an endogenous source of growing bank capital. Bank capital enhances the confidence of households to roll over their deposits. The theoretical arguments in Chu (2025) have laid the foundation for why active credit screening is necessary.

Active credit screening, aiming for a win-win loan contract, eliminates concerns about bank capital in Diamond and Rajan (2000). Because the bank capital ratio is exogenous, more capital will bring more deposits to new loan contracts. When capital is a bank's primary interest, monitoring loan borrowers will be a bank's job in priority. Meanwhile, a household's permanent interest is to grow family wealth faster. Households roll over deposits with happiness in episodes of rapid self-healing maintenance. Household withdrawal is a self-protection instead of monitoring bank operations suggested in Diamond and Rajan (2001).

This study has challenged the traditional identification of financial constraints. In Sufi (2009), access to credit lines and above median operating profit are necessary for a company to be unconstrained financially. This study proposes a new argument with reverse causality. Financially unconstrained is a necessary condition for a company to access credit lines.

Operating profit is a key indicator to determine whether a company is financially con-

strained. A financially constrained company reports profile 3 $EBIT_t$: regular negative $EBIT_t$ with a negative mean value. The solution to become unconstrained is to replace the project.

If a startup project reports profile 3 $EBIT_t$, an entrepreneur has two options. The project replacement is one. If the entrepreneur believes profits will fly in the future, the company must have sufficient cash reserves to sustain its operations.

Operating profits decide whether a company has access to credit lines. The bank will not offer access to companies in profile 3 $EBIT_t$ due to concerns about loan default. Some companies in profile 2 $EBIT_t$ do not have access to credit lines because they have sufficient $EBIT_t$. Access to credit lines is an auxiliary external tool to address temporary liquidity shortages.

This study explains the positive relationship between positive $EBIT_t$, cash holding, and company size in (Almeida, Campello, and Weisbach, 2004). If a company can maintain consistent profits throughout project replacements, its cash holdings will be positive. Through project upgrades, the company will grow in size.

The drawdown decisions on credit lines during an economic recession identify a borrower's side story. Regular users only draw down about 25% of their credit lines during the Great Recession. Moreover, evidence shows that the 25% drawn drowns is not constrained by the bank's liquidity supply. Our demand-side story complements the established supply-side shocks in the lending-channel literature[1].

Here are two more predictions from the AWWLB framework. First, an economic recession has a negative impact on financial stability. The spillover channel is independent of the known channels of risk spillovers. Chu and Ou (2025) offers empirical evidence in this regard. Second, if the bank follows the Basel II enhancement in 2006 to convert off-balance sheet commitments to on-balance sheet assets, the tension between systemic risk and access to credit lines, as discussed in (Acharya, Almeida, and Campello, 2013), shall be alleviated. We leave the approval or disapproval to future empirical research.

[1]See, among others, Campello (2002), Calomiris and Mason (2003), Ashcraft (2005), Khwaja and Mian (2008), Paravisini (2008), Leary (2009), Chava and Purnanandam (2011), Puri, Rocholl, and Steffen (2011), and Schnabl (2012).

2 The challenge of profit uncertainty to endogenous growth

2.1 What is profit uncertainty and why economists should care

The toehold of this study lies in re-examining the causality of endogenous growth in Romer (1990). In Romer's framework, innovations lead to monopolistic profits, which in turn drive growth. We introduce a wedge of *profit uncertainty* between innovations and monopolistic profits — the idea that inventive success does not guarantee commercial reward.

Empirically, this wedge is readily observed. For example, 23andMe pioneered consumer genomics. *Time* magazine named the project "Invention of the Year" in 2008. However, the company has yet to achieve profitability (Winkler, Wall Street Journal, 31 January 2024). Similarly, Sony's Betamax technology technically outperformed JVC's VHS, yet VHS dominated the market in the 1970s and 1980s. These examples illustrate that innovative superiority does not deterministically translate into profit dominance.

Given the endogenous growth model with added uncertainties, we pose the following question. How should entrepreneurs generate profits amid uncertainty? Before proposing a formal solution, we examine the historical trajectories of Compaq Computer and Apple Computer from their IPOs in the 1980s through 2007.

The comparison reveals two distinct phases. In the first phase, Compaq legally cloned the IBM PC architecture and, through the 1990s, achieved higher profits and faster growth than Apple, which pursued a closed ecosystem of proprietary hardware and software. In a static general equilibrium world, Compaq would appear to be the superior optimizer—akin to a firm that correctly applies the Lagrange multiplier to locate its profit maximum.

The second phase, beginning around 2000, illustrates the emergence of profit uncertainty. As low-cost PC manufacturers entered the market, Compaq faced intensified competition and declining margins. Despite launching a series of new projects, none achieved commercial success. Compaq was ultimately acquired by Hewlett-Packard in 2002, and the brand was discontinued in the United States by 2013.

In contrast, Apple successfully reoriented its business model toward consumer electronics. The iPod, introduced in 2001, marked its first major breakthrough, followed by accelerated growth after the release of the iPhone in 2007. The diverging outcomes of Compaq and Apple underscore that innovation and optimization alone do not guarantee enduring profits — an insight that resonates with the theme of profit uncertainty.

In an uncertain world, project replacement becomes the norm rather than the exception. The capacity to sustain profits over time is thus more valuable than the ability to identify a single "best" project ex ante. Indeed, selecting a project with the highest immediate return may constrain an entrepreneur's future strategic flexibility. Because every project replacement unfolds under uncertainty, the long-term winners are not those who merely maximize profits within a static general equilibrium, but those who evolve their investment philosophy toward sustainable profits through adaptive and durable growth. In short, the winner understands the challenge of uncertainties and focuses on wealth accumulation.

This updated philosophy has deep historical roots. As Ecclesiastes (9:11) observes, "The race is not to the swift… but time and chance happen to them all." The verse captures the essence of profit uncertainty: success in economic competition depends not only on skill or speed, but also on adaptability to unforeseen contingencies.

2.2 Axioms and assumptions in loan business

There are three main agents involved in the loan business: entrepreneurs, banks, and households. The model of a win-win loan business has two stages. The first stage is the loan organization. The goal of the first stage is to reach a loan contract with expected benefits to both borrowers and lenders. This study focuses on the first stage of loan origination. We identify that every bank loan origination includes two decisions. Entrepreneurs make the first decision about whether to apply for bank loans. A bank makes the second decision about the loan coupon rates, which may or may not be accepted.

After the loan drawdown, the coupon payment is due next month. The loan business has

entered its second stage. The goal of the second stage is to achieve mutually beneficial outcomes for both borrowers and lenders. The core mechanism of the second stage is the transformation of loan profits into bank capital accumulation. With new capital, a bank can make new loans or replace bad loans. Chu (2025) focuses on the second stage of loan maintenance.

In reality, a bank must operate the loan origination and maintenance simultaneously. Therefore, the twin studies, this study and Chu (2025), share the same axioms and assumptions. Of the shared axioms and assumptions, this study provides details on entrepreneurs, while Chu (2025) provides details on the bank and households.

Axiom 1. *Each agent cares only about wealth accumulation as its permanent interests.*

The term "permanent interest" is often attributed to Lord Palmerston in his 1848 speech to describe Britian's enduring foreign policy priorities[2]. We define *permanent interest* as cumulative profits over the lifetime (Π) of an agent. See Equation (1). Profits are generated from invested projects, and cumulative profits represent an agent's wealth.

$$\text{Permanent interest: } \Pi = \sum_{i=1}^{I} \sum_{t=1}^{m_i} P\&L_{i,t} \tag{1}$$

An entrepreneur, the bank, or a household each recognizes wealth accumulation as the agent's permanent interest. Wealth is an agent's permanent interest because it brings happiness in multiple dimensions. Wealth supports consumption, can be invested to generate more wealth, and is transferable from generation to generation.

The subscript i indicates the number of sequential projects for an agent. $i = 1, 2, ...I$. Upon starting a project, an entrepreneur expects the project to generate profits. Cumulative profits become the shareholder equity of an entrepreneur.

Due to the uncertainty of the profit, $P\&L_{i,t}$ represents the profit or loss incurred in time t for the project i. When a project stops making profits, continuing operations will accumulate

[2]"We have no eternal allies, and we have no perpetual enemies. Our interests are eternal and perpetual, and these interests it is our duty to follow." Henry Temple, 3rd Viscount Palmerston (1784-1865) British statesman, Prime Minister (1855-58, 1859-65) Lord Palmerston; Speech, House of Commons (1 Mar 1848)

losses. Project replacement refers to the process by which an entrepreneur searches for and initiates a new project to replace an existing one that is imposing losses. Therefore, each project i has a unique life, $Tenor = m_i$.

Due to profit uncertainty, a new project may not generate the expected profits. When cumulative losses exceed cumulative profits and the initial endowment AT_0, the entrepreneur has lost their wealth and cannot start a new project. The only option is to file for bankruptcy and announce retirement. The project I marks the end of the career as an entrepreneur, Equation (2). The cumulative tenors of projects from $i = 1$ to I are equal to the lifespan of an entrepreneur T_I.

$$AT_0 - \sum_{i=1}^{I} \sum_{t=1}^{m_i} NI_{i,t} = 0, \sum_{i=1}^{I} m_i = T_I. \tag{2}$$

Axiom 2. *A track record of business operations is necessary to access bank loans.*

Due to profit uncertainty, the bank shall evaluate whether a loan applicant can generate profits to pay back the loans. Therefore, a track record is necessary. It is too risky to offer loans to a company without a track record. Therefore, an entrepreneur must finance the first project with their endowment AT_0.

Axiom 2 highlights why Apple can access credit lines when producing Apple II but could not when producing Apple I. Wozniak and Jobs sell their personal properties to finance the production costs of Apple I. Once Apple I has generated a positive $EBIT_t$, the record confirms that the entrepreneur has the ability to generate profits to repay the loans. Apple Computer, Inc. was able to access credit lines from Bank of America in 1977 to produce the Apple II after successfully selling the Apple I in 1976. See Appendix A for details.

Axiom 3. *Bad loans are unavoidable in the banking system.*

Axiom 3 identifies a simple yet profound result of profit uncertainty. Non-performing loans, or bad loans, are part of the bank loan business. Here is how profit uncertainty and bad loans change the economic decisions of agents.

Let us start in the world of endogenous deterministic growth by Romer (1990) without uncertainty of profits. The only risk for an entrepreneur is whether the heavy investments in *R&D* can produce a successful innovation. The solution is straightforward. Finance all *R&D* projects with venture capital. Entrepreneurs without successful innovations are out.

For entrepreneurs with successful innovations, their operational assets are safe but illiquid as in Diamond and Dybvig (1983). Company assets are safe because innovations definitely lead to monopolistic profits Romer (1990). Upon receiving borrowing demands, the bank only makes passive decisions as in Holmström and Tirole (1998).

When agents are aware of the uncertainty of the profit that sits between innovations and monopolistic profits, the operating assets of an entrepreneur become not only illiquid but also risky. The bank must assess whether the borrower can repay the loans. That is why active credit screening becomes necessary for the bank.

Credit screening of loan applicants can reduce default events, but cannot eliminate bad loans in the banking system. Therefore, bad loans are unavoidable. The losses from bad loans can erode the bank's capital and compromise the interests of households through deposit contracts. In a nutshell, profit uncertainty has extended risks beyond entrepreneurs to the bank and households in the loan business. Therefore, we propose three new assumptions on the risks associated with each agent that are absent from the seminal papers Diamond and Dybvig (1983); Diamond (1984); Romer (1990); Holmström and Tirole (1998).

Assumption 1. *Profits of an entrepreneur's project are uncertain.*

Profit uncertainty is measured against the expected profit. If a project generates profits higher than expected, the entrepreneur is satisfied and will continue to operate the project. The uncertainty of the profit arises when the realized profits are lower than expected.

Profit uncertainty can be strategic or tactical. Before starting a new project, an entrepreneur has an expectation of the annual profits and the number of years they will reap those profits. Strategic uncertainty refers to a scenario in which realized profits are consistently lower than

expected. An entrepreneur seeks to replace a project that is experiencing strategic uncertainty.

There are two types of project replacement due to strategic uncertainty. First, during the operation of Project A, an entrepreneur identifies that Project B can generate more profits. The entrepreneur terminates Project A and starts Project B; This is an active project replacement. Second, when Project B is developed by another entrepreneur, the entrepreneur is forced to replace Project A with Project C; This is a passive project replacement. An entrepreneur operating with existing technologies is often forced to replace their project due to creative destruction, as noted in Aghion and Howitt (1992). A special case of passive replacement is after a loan default. Loan default events and associated impacts on the bank loan business will be covered exclusively by Chu (2025).

Experiencing tactical profit uncertainty, a project occasionally reports profits below expectations while generating profits consistent with expectations most of the time. The profit-generating process can be captured by a stochastic process. A liquidity gap arises when the profits of a project are insufficient to cover its operating costs in the next period. This study addresses strategic uncertainty in the absence of default events and tactical uncertainty.

Assumption 2. *The bank is vigilant for bad loans.*

Caring for wealth accumulation, a bank is sensitive to news of bad loans and intends to replace bad loans as soon as possible.

Assumption 3. *Households recognize the risk of term deposits.*

In caring for family wealth growth, households prefer term deposits over risk-free Treasury due to the higher returns of the deposits. Meanwhile, households recognize the risk of term deposits. The risk comes from a scenario where a bank cannot absorb the losses of removing bad loans. Households will withdraw their deposits and invest in risk-free Treasury if they feel their bank deposits are not safe.

2.3 Describe tactical profit uncertainty by a mean-reverting process

We measure $P\&L$ of project i by operating profits, $EBIT$, and net income, NI. A company records a net income (NI_t) after paying interest rate payments if it has outstanding debt and corporate tax. Entrepreneurs pay the costs of sales ($Cost_t^{sales}$) and operating expenses ($OpEx_t$) at the beginning of each period. $Cost_t^{sales}$ is the direct production cost. $OpEx_t$ are ordinary costs of running the business, but not directly related to production. We term the sum of $(Cost_t^{sales} + OpEx_t)$ business expenses in Equation (3)[3].

$$EBIT_t = Rev_t - Cost_t^{sales} - OpEx_t;\ NI_t = EBIT_t - IR_t - Tax_t. \tag{3}$$

Entrepreneurs receive sales revenues (Rev_t) at the end of each period. The business expenses are pre-planned. However, sales revenues (Rev_t) vary over time due to uncertain market demand. Sales revenues could be lower than business expenses temporarily.

Because $EBIT_t$ and NI_t are uncertain and vary over time, we model the returns of an individual project, r_i, through a mean-reverting process. We adopt a discrete Euler version of arithmetic Brownian motion in Vasicek (1977); See Equation (4)[4]. μ_i and σ_i are expected returns of net income and the volatility of the returns of an individual project. h is a period of time. The random variable (z) has a mean of zero and a variance of one.

$$r_{t,i} = ROA_t = \frac{NI_t}{AT_t};\ \Delta r_{t,i} = \frac{\mu_i - r_{t,i}}{2}h + \sigma\sqrt{h}z_{t+1}. \tag{4}$$

[3] Accounting definitions follow (Berk and DeMarzo, 2017, Section 2.4, page 64). *Net Income = EBIT - interest expenses - corporate tax* (Table 2.2, page 63). IR_t is interest expense. Tax_t is corporate tax. *EBIT = sales revenues – cost of sales - operating expenses*. For the sake of modeling, we ignore entries of noncash accounting adjustments, such as depreciation and amortization, other noncash items, cash effect of changes in accounts receivable, payable, and inventory.

[4] $ROA = \frac{\text{Net Income + Interest Expenses}}{\text{Book Value of Assets}}$ (2.21, page 77); For an agent operating a business without debt, the return on equity is $ROE = \frac{\text{Net Income}}{\text{Book Value of Equity}}$, (2.20, page 76).

2.4 Project replacement due to strategic profit uncertainty

We propose a wedge between innovations and monopolistic profits in Romer (1990). The wedge is the uncertainty of profits. Uncertainties can be strategic or tactical.

When a project is hit by strategic profit uncertainty, realized profits fall consistently below expectations, $\bar{r}_{i,realized} < \mu_i$. Motivated to accumulate more wealth, an entrepreneur terminates the project earlier than expected $m_{i,realized} < m_i$. m_i is the expected tenor of a project, which counts the number of years of a project in operation.

The wealth accumulated (AT_i) from the operation of the project i will be invested in the next project $i+1$ to continue the growth of wealth, AT_{i+1}. Equation (5) quantifies active project replacements in two projects.

$$AT_i = AT_{i-1} \times (1 + \bar{r}_{i,realized})^{m_{i,realized}},\ i = 1;\ AT_i = AT_{i-1} \times (1 + \mu_i)^{m_i},\ i = 2. \tag{5}$$

We use Apple's product replacement as an example to illustrate the intuition behind active project replacement and growth. Apple I computer is Wozniak and Jobs's first project. $i = 1$. Without a track record, Wozniak and Jobs must use their personal wealth (AT_0) to produce Apple I. The expected return is μ_1 per year and the expected duration of the project is m_1 years. With the successful sales of Apple I, Wozniak and Jobs identified that a new project, Apple II where $i = 2$, could generate more profits. They replaced Apple I with Apple II. Capital expenditure (AT_1) to produce the Apple II comes directly from the accumulated wealth from selling Apple I computers.

2.4.1 Endogenous project replacements to accumulate wealth

It is important to note that the replacements of the projects in Equation (5) are endogenous. A company that chooses a project to maximize its immediate profits may end up with limited choices when uncertainties arise. In a world of profit uncertainty, the ability to maintain sustainable profits through project replacements is more valuable to an entrepreneur's long-term

interests than the skill of capturing a single project with the highest returns. The comparison between Compaq Computer and Apple Computer in Section 2.1 provides intuition.

Equation (6) generalizes the iterative project replacements defined in Equation (5). The interest of an entrepreneur is to accumulate wealth, defined in Equation (1). The challenge to the goal is the uncertainty of the profit.

$\bar{r}_{i,realized} \cong E[\mu_i > 0]$ indicates the strategic uncertainty. Each selected project has an expected profit $E[\mu_i > 0]$ and an expected tenor of m_i years. An entrepreneur decides to terminate an existing project because $\bar{r}_{i,realized} < E[\mu_i > 0]$. However, the replacement project faces the same constraint as whether $\bar{r}_{i,realized} \cong E[\mu_i > 0]$ can be achieved.

$$\begin{aligned} \max_{\mu,\sigma} \quad & E\left[\sum_{i=1}^{I} AT_{i-1} \times (1+r_i)^{m_i}\right] \\ \text{s.t.} \quad & \bar{r}_{i,realized} \cong E[\mu_i > 0], \\ & Resources_{t-1} \geq Cost_t^{sales} + OpEx_t \text{ at every period } t. \end{aligned} \tag{6}$$

$Resources_{t-1} \geq Cost_t^{sales} + OpEx_t$ indicates tactical uncertainty. Free from strategic uncertainties, an entrepreneur still needs to ensure sufficient financial resources to cover business expenses in the next period. Financial resources from the previous period, $Resources_{t-1}$, include operating income $EBIT_{t-1}$, cash, or access to credit lines.

Equation (7) offers the closed-form solution in mathematics for Equation (6). Due to the uncertainty of profits, Equation (7) indicates a reference level of future wealth of an entrepreneur. Equations (6) and (7) predict heterogeneous wealth AT_{i-1} and the lifespan T_I of entrepreneurs in the company universe at any time t. An additional subscript j is needed such that $AT_{j,i-1}$ and $T_{j,I}$ demonstrate variations between entrepreneurs. We drop the subscript j with a focus on the subsequent projects of a specific entrepreneur.

$$\sum_{i=1}^{I} AT_{i-1} \times (1+\mu_i)^{m_i}. \tag{7}$$

The tenor of an individual project is m_i, and the duration of the career of an entrepreneur is T_i, where $m_i \leq T_i$. If project replacements are successful, the number of projects (i) and the entrepreneur's lifespan, T_i, grow. However, if Equation (2) is satisfied during project replacements, then I is the last project and T_I indicates the end of the entrepreneur.

We use three examples to illustrate the relationship between strategic profit uncertainty, project replacement, and the heterogeneity of entrepreneurs' lifespans. The first example is 23andMe. The company offers a direct-to-consumer genetic testing service. Being the first service of the entrepreneur, $i = 1$. The service tenor (m_1) lasts 4 years from 2021 to 2025. The service ends because "never made a profit"; see Winkler (2024). Filing for Chapter 11 indicates the end of the entrepreneur's lifespan. Therefore, $m_1 = T_1$ of 4 years.

The second example is the Nokia mobile phone, which performs multiple project replacements. We define a generation of entrepreneurs for 43 years because an individual starts a professional career at 22 years after graduating from a university and retires at 65 years of age. As a mobile phone entrepreneur, Nokia's lifespan is from 1982 to 2014.

The third example is Apple. Incorporated in 1977, Apple has been in business for 49 years, and its lifespan continues to expand. With constant project replacements, T_i of Apple has entered its second generation. The Appendix C has more details.

2.5 Tactical uncertainty and two motivations to access credit lines

In Equation (6), an entrepreneur dedicates their own shareholder equity AT_0 to start the first project $i = 1$. Let us focus on the tactical profit uncertainty. Although the project generates profits on average, an entrepreneur is exposed to liquidity shortages when profits in $t-1$ are insufficient to cover business expenses in t, as shown in Equation (8). The uncertainty also suggests that a liquidity shortage is unexpected.

$$NI_{t-1} < Cost_t^{sales} + OpEx_t. \tag{8}$$

Being exposed to a liquidity shortage, as in Equation (8), no entrepreneur can continue operations unless they pay their suppliers. Being exposed to negative profits in a specific period, a company only has two choices: saved cash and access to credit lines. Cash is saved from previous operating profits. With insufficient cash, access to credit lines becomes essential.

We start from the position that all companies recognize the importance of access to credit lines, having experienced historical liquidity shortages or witnessed other companies facing similar challenges. A bank loan business includes two sequential decisions. We code the company's decision to apply for bank loans as the first operation, or Op1.

Access to credit lines is a unanimous decision. However, there are two different motivations. The difference is in the distribution of $EBIT_t$. How often is a company hit by liquidity shortages? The difference can categorize all companies in the Compustat universe into two distinct groups, Op1A and Op1B.

Companies in the Op1A group report positive $EBIT_t$ most of the time. These companies can cover a small number of negative $EBIT_t$ with cash saved from previous periods where $EBIT_t$ is positive. Op1A companies demand credit lines as an insurance policy against a rare disaster of liquidity shortages. Not hit by a liquidity disaster, Op1A companies do not draw down loans from their credit lines. Figure I (A) shows an example of an OP1A company with $EBIT_t > 0$ in 97.5% of the periods.

All other companies are Op1B companies that not only experience unexpected liquidity shortages, but also have insufficient cash saved from periods to fill the liquidity gap. Therefore, these companies view credit lines as a necessary tool to address routine liquidity shortages. This is the second motivation.

As the mean of $EBIT_t$ decreases, Op1B companies develop two subgroups: Op1BA and Op1BR. The mean $EBIT_t$ of Op1BR companies becomes more negative in terms of frequency and magnitude in Equation (8) than that of Op1BA companies. Figure I (B) shows an example of an Op1BR company whose 75% $EBIT_t$ is negative.

Credit line application comes with upfront costs, with direct and indirect components. Di-

rect costs include expenses and resources to prepare for credit line applications. Indirect costs include the disclosure of private information about the firm's business operations[5].

Equation (9) quantifies different liquidity situations of an entrepreneur by liquidity meters. A firm scores a positive 1 point (1 pt) if the company expects sufficient internal liquidity for the next period. Applying for credit lines drains financial resources. Hence, the exercise costs a company -1 pt in the liquidity meter. Being shocked by unexpected liquidity shortages imposes -2 pts on the meter. However, the liquidity shortage will be neutralized (3-2-1=0) if the credit line application has been approved.

$$\text{Firm liquidity meter} \begin{cases} \text{-2 pts:} & \text{internal liquidity is insufficient;} \\ \text{-1 pt:} & \text{cost of applying for external financing;} \\ \text{1 pt:} & \text{internal liquidity is sufficient;} \\ \text{3 pts:} & \text{external debt application has been approved.} \end{cases} \tag{9}$$

External sources have higher meters than internal sources ($3pts > 1pt$) due to efficiency. The difference is consistent with theoretical and empirical studies. Credit lines are efficient liquidity sources (Kashyap, Rajan, and Stein, 2002; Gatev and Strahan, 2006; Sufi, 2009).

3 The permanent interest of a bank and active credit screening

After a company has submitted its credit line application, the bank loan business enters the second operation (Op2): loan origination. A bank loan origination includes two contracts: a loan contract in which the bank is the lender and a deposit contract where the bank is the borrower. There are three types of loans: credit lines, term loans, and convertible debt.

For a specific loan origination, the bank performs two exercises: active credit screening and loan capital preparation. Upon completion of Op2, the loan business enters the third operation

[5]Revealing liquidity shortages could have negative effects as supplies may withdraw from the established business relationship, and firms are forced to replace suppliers.

(Op3): loan maintenance. A bank makes new profits, accumulates its capital, originates new loans, or replaces bad loans with new loans. This study focuses on active credit screening. The preparation of the loan capital for Op2 and Op3 is covered in Section 2 in Chu (2025).

3.1 Permanent interest of bank loan origination

We reproduce three equations in Chu (2025) to indicate a specific bank loan borrower. NI is the net income of the bank loan business. The fact that the bank NI can be positive or negative is a key to understanding why active credit screening in Op2 is critical. Equation (10) identifies the profits in the bank loan business. AT is bank loans. r_{cpn} is the loan coupon income and r_{td} is the interest rates on household deposits. β is $(1 - BaselR)$. $BaselR$, the Basel capital ratio, is a constant and set exogenously by the regulatory agency. θ is the bank's operating costs. The bank loan business makes profits because the *expected* coupon income from loans is higher than the deposit interest rates paid to households, $r_{cpn} > r_{td}$.

$$NI = AT(r_{cpn} - \beta r_{td} - \theta) > 0. \tag{10}$$

NI of a bank varies in two dimensions. For an individual loan borrower, NI varies by time t. At a specific time t, a bank has loan contracts with multiple borrowers. Over time, NI varies from one loan portfolio to the next.

If a borrower does not default on its loans, Equation (10) indicates the bank's interest in Equation (1). Equation (11) identifies the growth engine in the bank loan business. Only profits from good loans are the permanent interest of a bank because profits raise bank capital (BC) from $t-1$ to t. In compliance with the Basel capital ratio, the new bank capital allows a bank to borrow new time deposits.

$$\because NI > 0,\ BC_t = BC_{t-1} + NI_{t-1};\ \because BC_t > BC_{t-1},\ TD_t > TD_{t-1}. \tag{11}$$

$$\because AT_t = BC_t + TD_t,\ AT_t > AT_{t-1}. \tag{12}$$

In dollars, bank loans (AT) are equal to the sum of bank capital (BC) and time deposits of households (TD). Equations (11) and (12) capture bank-specific endogenous growth in loan businesses. This model of bank operations and growth originated in the 14th to 15th centuries in Medieval and Renaissance Italy and has remained largely unchanged since then Chu (2025). The timestamp of the 15th century indicates that the bank growth model was in effect earlier than the First Industrial Revolution, which spanned from the mid-1700s to the mid-1800s. Therefore, the model for loan business and bank growth is independent of the neoclassical growth theory, pioneered by Solow (1956), and the endogenous growth theory, pioneered by Romer (1986, 1990). Successful loan businesses with continuous growth require rapid self-healing loan maintenance, as noted in Chu (2025).

We extend the three equations to a loan portfolio i with many borrowers. In addition, the bank can originate the next loan portfolio i if the previous one $i-1$ is successful. If all borrowers j in the portfolio $i-1$ make payments for debt service, the profits of a bank loan portfolio will increase the loan capital. $BC_i = BC_{i-1} + NI_{i-1}$ allows the bank to borrow more deposits and originate the next loan portfolio i, which is larger in dollar terms than the loan portfolio $i-1$. The profits of existing loans strengthen the confidence of existing households in rolling over their deposits and attract new households to sign new deposit contracts. The growth of a bank's loan portfolio is defined in Equation (13).

$$\begin{aligned} \max_{loan_{cpn,vol}} \quad & E\left[\sum_{i=1}^{I} AT_{i-1} \times (1+r_i)^{m_i}\right] \\ \text{s.t.} \quad & \text{regulatory capital constraint,} \\ & \text{liquidity constraint, every } t. \end{aligned} \tag{13}$$

AT_i are the i^{th} loan portfolio with j loans where $AT_i = loan_1 + loan_2 + ... + loan_j$. Each individual loan j has a unique coupon rate ($r_{cpn,i,j}$) and a unique multi-period maturity $m_{i,j} > 1$.

$r = \frac{NI}{AT}$ is the loan portfolio return. r_i is the weighted average return of j loans in the i^{th} loan portfolio. m is the tenor of the loan portfolio, and m_i is the weighted average maturity. The subscript j for individual borrowers is absorbed at the level of the loan portfolio.

When making its first loan portfolio $i = 1$, a financial institution is not officially a bank and must dedicate its own capital $AT_0 = BC_0$. Not all financial institutions can collect the debt service payments of the first loan portfolio. Only after receiving loan payments from the borrowers has an institution earned its banking license.

By securing the banking license, a registered bank has more bank capital $BC_1 = AT_0 \times (1 + r_1)^{m_1}$. In addition, the bank can take deposits from households. Without a banking license, a financial institution can only borrow from wholesale resources, such as interbank loan markets. Since the second loan business $i \geq 2$, bank loans are equal to bank capital BC_i and time deposits from households TD_i; See Equation (14).

$$\text{If } i = 1,\ AT_0 = BC_0;\ \text{For all } i \geq 2,\ AT_i = BC_i + TD_i. \tag{14}$$

3.2 Why active credit screening is important to a bank

By borrowing TD, the bank has increased its leverage. In Chu (2025) and this study, the maturity of TD is just one period. To address the maturity mismatch between multi-period loans and one-period deposits, the bank invites households to roll over their deposits each period. Bad loans are unavoidable and affect a bank's interest in two dimensions.

First, a bank's net income from bad loans becomes negative, which directly harms the bank's interest, as in Equation (10). Second, bad loans could erode household confidence. Household fears arise when they observe slow bad loan replacement. They worry about a scenario in which losses from bad loans could penetrate the protection of bank capital. Chu (2025) documents two negative results of the bank after some households do not roll over their deposits.

The goal of active credit screening is to identify applicants who can lead to win-win outcomes for three agents in the loan business. After signing a credit line contract, a borrower

draws down the loans to address unexpected liquidity shortages. Meanwhile, the borrower's $EBIT$ is sufficient to meet debt service payments. By receiving coupon income on time, a bank can pay deposit interest rates. Because deposit interest rates are higher than those of the risk-free Treasury, rolling over their deposits aligns with the permanent interests of households. The win-win outcome indicates that entrepreneurs, the bank, and households can grow their wealth as in Equation (1).

Replacements of bad loans are costly, and profits are the only endogenous source. Observing rapid self-healing due to strong profit-generating capacity, households feel secure in rolling over their deposits. Therefore, to maintain a bank's win in a win-win loan business, profits from bank loans must meet the profit benchmark $P\&L_{BM}$. We take the net interest rate margin (NIM) as the profit reference. $P\&L_{BM}$ is an average of the net interest margin for the entire bank loan portfolio in the last n years equal to the tenor of the loan portfolio as in Equation (15).

$$P\&L_{BM} = \frac{1}{n}\sum_{t=-n}^{-1} NIM_t;\ NIM = \frac{\text{Interest Income-Interest Expense}}{\text{Average Interest-Earning Assets}}. \tag{15}$$

$NI_{i,j}$ describes the net income of a bank in lending to the borrower j in the loan portfolio i. In the tenor m of a credit line contract, m_d and m_u indicate the drawdown periods and undrawn periods, such that $m = m_d + m_u$. $AT_{i,j}$ is the credit line limit offered by the bank for the borrower j. In reality, the drawdown can be partial $\delta \times AT_{i,j}$, where $0 \leq \delta \leq 1$. Allowing partial drawdown, $NI_{i,j} = AT_{i,j} \times [\delta \times (1 + r_{cpn,i,j})^{m_d} + (1-\delta)(1+fee)^{m_d} + (1+fee)^{m_u} - (1+\theta)^m] - \beta \times AT_{i,j} \times (1+\overline{r_{td}})^m$. For simplicity without loss of generosity, we let $\delta = 1$ and drop the subscript i for the sequential number of the loan portfolio. Equation (16) indicates that the borrower j draws down its credit line in full.

$$NI_j = AT_j \times \left[\underbrace{(1+r_{cpn,j})^{m_d}}_{income_d} + \underbrace{(1+fee)^{m_u}}_{income_u} - \underbrace{(1+\theta)^m}_{\text{ops cost}}\right] - \underbrace{\beta \times AT_j \times (1+\overline{r_{td}})^m}_{\text{deposit interest rate}}. \tag{16}$$

A bank's interest in a credit line business has four components. Component (1) is the drawn-

don income, coded as $income_d$. Component (2) is the income of the commitment fee when a borrower does not draw down its loans, coded as $income_u$. Component (3) is the costs of bank operations, coded as $ops\ cost$. Component (4) refers to payments to households through the interest rates on deposits. Due to the Basel capital requirement, the bank only borrows β percentage of the loans AT_j. Once a credit line contract is signed, the bank must convert the off-balance commitment to the on-balance sheet risk-weighted assets, according to Basel II enhancement in 2006[6]. Therefore, bank operating costs and deposit interest rates are paid for the full tenor m of the credit line contract.

3.3 Exercises of active credit screening on operating income

Credit screening exercises evaluate historical operating income and assign all applicants seeking credit lines to three profiles. Each profile is defined by a unique distribution of historical operating income $EBIT$. In theoretical analysis, we focus on the causality from operating profits of a potential borrower to a credit line offer from a bank. Due to profit uncertainty, operating income has additional effects on cash and company size. We will analyze additional effects in the empirical analysis.

Profile 1: companies regularly report negative operating income $EBIT_t^-$. In addition, in all evaluation periods, the mean positive income ($EBIT_t^+$) is higher than the mean negative income ($EBIT_t^-$) in absolute terms. See Equation (17).

$$\text{Profile 1: regular } EBIT_t^-, \text{ and } \overline{EBIT_t^+} > \overline{\left|EBIT_t^-\right|} \tag{17}$$

Here is the initial verdict for companies sharing Profile 1. They will regularly utilize loans within the credit line. Meanwhile, they are expected to make timely coupon payments and pay the principal on the maturity date. The screening exercises assign an Op1BA label to Profile 1.

Companies that share $EBIT$ Profile 2 report occasional negative income ($EBIT_t^-$). Further-

[6]See paragraphs 313, 595, 599 and 604 in bcbs128, June 2006, Basel II: International Convergence of Capital Measurement and Capital Standards: A Revised Framework - Comprehensive Version

more, the average positive operating income is significantly higher than the negative income in absolute terms. See Equation (18).

$$\text{Profile 2: sporadic } EBIT_t^-, \text{ and } \overline{EBIT_t^+} \gg \overline{\left|EBIT_t^-\right|} \tag{18}$$

Here is the initial verdict for $EBIT$ in profile 2. Companies sharing Profile 2 differ from Op1BA companies due to stronger internal $EBIT$. Unlike Op1BA companies, Op1A companies treat credit lines as an insurance policy. They are unlikely to draw down loans in the credit line contract unless they are hit by a rare liquidity disaster. In addition, Op1A companies have a lower risk of default than Op1BA companies if they draw down loans. To differentiate companies in Profile 2 from Op1BA companies, an Op1A label is assigned to Profile 2.

All other companies are in Profile 3. They report regular liquidity shortages. The difference between Profile 1 and Profile 3 is the change in the direction of the gap between positive and negative operating income. The average positive operating income ($EBIT_t^+$) is not higher than the mean negative income in absolute terms ($\left|EBIT_t^-\right|$). See Euqation (19).

$$\text{Profile 3: regular } EBIT_t^-, \text{ and } \overline{EBIT_t^+} \leq \overline{\left|EBIT_t^-\right|} \tag{19}$$

Here is the initial verdict for companies in Profile 3. These companies apply for credit lines to cover the largest liquidity gap $\max_{t-n}^{t-1}(\left|EBIT_t{}^-\right|)$, in recent history. The company draws down the loans in full during the tenor. However, a default is expected on or before the maturity date. The expected default is due to the average positive income being lower than the negative income. The bank assigns companies in Profile 3 as Op1BR companies. Due to regular $EBIT_t^-$, Op1BA companies and Op1BR companies together are Op1B companies.

The expected profits of a bank from the credit line contract with an individual company are determined by three key inputs: (1) whether a borrower draws down the loans from its credit line, (2) the drawdown tenor, and (3) whether the company defaults or not at maturity. Let

$r_{cpn,j}^{Op1BA}$, $r_{cpn,j}^{Op1A}$, and $r_{cpn,j}^{Op1BR}$ be coupon rates for individual companies with Profile 1, Profile 2, and Profile 3, respectively. Let $m_{d,j}^{Op1BA}$, $m_{d,j}^{Op1A}$, and $m_{d,j}^{Op1BR}$ be the expected drawdown tenor for individual companies in three profiles. The relative relationship of expected coupon and the drawdown tenor of three profiles is shown in Equation (20).

$$\overline{r}_{cpn}^{Op1A} < \overline{r}_{cpn}^{Op1BA} < \overline{r}_{cpn}^{Op1BR}; \; \overline{m}_{d}^{Op1A} \ll \overline{m}_{d}^{Op1BA} < \overline{m}_{d}^{Op1BR} \tag{20}$$

Including the probability of default (PD_j) and loss given default (LGD_j) in the input (3), the bank can evaluate the expected annualized return for each loan applicant, as shown in Equation (21). n is the tenor of the credit line contract. Op1A companies and Op1BA companies are expected to pay debts. However, Op1BR companies are expected to default on their loans at or before maturity.

$$\mathbb{E}\left[r_j\right] = \sqrt[n]{\frac{AT_{t+n} \times \left[PD_j \times (1 - LGD_j) + (1 - PD_j)\right]}{AT_t}} - 1 \tag{21}$$

The overall evaluation of the expected return takes into account two adjustments: the probability of drawdown and the probability of default. Can the adjusted return meet the profit benchmark? Based on the initial evaluation, it is straightforward that a credit line contract with Op1BA companies can meet the profit benchmark to maintain a win-win loan relationship.

On the other spectrum of internal and external liquidity, a loan default is expected for contracting with Op1BR companies. Op1A companies are unlikely to default on their loans if they draw down. However, contracting with Op1A companies will not meet the bank's profit benchmark due to shorter drawdown periods compared to Op1BA companies. Furthermore, a bank's expected returns from contracting with an Op1A company could be negative if the Op1A company does not experience a liquidity shortfall disaster. With regard to the bank

losses, Op1BR companies cause more severe losses than OP1A companies. See Equation (22).

$$\text{Adjusted expected returns} \begin{cases} \text{win-win:} & \mathbb{E}\left[r_j^{Op1BA}\right] \geq P\&L_{BM}; \\ \text{bank loss 1:} & \mathbb{E}\left[r_j^{Op1A}\right] < P\&L_{BM}; \\ \text{bank loss 2:} & \mathbb{E}\left[r_j^{Op1BR}\right] < 0. \end{cases} \tag{22}$$

The bank quantifies the verdict of active credit screening in Equation (22) in its decision guidelines. The convergent credit line contract (CL) for Op1BA companies aligns with the bank's goal to establish a mutually beneficial loan relationship. We standardize the bank profit benchmark to 1 point (1 pt), and a convergent credit line contract with an Op1BA company meets that benchmark.

If borrowing is merged with an Op1BR company, a bank expects a 2-point loss in net income. The losses of bad loans (-2 points) exceed the profits of good loans (1 point). This is because the costs of replacing bad loans are higher than the profits of good loans Chu (2025). Rejecting an Op1BR company helps the bank avoid future losses, and the rejection is rational. The bank reports 0 pts net income.

The bank's net income meter recognizes -1 points (-1 pt) if lending to an Op1A company. The recognition of -1 points is due to profits from contracting Op1A companies being below the bank's profit benchmark. Here is the good news. If drawing down loans, Op1A companies have very low default risk. We will discuss a bank's decision in the extensive-form game upon receiving the credit line application. The expected profits from credit line contracts with

different borrowing profiles are given in Equation (23).

$$\text{Bank NI meter} \begin{cases} \text{-2 pts:} & \text{CL with an Op1BR company;} \\ \text{-1 pts:} & \text{CL with an Op1A company;} \\ \text{0 pts:} & \text{Rejecting an Op1BR applicant;} \\ \text{1 pt:} & \text{CL with an Op1BA company} \end{cases} \tag{23}$$

4 Loan contract convergence through extensive-form game

4.1 Credit lines

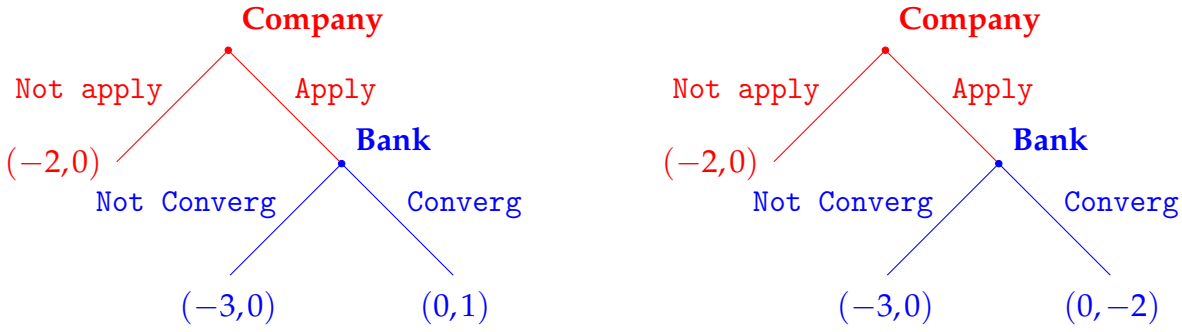
We analyze convergent decisions on credit line contracts through extensive-form games. Companies and banks make sequential endogenous decisions in their own interest. All companies apply for credit lines for the first time. If a company is convergent on a credit line contract, it will apply for the next one once the first contract expires. However, a bank's rejection provides the applicant with information about the reason for the rejection. Understanding the bank's rationale for rejection, a company has two choices: to depend on internal liquidity sources or to apply for credit lines.

In the credit line application, the company requires the loan amount. A bank performs an active credit check on the applicant's operating income. Upon completing the credit screening exercises, the bank makes an offer on the coupon rate if lending to the applicant is expected to be a win-win contract. The maturity of the contract is standard.

Of the two meter numbers (#1, #2) in each decision node, #1 is for the meter of firm liquidity, which is from Equation (9). #2 is for the bank's net income meter, which is from Equation (23). The higher the meter points, the better for either player.

After reviewing the track record of an Op1BA applicant's business operations, the bank makes an offer on the interest rate of the credit lines. Upon making the offer, the bank expects Op1BA companies to pay interest rates and repay the principal at maturity. Op1BA compa-

nies accept the offer and draw down the loans, neutralizing unexpected shocks from liquidity shortages in the future ($0 = -2 - 1 + 3$). The bank secures 1 point of profit that meets its profit benchmark. The preferred decisions converge on (0, 1) in the game I(A). Preferred decisions help the other contractor grow its wealth. In a healthy win-win contract, the letter "A" following Op1B represents the acceptance of each other in a loan contract.



(A) Op1BA company **(B)** Op1BR company

Game I. Op1B firms applying for credit lines

Households are the third agent acting as the bank lender in the loan business. The win-win framework works for households in the same way as for entrepreneurs and the bank. In this study, households are passive, signing up for a new deposit contract or rolling over existing contracts. Households can take an active role in the bank loan business by not rolling over their deposits. The reasons for withdrawals not due to self-fulfilling and the consequences of not rolling over are discussed in Chu (2025).

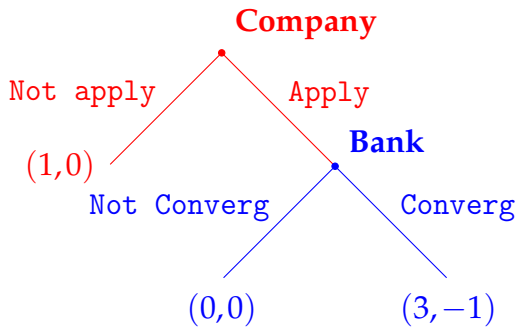
Being shocked by liquidity shortages, Op1BR companies also apply for access to credit lines. When offering loans, the bank is expected to recognize losses due to borrower default. The bank's preferred decision regarding the NI meter is to reject access to credit lines due to $0 > -2$.

Op1BR companies apply for credit lines because they share the same experience of regular $EBIT_t^-$ as Op1BA companies. When its application is rejected, the Op1BR company's liquidity meters have decreased from -2 to -3. The deterioration of the -1 points is due to the cost of applying for external financing in Equation (9).

After its application for credit lines is rejected, an Op1BR company rationally chooses not to

apply next time. The preferred liquidity meter for the company and the NI meter for the bank converge on $(-2,0)$ in Game I(B). The letter "R" following Op1B represents the rejection. The rejection is also two-directional. If the bank makes an offer on the loan with an interest rate that takes loss given default into consideration, the interest rate will be too high for the applicant to accept.

The game II illustrates the decision process for a credit line contract with Op1A companies. An Op1A firm applies for credit lines for insurance. If its application is approved, the company's liquidity meter will be 3 pts $(3 = 1 - 1 + 3)$.



Game II. Op1A companies and credit line contracts

However, offering liquidity insurance based on the expected drawdown of an Op1A borrower does not meet the bank's profit benchmark, as shown in Equation (22). The bank's net income meter will decrease by 1 point. The bank has two options: reject the Op1A companies or charge them a premium. Because borrowers are unlikely to default if they draw down the loans, the bank makes an offer by adding an insurance premium (α). With the insurance premium, the expected return of the bank from contracting Op1A companies will meet its profit benchmark as in Equation (24). There are two questions about the adjusted offer $\mathbb{E}\left[r_{j,prem}^{Op1A}\right]$. Will an Op1A company accept the offer? If an Op1A company decides to accept the offer, will the credit line contract compromise the win-win relationship?

$$\mathbb{E}\left[r_{j,prem}^{Op1A}\right] = \mathbb{E}\left[r_{j}^{Op1A}\right] + \alpha = P\&L_{BM} \tag{24}$$

Op1A companies will split according to their heterogeneous expectations about the liquidity disaster in the near future. An Op1A company will accept the adjusted offer $\mathbb{E}\left[r_{j,prem}^{Op1A}\right]$ if it expects that a liquidity disaster is likely based on its own operating income. Another Op1A rejects the offer based on the expectation that the cost and benefit are not in its favor. In the real world, Op1A companies with access to credit lines pay a premium for this access. If they draw down loans, default is unlikely.

4.2 Finance a new investment project by term loans

After concerns about unexpected liquidity shortages have been addressed, the next external liquidity demand arises when an entrepreneur plans a new investment project. The project can be an extension of the existing production line. For example, Foxconn plans to build a new factory in Vietnam. The project can also be a capital expenditure for a technological upgrade. For example, TSMC has projected $\$38 - \$42$ billion in 2025 in capital expenditure to support the advanced process demands of Apple, NVIDIA, AMD, and others.

If new investment projects are financed internally by saved profits, the discussion of external financing is unnecessary. In this study, we focus on projects where internal sources are insufficient, so the company must rely on external financing. With insufficient internal cash saved from profits in previous periods ($C = \sum_{t=-n}^{0} EBIT_t$), where $t = 0$ indicates the current period, a company seeks to borrow term loans (TL). ($TL - C$) covers capital expenditures for the new project. A term loan suits the purpose better than a credit line in three elements. The entrepreneur has developed an investment plan that outlines the capital investment amount, the time frame to develop the infrastructure that will deliver the new product or service, and the expected sales revenue.

Upon receiving a term loan application, the bank performs the same credit check for term loans as it does for credit line applications. However, term loans are significantly larger in capital than a credit line ($TL - C \gg CL$). Additionally, no sales revenues from the new product or service are anticipated during the construction period. Furthermore, the first coupon payment

is due at the end of the first period after the loans have been drawn down.

The bank evaluates the proposal for term loans against two key hurdles related to loan payment. The first hurdle is the cash flow for loan coupon payments. Before a project can generate sales, operating income from existing business operations ($EBIT_t$) is the only internal resource to service coupon payments of term loans ($r_{cpn,tl}$). The hurdle for coupon payments of term loans is in Equation (25).

$$\frac{1}{(N1+N2)} \sum_{t-(N1+N2)}^{t-1} EBIT_t - IR_t - Tax_t > (TL - C) \times r_{cpn,tl}. \tag{25}$$

$N1$ is the maturity of the term loans that cover all periods of factory build-up or technology upgrade. The term loans will be rolled over to the next $N2$ periods. The company requests to roll over the term loans because profits from the sale of the new product must be accumulated to repay the loan principal.

The second hurdle, which has two elements, is the repayment of the loan principal. Element 1 is an estimate of $N2$ such that the profit accumulation of the new project is equal to the principal of the loan. Element 1 needs input from three pieces of information. What are the expected first-year sales in S dollars? What is the annual growth rate of sales G? What is the probability of project success p_H in achieving S and G? Element 1 of the forward-looking hurdle is captured in Equation (26). The net profit margin is captured by $NPM = \frac{NI}{S}$.

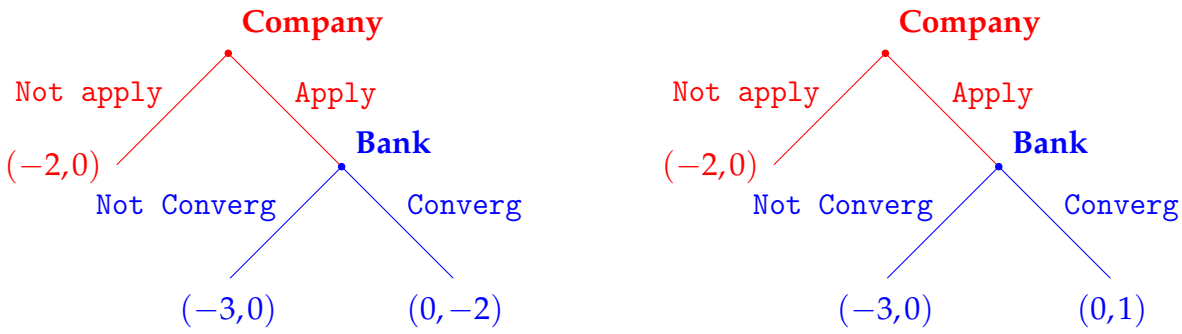
$$(1) : \sum_{t=0}^{N2} [S_t \times (1+G)^t] \times NPM \times p_H > (TL - C);\ (2) : N2 < m_{red}. \tag{26}$$

Element 2: Is $N2$ risky for principal repayment? The maturity $N2$ increases when the profit-generating capacity of the project decreases relative to the loan principal. The following factors contribute to a slow accumulation of profits in Equation (26): a lower sales performance in the first year (S), the growth rate (G), the net profit margin (NPM), or the success rate (p_H). m_{red} is the red flag tenor of a bank's term loan portfolio. It is a red flag because historical records

show a significant increase in the probability of default when $N2 \geq m_{red}$.

In game III, a company that plans to start a new project with insufficient internal savings (-2 pts) applies for term loans. In game III(A), a track record suggests that the borrower could not meet the interest rate payment hurdle, nor the principal repayment hurdle. With the expectation of a bank rejection, the company is better off not applying. The convergence decisions for the company's liquidity meter points and the bank's NI meter points are $(-2,0)$. A company that fails to satisfy either hurdle cannot access term loans. These companies must save cash from positive operating income.

In the game III(B), the term loan contract is a rational convergence because the hurdles of the coupon payments and the principal repayment are satisfied in Equations (25) and (26). Companies apply for term loans, and the bank's offer has been accepted. The borrower draws down the loans, and the bank receives all loan service payments. Convergent decisions recognize meters of $(0,1)$ for the company and the bank.



(A) Company satisfies neither hurdles

(B) Company satisfies both hurdles

Game III. Both hurdles or neither hurdle satisfaction

4.3 Finance a long-term growth project with convertible debt

Let us examine a special case in the game III(A). A new company has a poor operational history. However, the company has a great idea to develop a new product. For the principal repayment hurdle, element 1 is satisfied due to the expectation of above-average sales and growth. However, element 2 is not satisfied $N2 \geq m_{red}$, mainly because the size of the term

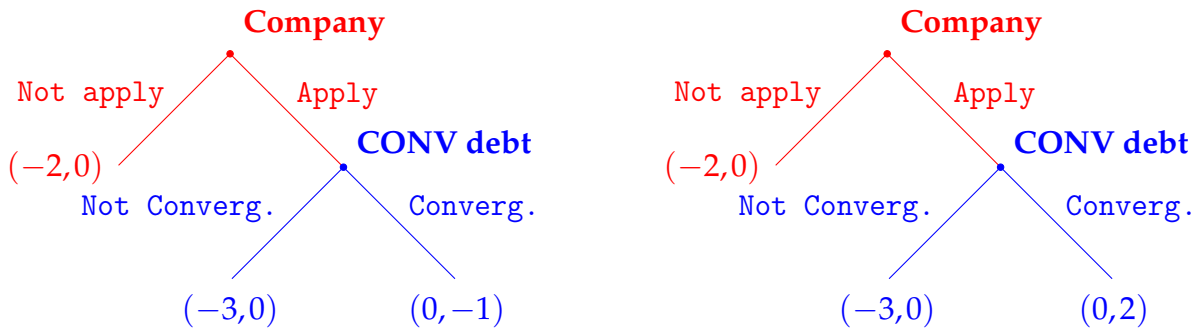
loans is quite large.

Term loans are unlikely to be a convergent loan contract. Due to the company's poor operational history, the loan coupon rates must be high to justify the risk borne by the bank. Due to the large capital on the term loans, poor operating income may be insufficient to meet interest rate payments. Therefore, the company will decline the loan offer.

The solution is convertible debt. The advantage for the bank to issue convertible debt is cash flow rights in the long term. When a bank switches its cash flow rights in the company from the debt holder to the shareholder, bank profits will be enhanced in two dimensions.

If the growth of the new company is strong, the equity returns will be higher than the profit benchmark for bank loans. To sustain this intuition, we resort to the profit benchmark in the real world. From 1984 to 2020, all U.S. banks have achieved an average net interest margin ($USNIM$) of 3.75%. We can take 3.75% as the profit benchmark of bank loan businesses. It is not surprising that the equity returns are easily higher than 3.75%. Furthermore, as an equity holder, the bank's cash flow rights last longer than the maturity of the bank loans, which is usually 5-7 years.

The game IV captures the two-stage convergent result. Offering convertible debt, the bank lowers the interest rate in the first stage than that indicated in Equation (25). Due to historically low cash flows, high-growth firms can afford the low-interest-rate coupons. However, it is a loss to the bank. see the game IV(A).



(A) convertible debt before conversion **(B)** convertible debt after conversion

Game IV. Poor cash flow history but high growth expectation on new project

Equity conversion is the right of the convertible debt holder. Higher returns are expected after equity conversion. Two sources contribute to the higher returns after the equity conversion. The bank chooses to convert the loans to the borrower's stocks when the stock prices of the borrower are higher. Furthermore, equity holders have cash flow rights as long as the company remains in operation and generates profits. Because the returns are higher than the profit benchmark for the loan portfolio and the higher returns last longer than the loan tenor, the NI meter for the bank will be notched 2 points (2 pts) as in the game IV(B). Convertible debt will be convergent decisions. The liquidity meter of the company and the NI meter of the bank will be $(0,1+)$. The $(1+)$ indicates that the bank profits are higher than its profit benchmark, and the higher profits last longer than the loan maturity.

The game IV addresses the intuition for Tesla's $2 billion convertible debt issuance in 2014. In May 2014, Tesla was assigned an unsolicited 'B-' corporate credit rating by *S&P*. The rating is based on financial statements in the past five years, since 2009. The average single-B effective yield in 2014 recorded by ICE Bank of America is 5.74%. Therefore, the coupon rate will be higher than 5.74% if Tesla borrows $2 billion term loans with a rating lower than single B. However, historical operating income shows that Tesla can only afford a coupon rate no higher than 1.5%. That is why the lead lenders come up with the proposal of convertible bonds. The 2019 Notes have a face value of $920 million with a coupon rate of 0.25%; The 2021 Notes have a face value of $1.38 billion with a coupon rate of 1.25%. The conversion price is $359.87 per share of Tesla's common stock.

5 Empirical predictions of a win-win loan contract

Now, it is time to answer the question raised in the Introduction. What are the predictions of active credit screening that could change the understanding in the existing literature? This study summarizes four predictions.

Empirical prediction 1: Operating profit is the driving force of a company's growth in the

endogenous growth model in Romer (1990).

The causality from profit to growth is an updated version of the causality from innovations to growth in Romer (1990). The update is due to the profit uncertainty. Due to uncertainties, innovations may not guarantee profits.

Operating profit has causal effects on company size and cash holdings. The capital invested in the current project, i, comes from the capital and profits of a previous project, $i-1$. There are three inputs to a financially unconstrained project: operating profits, cash reserves, and access to credit lines.

Being financially unconstrained, project i consistently generates profits. The accumulated profits, observed as cash reserves, of the entrepreneur grow. The wealth accumulated by the project i will become the capital of investments in a new project $i+1$ should a more attractive opportunity arise. This is the process of replacing two projects from project $i-1$ to project i.

What is the role of credit lines in project replacement? During the operations of a financially unconstrained project, a credit line contract can mitigate tactical profit uncertainty as an external source of auxiliary liquidity. To maintain a win-win relationship, access to credit lines is contingent upon healthy operating profits. There is no role for credit lines when a project is financially constrained.

Indicated in Equation (5), the current project is larger than the previous project if the project generates profits. The project replacement mechanism explains how a company grows. Equation (5) can also explain why a company collapses quickly when the project replacement is unsuccessful. The latest project incurs a loss. The hemorrhage of a larger project explains how a company can rapidly shrink in size.

Our analysis, focusing on operating profits, challenges the traditional view of financially constrained companies presented in Sufi (2009). Operating profits enable us to explain why financially constrained companies tend to be small (Almeida, Campello, and Weisbach, 2004). However, our analysis reveals why it is challenging for financially constrained companies to save cash from cash flows. Empirical prediction 1 has offered a "unifying theory" for interplay

of operating profits, cash holdings, company growth, and role of credit lines, as suggested in Campello et al. (2011). We will test the prediction on credit lines in Section 6.

Empirical prediction 2: A bank can honor drawdown requests from all its clients with a contract on credit lines when aggregate risk is prominent.

The rationale is simple. When signing every 1 unit of credit line contract with a loan principal of $100, a bank must convert its off-balance sheet commitments to on-balance sheet assets. The conversion is to comply with the enhanced Basel II in 2006. To finance the converted $100 on-balance sheet assets, the bank must commit $13 of its own capital and borrow $87 deposits from households, assuming the Basel capital ratio is 13%.

A win-win loan contract can mitigate the shock of credit line drawdowns to a bank in the event of aggregate risk, as discussed in (Acharya, Almeida, and Campello, 2013). This is because the bank has the loan capital ready before the arrival of the aggregate shock. Of course, if a bank chooses not to convert its commitment to on-balance sheet assets, thereby not complying with the enhanced Basel II in 2006, credit line drawdowns during a liquidity crisis will still harm the bank.

Empirical prediction 3: An economic recession will cause drawdowns on credit lines below the historical average. Lower-than-average drawdowns have a negative effect on bank profits.

Companies sign credit line contracts during economic expansions. During episodes of economic recession, the primary challenge for an entrepreneur changes from a shortage of liquidity to a lack of demand for their outputs. Therefore, regular borrowers draw down less in recessions than they do in expansions.

Lower drawdowns negatively affect bank profits. Meanwhile, cases of loan defaults increase during recession episodes. The costs of replacing bad loans increase because collateral is less valuable. The maintenance of bad loan replacement becomes longer. Slow healing may lead to bank liquidity shortages or capital damage, as in Chu (2025). In the worst-case scenario, financial stability could be compromised.

Empirical prediction 4: The returns of convertible debt are higher than those of vanilla debt

and can compete with the returns of equity.

This is because the convertible debt is endogenous. Although all loan demands are initiated by borrowing companies, convertible debt is the choice of the loan lender. Companies that can issue convertible debt share two characteristics. The product or service that needs loan financing has the potential to generate above-average long-term profits. However, current equity is undervalued because the company's existing operations cannot generate enough $EBIT$ to cover the coupon payments of vanilla term loans. The bank is happy to offer convertible debt because the expected success of the new product or service will boost the equity price of the borrowing companies before the closing date of equity conversion. Furthermore, the bank will share long-term cash flow rights of the new project.

6 Empirical Analysis of Credit Line Access in Economic Expansion

The theoretical analysis in Sections 2, 3, and 4 has developed a convergent rationale for the loan business of the three debt instruments, credit lines, term loans, and convertible debt. Our empirical analysis focuses on credit line contracts and drawdowns. There are two reasons why we focus on credit line access.

Due to profit uncertainty, all companies experience time-varying operating income ($EBIT_t$). Experiencing liquidity shortages, companies seek external debt. Of the three debt instruments, credit lines are the best fit for the nature of temporary liquidity shortages. Furthermore, the debt payment hurdle on the credit line is the lowest, allowing more companies to have access.

Of three debt instruments, only credit lines separate loan drawdowns from contract origination. We utilize economic recessions to identify companies' drawdown decisions. We take all companies in the Compustat universe and analyze two credit line decisions. During economic expansions, the distribution of credit line contracts is a convergent decision made by companies and banks. However, during a recession, drawdown decisions are typically made by companies with unexpired contracts.

6.1 Distribution of operating profits and credit line contracts

Hypothesis 1 (Empirical)**.** *In the corporate universe, a positive relationship exists between positive operating profits and company size. Among companies with above-average size, there is a negative relationship between company size and cash holdings.*

Positive operating profits drive a company's growth. A larger company typically has more successful projects that generate large profits. Because investing profits in a promising project can generate additional profits, large companies can maintain lower cash holdings. Doing so can help an entrepreneur grow their wealth more efficiently.

Hypothesis 2 (Empirical)**.** *Being financially unconstrained is the necessary condition for a company to access credit lines. However, not all financially unconstrained companies have access to credit lines.*

Here is the main causality. Financial constraint is a phenomenon of operating profits, and solutions can only come from internally. If a company's operating income is negative, as in profile 3 of Equation (19), the company is financially constrained. The first-order solution is to replace the existing cash-draining project with a new one that can generate profits. The bank will not offer credit lines. The rejection is due to the concern that negative operating profits cannot cover the loan payments.

If a company's historical operating profits fit into profile 1 in Equation (17) or profile 2 in Equation (18), the company is not financially constrained regardless of cash holdings. The bank is pleased to offer credit line access for unconstrained companies. Bank loans help the company smooth out the liquidity gap due to stochastic operating profits.

If a company's operating profits fit into profile 3 in Equation (19), and the company has significant cash reserves, the company is constrained with cash relief. Cash from external sources can cover the costs of business operations. Until the new project generates profits, cash holdings serve as a temporary solution to internal liquidity constraints.

Some companies whose operating profits are in profile 2 in Equation (18) do not have access to credit lines. However, the bank does not reject access requests. Rather, these companies in

profile 2 do not accept the bank's offer because they expect that the benefits of having access are overshadowed by the costs of securing it, as in the Game II.

Hypothesis 3 (Empirical)**.** *Companies that report low internal liquidity and lack access to credit lines share characteristics of low profits or tangible assets or high volatility of profits.*

The third hypothesis tests the bank's rejection of active credit screening. Rejections are justified on three conditions. The applicants have low operating income, low tangible assets, or high income volatility. Low operating income or high income volatility will put drawdown interest rate payments and loan principal repayment at risk. Low tangible assets indicate thin collateral, making it difficult for banks to recover the principal loss in the event of default.

6.2 The Great Recession and drawdowns for regular borrowers

Unlike term loans and convertible bonds, only the credit line contract offers borrowers a two-step separation of drawdown activities from contract establishment. Additionally, drawdowns are the sole decisions made by borrowers, who determine when and how much to draw down. However, drawdown decisions in recessions will differ from those in a liquidity crisis.

When markets are hit by aggregate liquidity shortages, the bank has no problem honoring drawdown requests, assuming that the requests are in accordance with the contract terms. This is because, following the enhanced Basel II, the bank has converted off-balance sheet commitments to on-balance sheet assets when a contract is signed in expansions. Of course, drawdowns will be constrained if the bank has not yet converted the commitment to on-balance sheet assets. In this case, the constraint on drawdowns will be the same as the term loan constraint, as documented in the literature on the supply-side banking crisis.

On the other hand, aggregate demand decreases significantly when the economy is in recession. During recessions, companies reduce their production inputs in anticipation of lower demand. The cost reduction reduces the chances that the company will experience liquidity constraints. Therefore, they draw down less credit lines than they do in economic expansion.

To our knowledge, the drawdown behavior in recession has not been previously analyzed in the literature. This is the intuition of hypothesis 4.

Hypothesis 4 (Empirical)**.** *Credit line drawdowns during the Great Recession reveal a story of weak demand for loans.*

We study the drawdown decisions in 2008 and 2009. We ask two questions. How much did regular borrowers draw down their credit lines during the Great Recession in 2008 and 2009? Whether the drawdowns can satisfy their liquidity needs? We employ a two-stage strategy to discover comprehensive drawdown decisions that account for the majority of regular borrowers with access to credit lines.

First, we identify all new credit line contracts in the DealScan database from 2005 to 2007. We rank all borrowers by the dollar amount of their individual contracts; We focus on regular borrowers that account for the top 95% of the market value. Regular credit line borrowers are proxy for OP1BA companies in the previous sections.

Second, we manually collect drawdown information, which includes hard and soft elements. Elements of hard information include the dollar amount of total outstanding credit line contracts and the drawdown amount. For soft elements, we have designed a questionnaire to survey 10-K to locate the company's views on its internal and external liquidity. Regression analysis aims to verify whether drawdowns are sufficient to top up liquidity shortages during 2008 and 2009.

The drawdown analysis in this study is different from that of Ivashina and Scharfstein (2010). The laboratory of this study is an economy in recession, as defined by the NBER. Furthermore, banks that make loans in this study were not in bankruptcy in 2008 and 2009.

7 Operating Profits, Size Deciles, and Cash for Empirical Hypothesis 1

Our empirical analysis starts from operating income of all non-financial, non-utility firms in Compustat. A firm is included in our sample if it has no missing data on total assets (AT),

long-term debt (DLTT), short-term date (DLC), operating income (OIBDP) and cash holdings (CHE) in all three years from 2005 to 2007. 3,469 North American firms satisfy this condition.

We rank all 3,469 firms in the decile of size. Following Sufi (2009), the size of the company is measured by noncash total assets (AT – CHE). We use three-year average (AT – CHE) from 2002 to 2004. For firms in the smallest decile of size, the mean total of noncash assets is $1.2 million. For firms in the largest size decile, the mean of noncash total assets is $29.216 billion.

The OIBDP is $EBIT$ in accounting coded in Compustat. $EBIT$ is often referred to as cash flows in the literature. Since profit uncertainty is the focus of this study, we use *operating profit* for OIBDP in Compustat for our empirical analysis.

The operating profit ratio is defined as OIBDP/(AT - CHE). The cash holding ratio is defined as CHE/(AT - CHE). Holding the firm number constant in deciles, we calculate the equal-weighted average operating profit ratio and cash holding ratio for firms in the fiscal years 2008 and 2009. We winsorize 2.5% on both sides of the data. The averages are plotted in Figure II. Here are three characteristics of Empirical Hypothesis 1.

[Insert Figure II(A) and Figure II(B) about here]

Character 1: the proportion of companies that report regular negative operating income. Please refer to Figure II(A). Companies in the deciles 1 to 4 report negative average operating profits. In other words, about 40% of the companies in the Compustat universe report negative operating profits in more than half of their operating histories. Overall, approximately 62.3% of observations in decile 1 to decile 4 report negative operating profits.

To cover ongoing business expenses, companies must maintain sufficient cash reserves. This is what is documented in Figure II(B). In size deciles 1 and 2, the cash reserves are higher than non-cash assets[7].

Character 2: the negative relationship in decile 1 to decile 4 between operating profits and

[7]The different levels of winorization have different effects on firms in the 1^{st} decile and 2^{nd} decile only. For example, with 5%, 2.5%, and 0.5% winsorization, the cash ratio for firms in the smallest decile size is 100%, 160%, and 400%.

cash holdings. This negative relationship differs from the concept that companies save cash from operating profits in Almeida, Campello, and Weisbach (2004). This is because firms that report the most negative operating profits cannot save the highest cash reserves. Critical reasoning suggests that external sources of cash holdings are associated with negative operating profits, although the discussion is outside the scope of this study (Denis and McKeon, 2020).

Character 3: Due to positive operating profits, the company's size increases. Please refer to Figures II(A) and II(B) from decile 5 to decile 10. This observation is consistent with 0.5%, 2.5% and 5% winsorization on both sides. About 89.3% of observations have positive operating profits in the top six deciles (decile 5 to decile 10), in the 2008 and 2009 fiscal years.

That entrepreneurs strive to grow their wealth, as shown in Equation (6), can explain this pattern. Companies invest profits from old projects into new, larger projects. New projects generate more profits. This positive feedback effect drives the growth of companies.

The positive feedback effect has a side effect. The cash holdings decrease as a percentage of non-cash assets among companies whose size is above the median. The endogenous growth theory can explain the side effect. On the condition that projects maintain profit-generating capacity, a company that runs more projects will generate more profits. Therefore, the company has fewer needs to save cash.

8 The Convergence of Credit Line Contracts in Economic Expansion

When a company is free from strategic profit uncertainties, we document the convergence of the credit line contract to address a company's tactical uncertainties. Both firms and banks are seeking a win-win loan contract. The convergence typically occurs in normal times, without major financial crises.

We search Dealscan with a focus on credit line facilities. In DealScan, we sum the dollar amount of credit lines for each borrower at Compustat GVKEY level each year. In total, 1,372 borrowers have signed $1.5958 trillion on lines of credit from 2005 to 2007.

We rank all borrowers by their aggregated credit line contracts in three years. The borrowers ranked in the top 95% (bottom 5%) of the $1.5958 trillion are identified as regular credit line borrowers (as occasional credit line borrowers). There are 655 regular borrowers (coded regular CL) and 599 occasional borrowers (coded occasional CL).

Mapping 1,254 DealScan credit line borrowers, we can allocate 3,469 firms into three groups. 458 firms are regular borrowers, 417 firms are occasional borrowers. These new credit line borrowers are in group one. Of the rest 2,588 firms[8] without new credit line access in DealScan from 2005 to 2007, 641 firms have unexpired credit line contracts signed between 1995 and 2004. These firms are in group two. The rest of the 1,947 firms have no history of credit line access and are in group three.

8.1 The persistence of with or without credit line access

The 1,947 firms without a history of credit line access over 13 years, from 1995 to 2007, support the persistence of not having access to credit lines. Meanwhile, persistence holds among companies with access to credit lines. We can describe persistence in three perspectives.

The first perspective is the firm number (Table I, Panel A). More than 520 of the 641 firms that signed contracts between 1995 and 2004 but did not sign new contracts between 2005 and 2007 had access to lines of credit in each year for a period of five years, from 2005 to 2009. Persistence is also observed among regular and occasional borrowers. At least 96% of regular borrowers and 78% of occasional borrowers have access to credit lines in each year from 2005 to 2007. The ratio is even higher in 2008 and 2009.

The second perspective is the dollar amount of credit line contracts. All borrowers have kept their outstanding contracts consistently, where the regular (occasional) borrowers report the highest (lowest) dollar amount, with the borrowers signing contracts from 1995 to 2004 in the middle (Table I, Panel B). Furthermore, borrowers report about 14% to 39% higher dollar amounts on credit lines in 2009 than in 2005.

[8]Six firms are dropped from 3,469 from 2002 to 2004. So, 3,463-458-417=2,588.

The third perspective is the generous credit to the borrowers. The contract amount represents 40% to 70% of the noncash assets of the borrowers. The contract amount as a percentage of noncash assets is higher in 2009 than in 2005 (Table I, Panel C).

[Insert Table I about here]

8.2 Tests of Empirical Hypothesis 2

Empirical Hypothesis 2 indicates that companies without access to credit lines have different operating profits. We categorize all North American non-finance, non-utility firms in Compustat into two groups: high and low internal liquidity. The internal liquidity of an individual firm is defined as a sum of cash holdings (CHE) and operating profits (OIBDP) scaled by noncash assets (AT-CHE). The internal liquidity reference (or liquidity reference for short) is defined as the three-year average, from 2002 to 2004, of the median internal liquidity of an industry. We follow the Fama-French 12-industry classification. An individual firm whose average internal liquidity from 2002 to 2004 is higher than its industry liquidity reference will be in the high internal liquidity group. Otherwise, the firm is in the low internal liquidity group. High or low internal liquidity, with or without credit line access, is reported in Table II.

[Insert Table II about here]

Firms with access to credit lines are in the high (or low) liquidity categories 1 and 2. However, firms without access to credit lines are in category 3 of high or low liquidity. The median operating profit for companies in the low liquidity category 3 is -22.3%. This is the only group reporting negative median operating profits. The lack of access to credit lines is consistent with the hypothesis that financial constrained companies have no access because they could not make loan payments.

Companies in category 3 of high liquidity also do not have access to credit lines. The median operating profit of these companies is positive at 10.4%. However, these companies have more

cash holdings. The median of the cash holdings of these companies is 65% of their non-cash assets, which is substantially higher than that of all the other groups. The hypothesis that credit lines are not necessary for these companies si the correct explanation.

8.3 Tests of Empirical Hypothesis 3

Reviewing past financial statements, banks reject applications that may not service interest rate payments or make principal repayment. Empirically, we set $1 million of noncash assets as the collateral bar. There is no credit line contract convergence for applicants with noncash assets lower than the collateral bar. Applying this filter, we drop 227 firms. 225 of the 227 dropped firms have no history of access to lines of credit. In other words, the low collateral filter has achieved 99% accuracy. The 178 of the 225 low collateral firms come from Table II, Panel B, Low liquidity 3[9]. These 178 low-asset companies in Table II, Panel B, have very negative operating profits.

Dropping 227 low-collateral firms, we apply logit regression to test the joint decisions of firms and banks. The dependent variable is *Access to LC*, a dummy variable equal to one for firms in High and Low liquidity 1 and 2, either signing new or having unexpired credit line contracts or zero otherwise. The main independent variable is *Internal liquidity* $((CHE + OIBDP)/(AT - CHE))$, and we add two control variables: *Size* $(log(AT - CHE))$, and *Market-to-book* $(AT - BE + PRCC\_F \times CSHO - CHE)/(AT - CHE))$. The two controls in Table III follow Sufi (2009) because the two variables are significant and consistent in all specifications. Because having access (or without access) to credit lines has persistence, the regression specifications are cross-sectional. For each firm, the value of independent variables is an average of a three-year window from 2002 to 2004. The observations of the dependent variable *Access to LC* equal to one are firms signing new contracts from 2005 to 2007 (High and Low liquidity

[9]For the 227 firms, the mean, the 25^{th} percentile, the median, the 75^{th} percentile of internal liquidity as a ratio of non-cash assets is 1,417.4%, -738.2%, -219%, 3.5% separately. For firms with non-cash assets larger than $ 1 million, the mean, the 25^{th} percentile, the median, the 75^{th} percentile of internal liquidity is 50%, 13.7%, 24.8%, and 51.2% separately.

1) or with unexpired contracts from 1995 to 2007 (High and Low liquidity 2). We also exercise robustness tests where firms in high and low liquidity 2 are coded zero for *Access to LC*. Both results support a consistent relationship between internal liquidity and access to the credit line. The regression results are reported in Table III.

[Insert Table III about here]

The coefficients for internal liquidity are negative and significant in all four columns (Table III, Panel A). Meanwhile, the coefficients for size are positive and significant in all three columns. In general, the firms that apply for lines of credit and that banks have accepted their applications are indeed short of internal liquidity.

To gain a deeper understanding of how firms and banks make decisions, we break down internal liquidity into operating profits and cash holdings. The test results are reported in Panel B. The coefficients for operating profits and size are positive and significant. Additionally, we present new evidence: the negative coefficients for cash holdings.

Here is the new interpretation of the relationship between operating profits and credit lines in this study compared to that in Sufi (2009). In this study, having access to credit lines depends on positive operating profits. In other words, a company's profit-generating capacity determines whether it can access credit lines. From the bank's perspective, positive operating profits are necessary to meet loan payments. Therefore, banks choose to offer credit lines to companies with consistent operating profits. These companies may be temporarily short of profits, and their cash holdings are insufficient. Credit lines are an appropriate auxiliary tool to address tactical profit uncertainty rather than to address chronically low operating profits.

To further enhance the causality from operating profits to credit line access, we examine credit line realization in relation to strong or weak internal liquidity. We first study companies with above industry liquidity reference In Table II, Panel A. Companies in high liquidity 1 and 2 have lower internal liquidity than high liquidity 3. Regression results confirm that these firms' internal liquidity is lower than firms without access to credit lines in the high liquidity

subsample firms (Table IV, Panel A). The size effect is still positive as in Table III.

Furthermore, firms with above industry liquidity reference have access to credit lines because they have low cash holdings (Panel B). Firms in the subgroup of high liquidity reveal new information in addition to those in full sample tests. On the firm side, firms that apply for credit line access are short of cash holdings but not operating profits. There is also new information from the bank side. When banks make decisions, the evaluation hurdle is not operating profit because these applicants can generate sufficient operating profits. In other words, banks do not worry about operating profits from these applicants.

[Insert Table IV about here]

Next, we turn our analysis to firms in the category below the industry liquidity reference. In the same logic as in Table IV, all firms below the liquidity reference should apply for lines of credit. Therefore, the main reason that many firms have no access history in this category must be outside of firms' decisions. In other words, banks reject their applications. Test results are reported in Table V.

Unlike firms in the above-median bucket, firms in the below-median category with access to lines of credit have higher internal liquidity (Table V, panel A). The difference is mainly because of banks' selection. If it were a firm's choice, a firm with lower internal liquidity should be more dependent on external liquidity.

Breaking down internal liquidity, we find that the credit line contract is convergent among applicants with higher operating profit (positive and significant coefficients on *operating profits*) and higher tangible assets (positive and significant coefficients on *Size*) (Panel B). The higher operating profits and larger size enhance banks' confidence that borrowers can service drawdown interest rates and make principal repayment. In other words, banks reject credit applications from firms with low operating profits and low assets in the below-median bucket.

[Insert Table V about here]

Our low collateral filter reveals the first quantitative bar on which banks actively reject low collateral applicants. We next generate the second quantitative bar on which banks actively reject low operating profit applicants. To make consistent interest rate payments, any firm must have a healthy stream of operation income. Since the drawdown interest rate should be higher than the risk-free rate, we conjecture that 6% return on assets would be a ballpark number, under which banks likely reject applications. *Low operating profits* is a dummy variable equal to one (1) if the average return on assets (OIBDP/(AT-CHE)) in the window of three years from 2002 to 2004 is lower than 6% per annual, or zero otherwise. We test the relation between low operating profits and access to lines of credit. Results are reported in Table VI.

Table VI, Panel A (Panel B) reports the firms in the above (below) internal liquidity reference. The coefficients for *Low operating profits* are negative and significant for both buckets. The results reveal straightforward evidence that banks' concerns on interest rate payments. Taken the results together with the operating profits in Tables IV, V, and VI, banks turn down applications whose operating profits are unlikely to service interest rate payments.

[Insert Table VI about here]

Up to now, we have examined sequential decisions on credit line realization by firms and banks. For the banks' concerns, we have tested the average operating profits and tangible assets. As suggested by the Brownian motion, firms may not be able to service interest rate payments because their asset returns are too volatile. To test this conjecture, we generate a variable *operating profit volatility*, a standard deviation of a firm's ten-year annual operating profit from 1995 to 2004. To be included in the sample, we require that each firm have at least eight annual data points.

Because the operating profit volatility is the second-moment statistic, by nature, it is a bank's consideration after banks have made their first-moment decisions on operating profits and tangible assets. In other words, some firms that have already passed the operating profit rejection bar will be rejected because their operating profit volatility is too high. In the line of

reasoning, we test firms above the liquidity reference only. Four hundred thirty-seven firms drop out of the sample because they do not have at least eight-year data points. The results are reported in Table VII.

The coefficients for *operating profit volatility* are negative and significant in Panels A and B. It confirms our prediction that banks turn down applications with high operating profit volatility even if firms' operating profits have passed the first-moment screening. The coefficients for *Internal liquidity* are negative and significant in Panel A, confirming that firms have credit line access because they are short of internal liquidity. The negative and significant coefficients for *Cash holdings* and insignificant coefficients for *operating profits* confirm that these borrowers are short of cash holdings but not operating profits.

[Insert Table VII about here]

In summary, we could explain why some firms have access to credit lines, whereas others do not. There are two reasons that firms have no record of access to lines of credit. Some firms have sufficient internal liquidity, so they do not need to apply for credit lines in the first place. Firms that are short of internal liquidity apply for credit lines, but banks accept some applications while rejecting others. Banks likely reject applicants with lower assets, lower operating profits, or higher operating profit volatility. Our results consolidate the findings in Sufi (2009) and Campello et al. (2011). Yet, our analysis and empirical results have two additional findings. Firms do not apply for credit lines because they have sufficient internal liquidity. Banks reject applications to manage the drawdown risk. Because banks reject contract applications because of the concerns on drawdown risk, we analyze the realized drawdown activities during the crisis period in the next section.

9 Tests of Empirical Hypothesis 4, Drawdowns in the Great Recession

As we discussed in previous sections, the contract establishment of credit lines is a convergent decision between a borrower and a bank. Firms make the first move. Once a contract has

been convergent, banks must honor drawdown requests from those with unexpired contracts and paying commitment fees. Therefore, we examine a demand-side story through drawdown decisions.

9.1 The 10-K survey in crisis, questionnaire design

Because the drawdown information is not available in DealScan, we collect from the company's 10-K. Because the 655 firms have been regular borrowers that have signed 95% of new credit line contracts from 2005 to 2007, we survey 10-Ks for the 655 firms in 2008 and 2009. In short, we are interested in the drawdowns of regular borrowers (with access to credit lines) in 2008 and 2009.

Although both studies analyze drawdowns, our research agenda is different from that of Ivashina and Scharfstein (2010). The authors have analyzed the bankruptcy shocks on drawdown externality. When a lender (Lehman Brothers) becomes insolvent, the co-syndicated banks of the same credit line contract will face heavier drawdown requests. Due to the restriction on the co-syndicated credit line contracts with Lehman, only 6% of the credit lines are analyzed in Ivashina and Scharfstein (2010).

We explore the drawdown behaviors of a different group of borrowers to answer a different question. We focus on regular borrowers that have signed 95% of the new credit line contracts in the three years from 2005 to 2007. We first document how much they drew in 2008 and 2009. With the drawdown variations, we answer the following question. Are drawdowns able to neutralize their liquidity shortages? The results can confirm or reject the demand side story.

Our survey collects both soft and hard information. The two hard information pieces are the total credit line outstanding and the drawdown amount. The soft information includes a firm's 10-K narrative about the firm's view on its liquidity situation, access to external credit, and what they have done if the external credit has been shocked. The goal of collecting soft information is to interpret the hard information correctly. For example, the hard information can tell us that the drawdown amount during the crisis period is low. We hope that a borrower

may disclose which side is responsible for the drawdown. Is this because banks could not honor the drawdown requests or because firms have sufficient liquidity already?

Our survey method is similar to the methods adopted in the literature (Lins, Servaes, and Tufano, 2010; Campello, Giambona, Graham, and Harvey, 2011). We ask questions about corporate liquidity management and companies' views about market liquidity during the crisis period. The uniqueness of our survey is the interviewees. Unlike the CFOs who the previous studies have interviewed, we ask questions and collect responses from a company's 10-K. More specifically, we read the Liquidity and Capital Resources section under Item 7 on Management's Discussion and Analysis of Financial Condition and Results of Operations. The same source has been used in Kaplan and Zingales (1997), Sufi (2009), Bodnaruk, Loughran, and McDonald (2015), and Hoberg and Maksimovic (2015). We trust the information collected from 10-K for two reasons. By law, regulators (SEC) prohibit companies from providing misleading or materially false information in 10-Ks. Furthermore, since the Sarbanes-Oxley Act of 2002, a company's CEO and CFO must certify the accuracy of the information provided in the company's 10-K. In summary, the survey results based on 10-K statements should be free of concerns about litigation risk. After reading the relevant section in 10-K, we ask six questions and collect responses, if any.

[1] What are the top sources of liquidity for your company?

[2] How did you describe the company's overall liquidity condition in 2008/2009?

[3] Did you find it difficult to access external credit markets in 2008/2009?

[4] Did the supply side or the demand side negatively affect your business more?

[5] Did your company have a specific relationship bank(s) that was(were) in trouble? If so, did the company try to find a replacement?

[6] What is your company's total credit line? How much did your company draw down?

Because 10-K has been certified, we treat the answers collected from 10-Ks as legal answers from the firm's CEO or CFO. The questionnaire is reported in Appendix A. We include the sample answers we have coded for the question.

[Insert Appendix A about here]

9.2 Qualitative and quantitative responses, regular borrowers

We read the 10-K sections, identify the answers, and coded answers to each question if 10-K has provided an answer. Five of the six questions target all regular borrowers. Question five is for firms with one or more relationship banks being shocked, such as Lehman Brothers. We expect only the firms with connections to bank(s) being shocked may offer their views on question five. Furthermore, because we design the questions after firms file their 10-Ks, it is not a surprise that not every 10-K answers all questions. If they don't answer, we don't speculate the official view on the unanswered question(s). The following is a summary of the answers.

Eight hundred and thirty-five firm-year 10-Ks have answered the first question. The top three sources of liquidity in decreasing order are internal liquidity (including cash holdings and operating profits), credit lines, and commercial paper. The results are reported in Table VIII. Recall that 655 firms are regular users that signed 95% new contracts in dollar amount from 2005 to 2007. However, internal liquidity is ranked as the number one source of liquidity for these regular borrowers with access to credit lines. Credit lines are the number two liquidity source, but the number one among external liquidity sources.

[Insert Table VIII about here]

Do companies have sufficient total liquidity? Seven hundred and seventy-eight firm-year 10-Ks have answered the second question. Among the 792 responses, 789 firm-year 10-Ks describe that their companies had adequate liquidity overall in 2008 and 2009. Only 3 firm-year 10-Ks note that overall liquidity was constrained.

The answers to questions 1 and 2 do not support that these regular borrowers of credit lines were short of liquidity in the two-year crisis period. Because this question is about total liquidity, sufficient total liquidity could come from two different sources: internal or external. We will shortly further test internal liquidity and drawdowns in regression analysis.

Did companies find it difficult to access external credit markets in 2008/2009? 224 firm-year 10-Ks have discussed access to external liquidity. 213 firm-year responses identify that their firms had no difficulty accessing external liquidity in 2008-2009. Only 11 firm-year 10-Ks mention the problem.

Did the supply side or the demand side negatively affect the company's business more? 104 10-Ks have discussed their views on the supply-side shock or demand-side shock. 101 firm-year 10-Ks mention the demand-side shock. 3 firm-year 10-Ks mention the supply-side shock.

Did your company have a specific relationship bank(s) that was(were) in trouble? If so, did the company try to find a replacement? 35 firm-year 10-Ks claimed that one of their banks had some issues. However, none of the 10-Ks mentioned bank changes.

844 firm-year 10-Ks answer to question six: the outstanding credit lines and the drawdown amounts. 839 firm-year responses give us information on both the total lines of credit outstanding and the drawdown amount. On average, regular borrowers drew down 25% of their total credit lines in 208 and 2009.

The qualitative information reveals three pieces of information. First, even for regular credit line users, internal liquidity is still their number one liquidity source. Second, these firms have sufficient liquidity during the crisis period and have no problem accessing external liquidity if they wish. Third, the companies in our sample are different from those in Ivashina and Scharfstein (2010). Lehman's bankruptcy filing had a limited impact on the regular borrowers in 2008 and 2009.

Up to now, we have analyzed the demand side story from two fronts. If we agree that financial contracts should be a balance between supply and demand, drawdowns are solo decisions

of the borrowers. From the soft and hard information collected from regular borrowers, companies do not seem to experience liquidity shortages. They only drew a small proportion of their outstanding lines, and their official narratives did not complain about liquidity shortages. One concern is that the Management Discussion in Item 7 could be rhetorical on the bright side. However, real liquidity shortages could be much more serious. To rule out rhetorical concerns, we turn to regression analysis to see whether drawdowns can neutralize liquidity shortages during the crisis period. For example, if for some reason supply constraints did play significant roles in driving the 25% drawdowns, these regular borrowers must display short of total liquidity, equal to the sum of internal liquidity and drawdowns. This is what we will test in Section 9.3.

9.3 Can drawdowns neutralize internal liquidity shortages?

Because firms with regular credit line access are in the 7^{th} to 10^{th}decile, we only include firms without credit line access records in the same four size deciles. For firms with regular usage of lines of credit, we create two total liquidity measures. *Total liquidity I* is a sum of internal liquidity and drawdown credit lines. *Total liquidity II* is a sum of internal liquidity and the total credit lines, which include undrawn lines of credit. Both drawdown and total outstanding are from firms' 10-Ks.

Before running the regressions, we plot the equal-weighted liquidity in 2008 and 2009 in Figure IV. The internal liquidity for regular CL borrowers (in group 1A) is a blue dashed line, coded as *Regular borrowers, drawdown=0* (Internal liquidity/(AT-CHE)). The *Total liquidity I*, the sum of internal liquidity and drawdown ((Internal liquidity + CL drawdown)/(AT-CHE)), is an orange dotted line, coded as *Regular borrowers with CL drawdown*. The *Total liquidity II*, the sum of internal liquidity and total credit lines ((Internal liquidity + total CL)/(AT-CHE)), is a green dotted line, coded as *Regular borrowers with total CL*. The internal liquidity for firms without a history of credit line (in group 3) is a solid crimson line, coded as *Firms without CL*.

[Insert Figure IV about here]

Panel A is for all regular borrowers and their industry peers in the same size deciles from decile 7 to decile 10. Panel B and Panel C have separated the firms into above or below internal liquidity reference. There are three observations. First, the regular borrowers' internal liquidity is lower than that of their peers without a history of credit line access. Second, regular borrowers only draw a part of their credit lines. Third, larger firms (in decile 10) draw a lower amount relative to their size than smaller firms (in decile 7).

Next, we turn to regression analysis to further understand the above observations. As in the previous tables, regressions are conducted for firms above and below the liquidity reference, separately. There are three independent variables *Size*, *Market-to-book*, and *Access to LC*. *Access to LC* is a dummy variable equal to one if a firm is identified as a regular credit line borrower in 2005-2007 (in group 1A) or zero otherwise (in group 3).

The two dependent variables are (Total liquidity I) and (Total liquidity II). For firms without records of credit line access, the total credit lines and the drawdown credit lines will be zero. The dependent variables are the average of 2008 and 2009. The firm classification of above and below industry peers uses the data in 2005-2007. We report test results for firms above the internal liquidity reference in Table IX. The results for firms below the internal liquidity reference are reported in Table X.

[Insert Table IX and X about here]

We discuss each coefficient for firms above or below the internal liquidity reference. In univariate specifications, the coefficient for *Access to CL* is negative and significantly related to *Total liquidity I* for firms above liquidity reference (Table IX Panel A, column 1). Still, the coefficient keeps positive for firms below the liquidity reference (Table X Panel A, column 1). But after controlling for firm size, market-to-book, and industry effect, both coefficients become insignificant (Table IX and Table X Panel A, column 4). The regression results confirm that the drawdowns helped to satisfy internal liquidity shortages between the total liquidity of regular

borrowers and the internal liquidity of firms without access to the credit line. In other words, 25% drawdowns are voluntary, not restricted by lending banks.

Although it is not a supply-side story in the win-win contract rationale, we tempt to explain the empirical findings in this section from the supply-side story to serve as counterfactual arguments. If lending banks were functional, but had restricted drawdown requests due to bank problems, borrowers from the below reference liquidity subgroup would have drawn down less (Table X, Panel A, column 4). However, the coefficients for *Access to CL* for firms below the liquidity reference are not significant.

Firm size is a proxy for profit-generating capacity, and a loan contract is more likely to converge for larger borrowers. Now, companies make their drawdown decisions. If there had been bank problems to restrict drawdowns, banks would have restricted the drawdowns for smaller borrowers. This explanation is consistent with the positive and significant coefficients for size control for firms below the liquidity reference (Table X, panels A and B, column 4).

However, the supply side story cannot simultaneously explain the drawdowns of borrowers above the liquidity reference. *Size*'s coefficients become negative and significant (Table IX, Panel A, columns 2 to 4). Putting firms below or above the internal liquidity reference in perspective, only the demand side story can simultaneously explain the size effect of drawdown decisions of regular borrowers.

The results are similar for the coefficients of *Market-to-book*. When companies in the subgroup below the internal liquidity reference sign new contracts, *Market-to-book* coefficients are positive and significant (Table III, Panel B, column 4; Table V, Panel B, column 4). In the contract establishment stage, the supply side story that access to firms with greater growth potential is natural. Growth potential, similar to size, is dependent on profit generating capacities.

In the drawdown stage, as we argue from lender obligations, regular borrowers have complete control of drawdown decisions. However, if there were bank problems to restrict drawdowns, banks would start from firms with lower market-to-book because the principal repayment risk is higher. In other words, coefficients should be positive and significant for regular

borrowers below the internal liquidity reference. However, we observe negative and significant coefficients for *Market-to-Book* for borrowers below the liquidity reference (Table X, Panel A and B, column 4). Again, only the demand-side story can explain the coefficients for *Market-to-Book* for all regular borrowers, above or below the internal liquidity reference.

The test results also confirm that the total liquidity II is higher than that of firms without access to lines of credit. The coefficients for *Access to CL* are positive and significant (Table IX Panel B and Table X Panel B column 4). This observation is consistent for firms above and below the liquidity reference. The comprehensive information that we have collected supports the demand-side story.

To further address the concern that bank problems cause fractional drawdowns, we carry out one more test. We compare the drawdown ratio of regular borrowers only. The dependent variable, *Drawdown LC*, is the CL drawdown scaled by noncash assets (*Drawdown LC/(ATCHE)*). For each regular borrower, the drawdown is an average of 2008 and 2009. The main independent variable is a dummy variable, *Above liquidity reference*, which is equal to one if a regular borrower is in the subgroup above the internal liquidity reference or zero otherwise. The (*Above liquidity reference*) is based on credit line access from 2005 to 2007, so are two independent variables of (*Size*) and (*Market-to-book*). The results are reported in Table XI.

[Insert Table XI about here]

Internal liquidity for regular borrowers is 30% (median) and 43% (mean) above the internal liquidity reference vs. 15.3% (median) and 15.7% (mean) below the liquidity reference before the crisis as in Table II. If it were bank problems to restrict drawdown requests, the impact on borrowers below the liquidity reference would be more severe. Therefore, we expect a positive correlation between *Drawdown CL* and *Above industry median* if it were a supply-side story.

However, the coefficients are negative and significant (Table XI, columns 1 to 4). In other words, banks honor the drawdown requests more from borrowers that have lower internal liquidity prior to the crisis. Therefore, there is no reason banks did not honor requests from

borrowers with higher internal liquidity if the latter have drawdown requests. The only answer left here is that these firms don't need to draw down that much. This is a demand-side story.

10 Conclusion

The analytical foundation for why a bank must be active is the uncertainty of profit. This study identifies an overlooked wedge in the causality of the endogenous growth theory in Romer (1990). The wedge is profit uncertainty, which lies between innovations and monopolistic profits.

We propose a win-win loan contract based on profit uncertainty. This study addresses three questions on why, how, and what. Why should a bank be active? How should a bank play its active role? What could change in the bank loan business when the bank is active?

We have solved convergent decisions from the liquidity demand and supply sides through extensive-form games. Our model has three predictions. First, companies must prioritize the liquidity needs of existing operations over new investment projects. Second, our model predicts the distribution of credit line contracts. The prediction has identified two reasons why a company has no access to credit lines. A company that is rich in internal liquidity will not apply for credit lines. On the other end of the internal liquidity spectrum, companies in the bottom tercile internal liquidity are desperate to access credit lines. However, banks will reject their applications simply because they have a poor operating record generating operating profits that are critical to meeting debt payment obligations. Our model also predicts the conditions of access to term loans or convertible debt.

For identification purposes, we analyze the access to credit lines of Compustat firms from 2002 to 2009. We have two findings on the realized distribution of credit line access during normal times, one on each side of the borrowers and banks. The pecking order theory plays an important role on the borrower side. Some firms have sufficient internal liquidity. Therefore, these firms won't apply for external liquidity in the first place. Among firms that are short of

internal liquidity, most of them will apply for it. However, now it is up to banks' decision. Banks will reject the application at least for two reasons. Intuitively, banks reject applications that borrowers may have difficulty servicing interest rate payments or principal repayment.

We have also documented a demand-side story of how borrowers draw down credit lines during the 2008 crisis period. The regular borrowers claim that they have sufficient internal liquidity and have no problems accessing external liquidity. When their relationship banks could not fulfill the commitment, they did not seek replacements. In addition to the supply-side shock, we also document, perhaps the first time, a large-scale borrowing reduction from the borrower side. Larger regular borrowers draw down less than smaller regular borrowers when their internal liquidity was above the liquidity reference. Furthermore, regular borrowers with high internal liquidity draw down less than regular borrowers with low internal liquidity.

References

Acharya, V. V., H. Almeida, and M. Campello (2013). Aggregate risk and the choice between cash and lines of credit. *Journal of Finance 68*(5), 2059–2116.

Acharya, V. V., L. H. Pedersen, T. Philippon, and M. Richardson (2017). Measuring systemic risk. *Review of Financial Studies 30*(1), 2–47.

Aghion, P. and P. Howitt (1992). A model of growth through creative destruction. *Econometrica 60*(2), 323–351.

Almeida, H., M. Campello, I. Cunha, and M. S. Weisbach (2014). Corporate liquidity management: A conceptual framework and survey. *Annual Review of Financial Economics 6*(1), 135–162.

Almeida, H., M. Campello, and M. S. Weisbach (2004). The cash flow sensitivity of cash. *Journal of Finance 59*(4), 1777–1804.

Ashcraft, A. B. (2005). Are banks really special? new evidence from the fdic-induced failure of healthy banks. *American Economic Review 95*(5), 1712–1730.

Bae, K.-H., J.-K. Kang, and C.-W. Lim (2002). The value of durable bank relationships: evidence from korean banking shocks. *Journal of Financial Economics 64*(2), 181–214.

Bates, T. W., K. M. Kahle, and R. M. Stulz (2009). Why do us firms hold so much more cash than they used to? *Journal of Finance 64*(5), 1985–2021.

Berg, T., A. Saunders, and S. Steffen (2016). The total cost of corporate borrowing in the loan market: Don't ignore the fees. *Journal of Finance 71*(3), 1357–1392.

Berger, A. N. and C. H. S. Bouwman (2009, 01). Bank Liquidity Creation. *Review of Financial Studies 22*(9), 3779–3837.

Berk, J. and P. DeMarzo (2017). Corporate finance, 4th edition, global ed. *Essex: Person Education Limited*.

Bernanke, B. (1983). Non-monetary effects of the financial crisis in the propagation of the great depression. *The American Economic Review 73*(3), 257–276.

Bernanke, B., M. Gertler, and S. Gilchrist (1996). The financial accelerator and the flight to quality. *The Review of Economics and Statistics 78*(1), 1–15.

Bernanke, B. S. (2009, January 13). The crisis and the policy response. *Speech, Stamp Lecture at the London School of Economics*.

Bernanke, B. S. (2023, May). Nobel lecture: Banking, credit, and economic fluctuations. *American Economic Review 113*(5), 1143–69.

Bodnaruk, A., T. Loughran, and B. McDonald (2015). Using 10-k text to gauge financial constraints. *Journal of Financial and Quantitative Analysis*, 623–646.

Boot, A., A. V. Thakor, and G. F. Udell (1987). Competition, risk neutrality and loan commitments. *Journal of Banking & Finance 11*(3), 449–471.

Calomiris, C. W. and J. R. Mason (2003). Consequences of bank distress during the great depression. *American Economic Review 93*(3), 937–947.

Campello, M. (2002). Internal capital markets in financial conglomerates: Evidence from small bank responses to monetary policy. *Journal of Finance 57*(6), 2773–2805.

Campello, M., E. Giambona, J. R. Graham, and C. R. Harvey (2011). Liquidity management and corporate investment during a financial crisis. *Review of Financial Studies 24*(6), 1944–1979.

Chava, S. and A. Purnanandam (2011). The effect of banking crisis on bank-dependent borrowers. *Journal of Financial Economics 99*(1), 116–135.

Chu, J. (2023). On the choices of lifestyle and growth. *work-in-progress paper*.

Chu, J. (2025). Self-healing loan maintenance. *Working paper*.

Chu, J. and J. Ou (2025). Great recession and systemically important banks. *Working paper*.

de Roover, R. (1963). The rise and decline of the medici bank, 1397–1494. *Cambridge, Mass.: Harvard University Press. xxii, 500 p.*

Denis, D. J. and S. B. McKeon (2020). Persistent negative cash flows, staged financing, and the stockpiling of cash balances. *Journal of Financial Economics forthcoming*.

Diamond, D. W. (1984, jul). Financial Intermediation and Delegated Monitoring. *The Review of Economic Studies 51*(3), 393.

Diamond, D. W. (2007). Banks and liquidity creation: A simple exposition of the diamond-dybvig model. *FRB Richmond Economic Quarterly 93*(2), 189–200.

Diamond, D. W. (2023). Nobel lecture: Financial intermediaries and financial crises. *Journal of Political Economy 131*(10), 2597–2622.

Diamond, D. W. and P. H. Dybvig (1983). Bank runs, deposit insurance, and liquidity. *Journal of political economy 91*(3), 401–419.

Diamond, D. W. and R. G. Rajan (2000). A theory of bank capital. *Journal of Finance 55*, 2431–2465.

Diamond, D. W. and R. G. Rajan (2001). Liquidity risk, liquidity creation, and financial fragility: A theory of banking. *Journal of Political Economy 109*.

Diamond, D. W. and R. G. Rajan (2005). Liquidity shortages and banking crises. *Journal of Finance 60*(2), 615–647.

Garcia-Appendini, E. and J. Montoriol-Garriga (2013). Firms as liquidity providers: Evidence from the 2007–2008 financial crisis. *Journal of Financial Economics 109*(1), 272–291.

Gatev, E. and P. E. Strahan (2006). Banks' advantage in hedging liquidity risk: Theory and evidence from the commercial paper market. *Journal of Finance 61*(2), 867–892.

Gertler, M. and S. Gilchrist (1994). Monetary policy, business cycles, and the behavior of small manufacturing firms. *Quarterly Journal of Economics 109*(2), 309–340.

Gibson, M. S. (1995). Can bank health affect investment? evidence from japan. *Journal of Business*, 281–308.

Hoberg, G. and V. Maksimovic (2015). Redefining financial constraints: A text-based analysis. *Review of Financial Studies 28*(5), 1312–1352.

Holmström, B. and J. Tirole (1998). Private and public supply of liquidity. *Journal of Political Economy 106*(1), 1–40.

Holmström, B. and J. Tirole (2011). *Inside and Outside Liquidity*. The MIT Press.

Ivashina, V. and D. Scharfstein (2010). Bank lending during the financial crisis of 2008. *Journal of Financial Economics 97*(3), 319–338.

Kahle, K. M. and R. M. Stulz (2013). Access to capital, investment, and the financial crisis. *Journal of Financial Economics 110*(2), 280–299.

Kang, J.-K. and R. M. Stulz (2000). Do banking shocks affect borrowing firm performance? an analysis of the japanese experience. *Journal of Business 73*(1), 1–23.

Kaplan, S. N. and L. Zingales (1997). Do investment-cash flow sensitivities provide useful measures of financing constraints? *Quarterly Journal of Economics 112*(1), 169–215.

Kashyap, A. K., O. A. Lamont, and J. C. Stein (1994). Credit conditions and the cyclical behavior of inventories. *Quarterly Journal of Economics 109*(3), 565–592.

Kashyap, A. K., R. Rajan, and J. C. Stein (2002). Banks as liquidity providers: An explanation for the coexistence of lending and deposit-taking. *Journal of finance 57*(1), 33–73.

Kashyap, A. K., J. C. Stein, and D. W. Wilcox (1993). Monetary policy and credit conditions: Evidence from the composition of external finance. *American Economic Review 83*(1), 78–98.

Keynes, J. M. (1936). The general theory of employment, interest and money. *Palgrave Macmillan*.

Khwaja, A. I. and A. Mian (2008). Tracing the impact of bank liquidity shocks: Evidence from an emerging market. *American Economic Review 98*(4), 1413–42.

Kiyotaki, N. and J. Moore (1997). Credit cycles. *Journal of Political Economy 105*(2), 211–248.

Leary, M. T. (2009). Bank loan supply, lender choice, and corporate capital structure. *Journal of Finance 64*(3), 1143–1185.

Lins, K. V., H. Servaes, and P. Tufano (2010). What drives corporate liquidity? an international survey of cash holdings and lines of credit. *Journal of Financial Economics 98*(1), 160–176.

Longstaff, F. A., S. Mithal, and E. Neis (2005). Corporate yield spreads: Default risk or liquidity? new evidence from the credit default swap market. *The Journal of Finance 60*(5), 2213–2253.

Merton, R. C. (1974). On the pricing of corporate debt: The risk structure of interest rates. *Journal of Finance 29*(2), 449–470.

Mueller, R. (1997). The venetian money market: Banks, panics, and the public debt, 1200-1500. *The Johns Hopkins University Press*, 223.

Myers, S. C. and N. S. Majluf (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics 13*(2), 187–221.

Nikolov, B., L. Schmid, and R. Steri (2019). Dynamic corporate liquidity. *Journal of Financial Economics 132*(1), 76–102.

Paravisini, D. (2008). Local bank financial constraints and firm access to external finance. *Journal of Finance 63*(5), 2161–2193.

Peek, J. and E. S. Rosengren (2000). Collateral damage: Effects of the japanese bank crisis on real activity in the united states. *American Economic Review 90*(1), 30–45.

Puri, M., J. Rocholl, and S. Steffen (2011). Global retail lending in the aftermath of the us financial crisis: Distinguishing between supply and demand effects. *Journal of Financial Economics 100*(3), 556–578.

Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy 94*(5), 1002–1037.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy 98*(5), S71–S102.

Schnabl, P. (2012). The international transmission of bank liquidity shocks: Evidence from an emerging market. *Journal of Finance 67*(3), 897–932.

Shleifer, A. and R. W. Vishny (1992). Liquidation values and debt capacity: A market equilibrium approach. *Journal of Finance 47*(4), 1343–1366.

Solow, R. M. (1956, 02). A contribution to the theory of economic growth. *The Quarterly Journal of Economics 70*(1), 65–94.

Strebulaev, I. A. and B. Yang (2013, jul). The mystery of zero-leverage firms. *Journal of Financial Economics 109*(1), 1–23.

Sufi, A. (2009). Bank lines of credit in corporate finance: An empirical analysis. *Review of Financial Studies 22*(3), 1057–1088.

Thakor, A., H. Hong, and S. I. Greenbaum (1981). Bank loan commitments and interest rate volatility. *Journal of Banking & Finance 5*(4), 497–510.

Thakor, A. V. (1982). Toward a theory of bank loan commitments. *Journal of Banking & Finance 6*(1), 55–83.

Whalen, E. L. (1966). A rationalization of the precautionary demand for cash. *The Quarterly Journal of Economics 80*(2), 314–324.

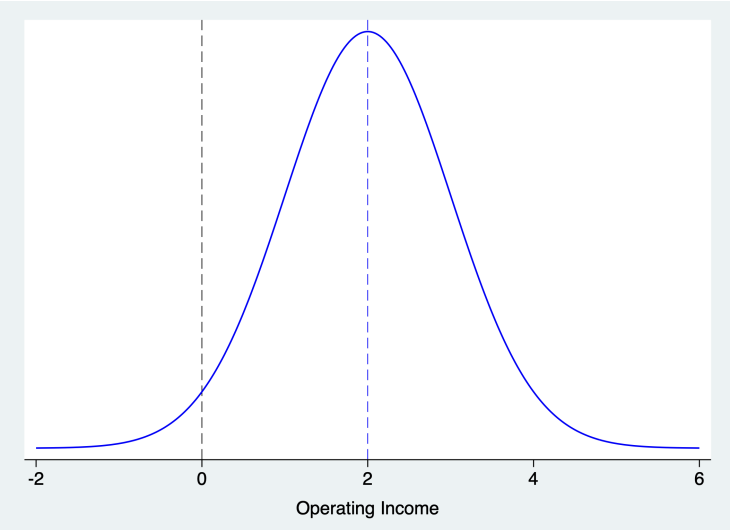
Winkler, R. . (January 31, 2024). 23andMe's fall from billion to nearly $0. *Wall Street Journal*.

Figures

Figure I. Company's $EBIT$ distribution

Figure I illustrate the distribution of $EBIT_{i,t}$ of two types of firms. The distribution is normal with $\sigma = 1$. The mark 0 indicates breakeven $EBIT$, with positive (negative) numbers for positive (negative) $EBIT$. For companies of Op1A (Fig. A), mark 0 equal to $\mu - 1.96 \times \sigma$. In 97.5% of the periods, Op1A firms report positive $EBIT_t$. For companies of Op1BR (Fig. B), mark 0 equal to $\mu + 0.67 \times \sigma = 0$. In 75% of the periods, Op1BR firms report negative $EBIT_t$.

(A) Op1A



(B) Op1BR

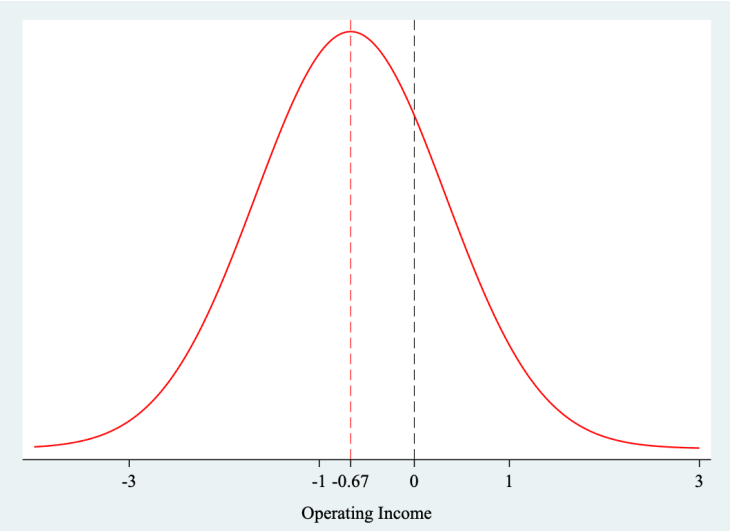
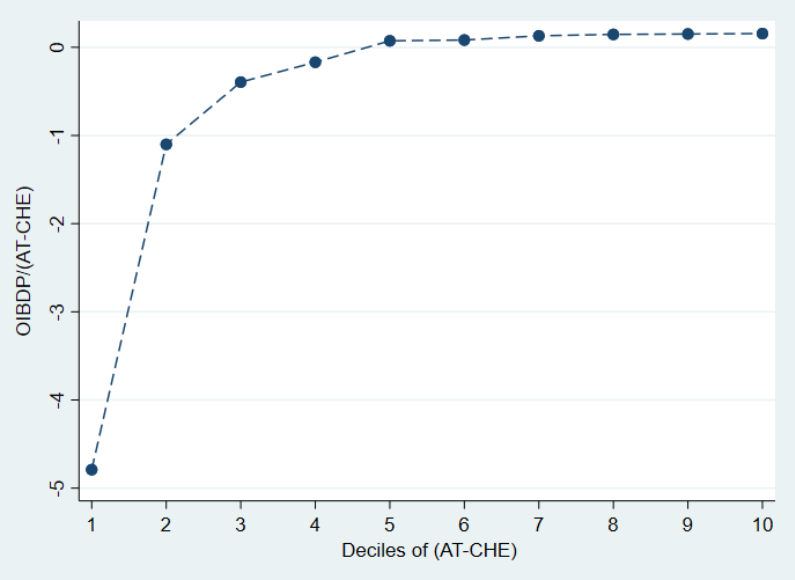


Figure II. operating profit ratio and cash holding ratio in size decile

Figure II plot operating profits and cash holdings as a percentage of the firm's non-cash total assets. There are 3,469 non-financial, non-utility firms in North America. Cash holding ratio is *(CHE/(AT-CHE))*. operating profit ratio is *(OIBDP/(AT-CHE))*. Size is *(AT-CHE)*. The size decile is average of 2005-2007. The cash and operating profit ratios are in the fiscal year 2008 and 2009 data, which are winsorized at 2.5% on each side.

(A) Equal-weighted operating profit ratio



(B) Equal-weighted cash ratio

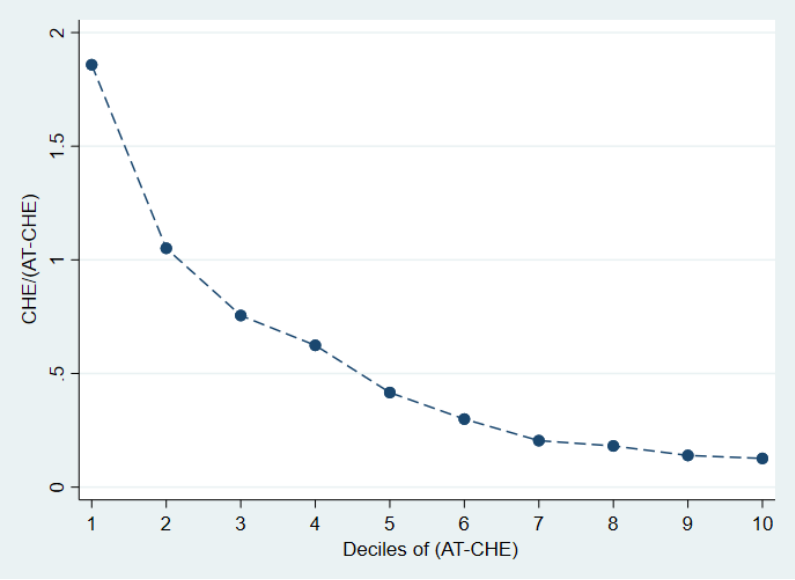


Figure III. The internal liquidity and access to lines of credit.

We identify 655 regular borrowers on lines of credit (Regular borrowers, new CL, group 1A) and 599 occasional borrowers on lines of credit (Occasional borrowers, new CL, group 1B), based on the dollar amount new contracts of lines of credit reported in DealScan in 2005-2007. The 1,254 borrowers are in North America, with GVKEY in non-financial, non-utility industries. The 655 regular borrowers account for 95% of the dollar amount on credit line contracts from 2005 to 2007. The occasional borrowers account for the rest 5% of the contract dollar amount. Firms that have unexpired credit line contracts signed in the period of 1995-2004 but without signing new credit line contracts in 2005-2007 are in group 2 (Borrowers with unexpired CL but no new CL). The rest firms without access to credit lines from 1995 to 2007 are in group 3. The internal liquidity ratio is *(CHE + OIBDP)/(AT-CHE)*. For each firm, we calculate and plot the average internal liquidity ratio in the two years of 2008-2009. The size deciles are based on Compustat data from 2002 to 2004.

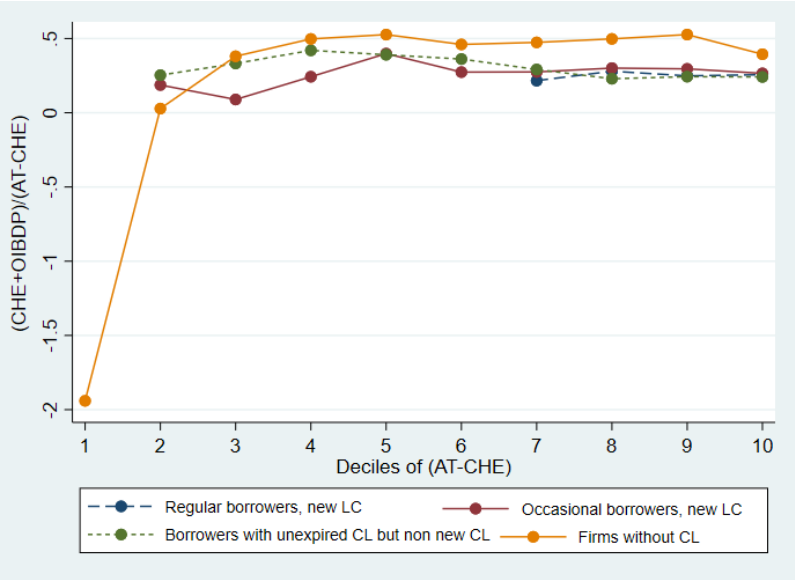
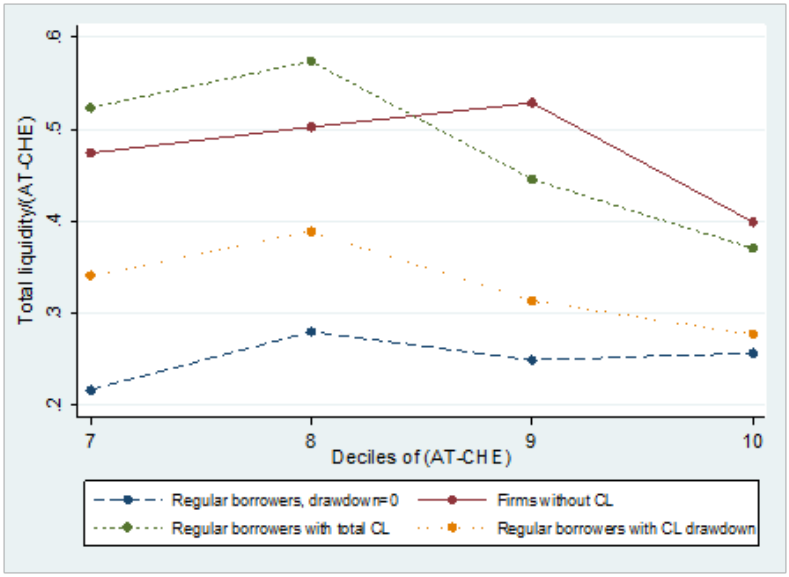


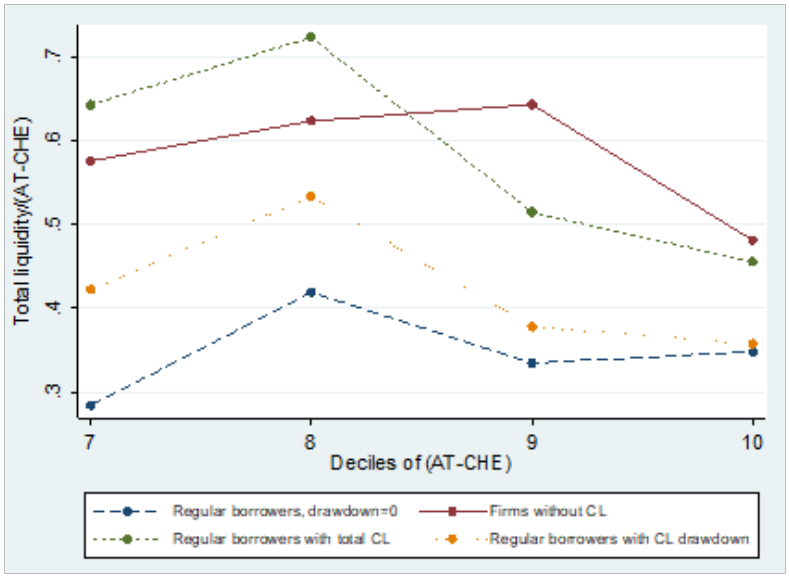
Figure IV. Drawdown and total CL of regular borrowers in 2008-2009

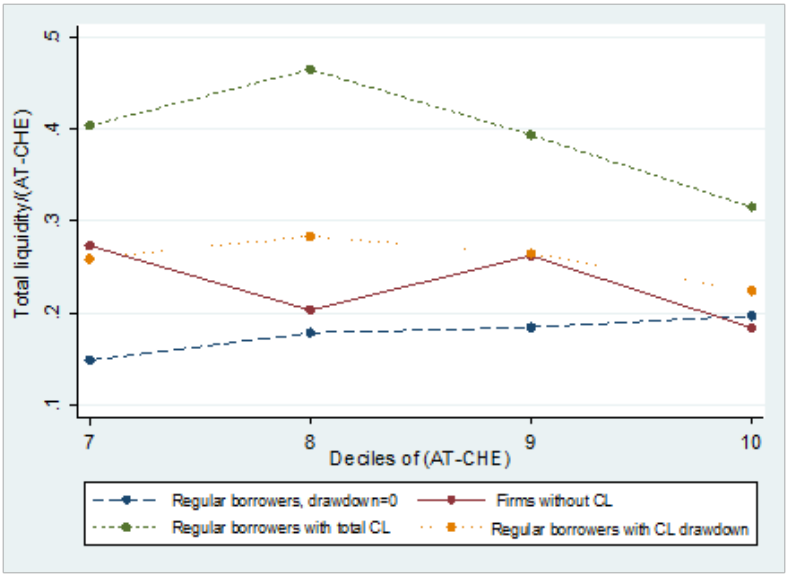
This figure plots regular credit line borrowers (group 1A) and firms without access to credit lines in size decile 7 to decile 10. The firm and firm size identification follow that in Figure II. The total liquidity is the sum of cash holdings (CHE), operating profits (OIBDP) and lines of credit. Each plot includes four equal-weighted average of liquidity measurements. The bottom blue cashed line is the internal liquidity *(CHE + OIBDP)/(AT - CHE)* of regular borrowers of lines of credit (Regular borrowers, drawdown=0). The solid crimson line is the internal liquidity *(CHE + OIBDP)/(AT - CHE)* of firms without credit lines (Firms without CL). The orange dotted line is the total liquidity I *(CHE + OIBDP + CL drawdown)/(AT - CHE)* for regular borrowers of lines of credit (Regular borrowers with CL drawdown). The top green dotted line is the total liquidity II *(CHE + OIBDP + total CL)/(AT - CHE)* for regular credit line borrowers (Regular borrowers with total CL).

(A) All firms



(B) Firms with internal liquidity above the internal liquidity reference





(C) Firms with internal liquidity below the liquidity reference

Tables

Table I. With or without credit line access and internal liquidity, full sample

This table provides the summary statistics of the sample. Our sample starts from 3,469 North American non-finance, non-utility firms in Compustat with no missing data on assets (AT), long-term debt (DLTT), short-term date (DLC), operating profits (OIBDP) and cash holdings (CHE) in all three years from 2005 to 2007. *Internal liquidity =(CHE+OIBDP)/(AT–CHE); Cash holdings =CHE/(AT–CHE); operating profits=OIBDP/(AT–CHE); No cash assets=AT–CHE*. Using the data in 2002-2004, we allocate sample firms (sample number drops to 3,463) into ten size deciles and two subgroups. Size is based on no cash assets. Suppose a firm's average internal liquidity in 2002-2004 is higher (lower) than its internal liquidity reference in the same period. In that case, this firm is in the subgroup of above (below) the internal liquidity reference. We follow the Fama-French 12-industry classification. We map 655 regular borrowers and 599 occasional borrowers of lines of credit to 3,463 sample firms. 458 regular borrowers (Regular borrowers, new CL) and 417 occasional borrowers (Occasional borrowers, new CL) are left in the sample. The rest 2,588 firms have no new credit line contract in 2005-2007, but 641 firms have unexpired credit line contracts signed between 1995 and 2004. Panel A reports the number of unique firms with access to credit lines, either historical contracts signed between 1995 and 2004 or new contracts signed between 2005 and 2007. Panel B reports total outstanding credit lines ($ billions) in all contracts that a firm has signed but has not matured yet. Panel C presents the credit line ratio = CL/(AT-CHE).

Panel A. Number of distinct firms

	Number of firms				
	2005	2006	2007	2008	2009
Regular borrowers, new CL	443	451	456	457	457
Occasional borrowers, new CL	327	375	415	401	377
Borrowers with unexpired CL but no new CL	553	521	520	578	608

Panel B. Unexpired credit line contracts in dollar amount ($ billions)

	Total unexpired credit line contracts				
	2005	2006	2007	2008	2009
Regular borrowers, new CL	772	941	1,140	1,140	1,080
Occasional borrowers, new CL	69.7	74.5	76.5	80.4	79.4
Borrowers with unexpired CL but no new CL	471	533	610	615	576

Panel C. Credit line as a ratio of non-cash assets

	LC/(AT-CHE)				
	2005	2006	2007	2008	2009
Regular borrowers, new CL	0.511	0.605	0.726	0.719	0.701
Occasional borrowers, new CL	0.532	0.587	0.621	0.668	0.682
Borrowers with unexpired CL but no new CL	0.403	0.479	0.538	0.59	0.581

Table II. Internal liquidity, liquidity reference, and access to lines of credit

Our sample starts from 3,469 North American non-finance, non-utility firms in Compustat with no missing data on assets (AT), long-term debt (DLTT), short-term date (DLC), operating profits (OIBDP), and cash holdings (CHE) in all three years from 2005 to 2007. *Cash holdings: CHE/(AT–CHE); operating profits: OIBDP/(AT–CHE); Internal liquidity is the sum of cash holdings and operating profits, (CHE+OIBDP)/(AT–CHE); Non-cash assets: AT–CHE*. Using the data in 2002-2004, we allocate sample firms (sample number drops to 3,463) into two subgroups. Suppose a firm's average internal liquidity in 2002-2004 is higher (lower) than its internal liquidity reference in the same period. In that case, this firm is in the subgroup of above (below) the internal liquidity reference. We follow the Fama-French 12-industry classification.

Panel A. Above internal liquidity reference and access to lines of credit

	N	Mean	Std Dev	25th	Median	75th
High liquidity 1A: Regular borrowers, new CL contracts in 2005-2007						
Internal liquidity	222	0.434	0.431	0.24	0.301	0.413
Cash holdings	222	0.244	0.587	0.069	0.117	0.232
operating profits	222	0.193	0.184	0.15	0.194	0.244
Non-cash assets	222	4600.428	6427.387	751.512	1915.219	4748.633
High liquidity 1B: Occasional borrowers, new CL contracts in 2005-2007						
Internal liquidity	217	0.589	0.61	0.267	0.398	0.635
Cash holdings	217	0.433	0.766	0.099	0.208	0.435
operating profits	217	0.15	0.3	0.124	0.176	0.237
Non-cash assets	217	518.545	1633.541	94.339	218.18	531.468
High liquidity 2: Borrowers with unexpired CL signed in 1995-2004 but no new contracts in 2005-2007						
Internal liquidity	317	0.527	0.557	0.262	0.334	0.536
Cash holdings	317	0.364	0.827	0.082	0.157	0.329
operating profits	317	0.143	0.548	0.137	0.192	0.248
Non-cash assets	317	3567.2	6611.423	122.47	408.848	2306.462
High liquidity 3: Firms without CL from 1995 to 2007						
Internal liquidity	1024	1.154	1.137	0.41	0.683	1.428
Cash holdings	1024	1.477	2.012	0.272	0.65	1.632
operating profits	1024	-0.521	2.095	-0.224	0.104	0.221
Non-cash assets	1024	702.871	2939.887	8.69	33.776	143.794
High liquidity 3: Firms without CL from 1995 to 2007, Non-Cash Assets>=1						
Internal liquidity	979	1.07	1.022	0.4	0.659	1.312
Cash holdings	979	1.279	1.735	0.264	0.621	1.461
operating profits	979	-0.294	1.508	-0.153	0.114	0.228
Non-cash assets	979	735.158	3002.811	10.942	38.102	154.585

Panel B. Below internal liquidity reference and access to lines of credit

	N	Mean	Std Dev	25th	Median	75th
Low liquidity 1A: Regular borrowers, new CL contracts in 2005-2007						
Internal liquidity	236	0.157	0.056	0.125	0.153	0.186
Cash holdings	236	0.041	0.04	0.016	0.029	0.051
operating profits	236	0.117	0.05	0.093	0.118	0.147
Non-cash assets	236	5478.953	6766.525	1050.433	2101.807	7026.027
Low liquidity 1B: Occasional borrowers, new CL contracts in 2005-2007						
Internal liquidity	200	0.083	0.579	0.107	0.14	0.177
Cash holdings	200	0.064	0.116	0.015	0.03	0.076
operating profits	200	-0.017	1.037	0.065	0.098	0.132
Non-cash assets	200	620.241	1799.558	98.318	252.289	601.33
Low liquidity 2: Borrowers with unexpired CL signed in 1995-2004 but no new contracts in 2005-2007						
Internal liquidity	324	0.133	0.193	0.108	0.149	0.188
Cash holdings	324	0.071	0.167	0.013	0.033	0.078
operating profits	324	0.061	0.304	0.063	0.106	0.137
No cash assets	324	2475.778	5152.545	91.862	430.166	1903.977
Low liquidity 3: Firms without CL from 1995 to 2007						
Internal liquidity	923	-0.847	1.832	-0.796	-0.001	0.149
Cash holdings	923	0.594	1.367	0.045	0.138	0.422
operating profits	923	-1.717	3.295	-1.414	-0.223	0.046
Non-cash assets	923	322.327	1987.362	1.892	9.273	43.636
Low liquidity 3: Firms without CL from 1995 to 2007, Non-Cash Assets>=1						
Internal liquidity	745	-0.254	1.004	-0.194	0.071	0.165
Cash holdings	745	0.355	0.814	0.037	0.112	0.306
operating profits	745	-0.673	1.775	-0.571	-0.08	0.071
Non-cash assets	745	399.234	2205.409	4.804	15.862	60.669

Table III. With or without credit line access and internal liquidity, full sample

This table reports test results on the relationship between credit line access and internal liquidity. The dependent variable *Access to CL* is a dummy, whose value is equal to one for CL borrowers in Group 1A, 1B, and 2 in Table II, or zero for firms without credit line access records from 1995-2007 in Group 3. Independent variables are *Internal liquidity =(CHE+OIBDP)/(AT–CHE), Size =Log(AT–CHE), Market-to-Book =(AT–BE+PRCC_F*CSHO–CHE)/(AT–CHE), operating profits =OIBDP/(AT–CHE), and Cash holdings =CHE/(AT–CHE)* . Firms with non-cash assets lower than $1 million are dropped. All independent variables are averaged for each firm in 2002-2004 and winsorized at 2.5% on both sides. Firms with non-cash assets smaller than $1 million are dropped. All tests are cross-sectional at the firm level. Regressions report the robust standard error in the parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A

	Dependent variable: Access to CL			
	(1)	(2)	(3)	(4)
Internal liquidity	-0.477***	-0.510***	-0.462***	-0.386***
	(0.052)	(0.082)	(0.085)	(0.087)
Size		0.668***	0.646***	0.644***
		(0.027)	(0.028)	(0.029)
Market-to-Book			-0.036**	-0.029*
			(0.016)	(0.015)
Observations	3236	3236	3236	3236
Industry FE	No	No	No	Yes

Panel B

	Dependent variable: Access to CL			
	(1)	(2)	(3)	(4)
operating profits	0.825***		0.645**	0.577**
	(0.280)		(0.268)	(0.243)
Cash holdings		-0.878***	-0.877***	-0.759***
		(0.148)	(0.159)	(0.156)
Size	0.597***	0.611***	0.581***	0.592***
	(0.031)	(0.028)	(0.032)	(0.032)
Market-to-Book	-0.045**	0.011	0.032*	0.033*
	(0.022)	(0.016)	(0.018)	(0.018)
Observations	3,236	3,236	3,236	3,236
Industry FE	No	No	No	Yes

Table IV. Firms above internal liquidity reference subgroup

This table reports test results on the relationship between credit line access and internal liquidity for sample firms above internal liquidity reference. The dependent variable *Access to CL* is a dummy, whose value is equal to one for CL borrowers in Group 1A, 1B, and 2 in Table II, or zero for firms without credit line access records from 1995-2007 in Group 3. Independent variables are *Internal liquidity =(CHE+OIBDP)/(AT–CHE), Size =Log(AT–CHE), Market-to-Book =(AT–BE+PRCC_F*CSHO–CHE)/(AT–CHE), operating profits =OIBDP/(AT–CHE), and Cash holdings =CHE/(AT–CHE)*. Firms with non-cash assets lower than $1 million are dropped. All independent variables are averaged for each firm in 2002-2004 and winsorized at 2.5% on both sides. Firms with non-cash assets smaller than $1 million are dropped. All tests are cross-sectional at the firm level. Regressions report the robust standard error in the parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. CL borrowers in Group 1A, 1B, and 2 with firms without CL in Group 3, Table II Panel A

	Dependent variable: Access to CL			
	(1)	(2)	(3)	(4)
Internal liquidity	-1.285***	-0.668***	-0.755***	-0.580***
	(0.150)	(0.126)	(0.128)	(0.131)
Size		0.524***	0.532***	0.574***
		(0.034)	(0.036)	(0.038)
Market-to-Book			0.027	0.020
			(0.018)	(0.018)
Observations	1,733	1,733	1,733	1,733
Industry FE	No	No	No	Yes

Panel B. CL borrowers in Group 1A, 1B, and 2 with firms without CL in Group 3, Table II Panel A

	Dependent variable: Access to CL			
	(1)	(2)	(3)	(4)
operating profits	0.808**		0.019	0.189
	(0.364)		(0.340)	(0.327)
Cash holdings		-0.894***	-0.889***	-0.697***
		(0.156)	(0.165)	(0.168)
Size	0.531***	0.495***	0.495***	0.540***
	(0.037)	(0.036)	(0.037)	(0.039)
Market-to-Book	-0.028	0.058**	0.058**	0.052**
	(0.023)	(0.024)	(0.024)	(0.024)
Observations	1,733	1,733	1,733	1,733
Industry FE	No	No	No	Yes

Table V. Firms below the internal liquidity reference

This table reports test results on the relationship between credit line access and internal liquidity for sample firms below the internal liquidity reference. The dependent variable *Access to CL* is a dummy, whose value is equal to one for CL borrowers in Group 1A, 1B, and 2 in Table II, or zero for firms without credit line access records from 1995-2007 in Group 3. Independent variables are *Internal liquidity =(CHE+OIBDP)/(AT–CHE), Size =Log(AT–CHE), Market-to-Book =(AT–BE+PRCC_F*CSHO–CHE)/(AT–CHE), operating profits =OIBDP/(AT–CHE), and Cash holdings =CHE/(AT–CHE)*. Firms with non-cash assets lower than $1 million are dropped. All independent variables are averaged for each firm in 2002-2004 and winsorized at 2.5% on both sides. Firms with non-cash assets smaller than $1 million are dropped. All tests are cross-sectional at the firm level. Regressions report the robust standard error in the parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. CL borrowers in Group 1A, 1B, and 2 with firms without CL in Group 3, Table II Panel B

	Dependent variable: Access to CL			
	(1)	(2)	(3)	(4)
Internal liquidity	4.522***	1.272***	1.099***	1.448***
	(0.418)	(0.402)	(0.396)	(0.415)
Size		0.754***	0.744***	0.697***
		(0.047)	(0.050)	(0.051)
Market-to-Book			-0.029	-0.007
			(0.035)	(0.030)
Observations	1,503	1,503	1,503	1,503
Industry FE	No	No	No	Yes

Panel B. CL borrowers in Group 1A, 1B, and 2 with firms without CL in Group 3, Table II Panel B

	Dependent variable: Access to CL			
	(1)	(2)	(3)	(4)
operating profits	1.950**		1.643**	1.656***
	(0.950)		(0.665)	(0.620)
Cash holdings		-2.792**	-1.808*	-1.444
		(1.170)	(1.020)	(1.104)
Size	0.672***	0.726***	0.682***	0.668***
	(0.057)	(0.046)	(0.059)	(0.058)
Market-to-Book			0.080***	0.084***
			(0.024)	(0.024)
Observations	1,503	1,503	1,503	1,503
Industry FE	No	No	No	Yes

Table VI. Low operating profits and bank rejections

This table reports test results on the relationship between credit line access and low operating profits. The dependent variable *Access to CL* is a dummy, whose value is equal to one for CL borrowers in Group 1A, 1B, and 2 in Table II, or zero for firms without credit line access records from 1995-2007 in Group 3. The main independent variable is a dummy Low operating profits, which is equal to one if a firm's average return on tangible assets (OIBDP/(AT-CHE)) is less than 6% from 2002 to 2004, or zero otherwise. The other independent variables are *Size =Log(AT–CHE), Market-to-Book =(AT–BE+PRCC_F*CSHO–CHE)/(AT–CHE), and Cash holdings =CHE/(AT–CHE)*. Firms with non-cash assets lower than $1 million are dropped. All independent variables are averaged for each firm in 2002-2004 and winsorized at 2.5% on both sides. Firms with non-cash assets smaller than $1 million are dropped. All tests are cross-sectional at the firm level. Regressions report the robust standard error in the parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. CL borrowers in Group 1A, 1B, and 2 with firms without CL in Group 3, Table II Panel A

	Dependent variable: Access to CL			
	(1)	(2)	(3)	(4)
Low operating profits	-1.168***	-0.769***	-0.769***	-0.771***
	(0.170)	(0.173)	(0.173)	(0.187)
Cash holdings		-0.701***	-0.701***	-0.562***
		(0.152)	(0.152)	(0.153)
Size	0.493***	0.464***	0.464***	0.511***
	(0.035)	(0.036)	(0.036)	(0.039)
Market-to-Book	-0.026	0.050**	0.050**	0.044*
	(0.019)	(0.024)	(0.024)	(0.024)
Observations	1,733	1,733	1,733	1,733
Industry FE	No	No	No	Yes

Panel B. CL borrowers in Group 1A, 1B, and 2 with firms without CL in Group 3, Table II Panel B

	Dependent variable: Access to CL			
	(1)	(2)	(3)	(4)
Low operating profits	-1.170***	-1.009***	-1.009***	-0.950***
	(0.159)	(0.185)	(0.185)	(0.193)
Cash holdings		-1.586*	-1.586*	-1.507
		(0.875)	(0.875)	(0.922)
Size	0.657***	0.651***	0.651***	0.643***
	(0.049)	(0.049)	(0.049)	(0.051)
Market-to-Book	-0.025	0.019	0.019	0.021
	(0.031)	(0.024)	(0.024)	(0.024)
Observations	1,503	1,503	1,503	1,503
Industry FE	No	No	No	Yes

Table VII. Firms above the internal liquidity reference: operating profit volatility

This table reports test results on the relationship between credit line access and operating profit volatility. The dependent variable *Access to CL* is a dummy, whose value is equal to one for CL borrowers in Group 1A, 1B, and 2 in Table II, or zero for firms without credit line access records from 1995-2007 in Group 3. Independent variables are *Internal liquidity =(CHE+OIBDP)/(AT–CHE), Size =Log(AT–CHE), Market-to-Book =(AT–BE+PRCC_F*CSHO–CHE)/(AT–CHE), operating profits =OIBDP/(AT–CHE), and Cash holdings =CHE/(AT–CHE)* and operating profit volatility which is measured as the standard deviation of operating profits of a firm over the past 10 years (1995-2004). As we require at least 8 data points to calculate a firm's operating profit volatility, 437 firms from above the sample median drop out. Firms with non-cash assets lower than $1 million are dropped. All independent variables are averaged for each firm in 2002-2004 and winsorized at 2.5% on both sides. Firms with non-cash assets smaller than $1 million are dropped. All tests are cross-sectional at the firm level. Regressions report the robust standard error in the parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A

	(1)	(2)	(3)	(4)
	Dependent Variable: Access to CL			
Internal liquidity	-1.487***	-0.689***	-0.945***	-0.743***
	(0.199)	(0.168)	(0.180)	(0.183)
operating profit volatility		-0.988**	-1.404***	-1.258***
		(0.455)	(0.459)	(0.452)
Size		0.527***	0.528***	0.569***
		(0.043)	(0.043)	(0.044)
Market-to-Book			0.096***	0.081***
			(0.028)	(0.028)
Observations	1,296	1,296	1,296	1,296
Industry FE	No	No	No	Yes

Panel B

	(1)	(2)	(3)	(4)
	Dependent Variable: Access to CL			
operating profits	0.181		-0.561	-0.324
	(0.443)		(0.373)	(0.361)
operating profit volatility	-1.507***	-0.810*	-1.043**	-0.881*
	(0.543)	(0.425)	(0.462)	(0.458)
Cash holdings		-1.019***	-1.126***	-0.916***
		(0.236)	(0.244)	(0.250)
Size	0.553***	0.517***	0.519***	0.561***
	(0.043)	(0.044)	(0.044)	(0.045)
Market-to-Book	0.006	0.104***	0.108***	0.096***
	(0.031)	(0.034)	(0.032)	(0.033)
Observations	1,296	1,296	1,296	1,296
Industry FE	No	No	No	Yes

Table VIII. Ranking of liquidity sources in 10-K for regular borrowers during the crisis period

This table reports a summary of liquidity source ranking collected from firms' 10-Ks. By reading 10-Ks in 2008 and 2009 for 655 regular credit line borrowers, we identify six popular liquidity sources. They are internal liquidity, cash holdings or operating profits, lines of credit, commercial papers, debt issuance, asset sales, and others. The rank is the sequence that liquidity sources are mentioned in each 10-K. We assume the first source is more important than the second, and so on. For example, if a company 10-K writes as follows: Our sources of liquidity are cash and operating profits, lines of credit, commercial papers, and debt issuance. For this company, internal liquidity is rank 1, lines of credit rank 2, commercial papers rank 3, and debt issuance rank 4. The number "835" refers to 835 firm-year 10-K filings that have mentioned cash or operating profits as their source of liquidity, of which 829 10-Ks are in rank 1. In 4 10-Ks, it is rank 2, and in 2 10-Ks as rank 3. The Weighted Average Rank is defined as $\frac{\sum_{i=1}^{6} \text{Rank}_i + number \text{ of firms } i}{\sum_{i=1}^{6} \text{ number of firms}_i}$. The sample period covers the year 2008 and year 2009.

Source and rank of liquidity							
Internal liquidity, cash holdings or operating profits							
Rank		1	2	3	4	5	6
Number of firm-year	835	829	4	2	0	0	0
Weighted Average Rank				1.01			
Lines of credit							
Rank		1	2	3	4	5	6
Number of firm-year	788	9	701	71	7	0	0
Weighted Average Rank				2.1			
Commercial papers							
Rank		1	2	3	4	5	6
Number of firm-year	115	0	55	59	1	0	0
Weighted Average Rank				2.53			
Debt issuance							
Rank		1	2	3	4	5	6
Number of firm-year	53	0	9	29	15	0	0
Weighted Average Rank				3.11			
Asset sales							
Rank		1	2	3	4	5	6
Number of firm-year	24	0	5	14	3	2	0
Weighted Average Rank				3.08			
Others							
Rank		1	2	3	4	5	6
Number of firm-year	57	0	25	20	12	0	0
Weighted Average Rank				2.77			

Table IX. Drawdown in crisis, regular borrowers, above the internal liquidity reference

This table reports regression results on the relationship between access to credit lines and total liquidity during the two-year crisis period. The sample includes regular credit line borrowers in Table II Panel A Group 1A and Group 3 above the internal liquidity reference. The dependent variable in Panel A is *Total liquidity I =(CHE + OIBDP+ drawdown CL)/(AT-CHE)*, and the dependent variable in Panel B is *Total liquidity II=(CHE+OIBDP + total CL)/(AT-CHE)*. The total CL and drawdown CL are collected from 10-Ks in 2008 and 2009. For firms in Group 3 without credit line access, the total CL and drawdown CL are equal to zero. The key independent variable Access to CL is a dummy variable equal to one for firms that are regular CL borrowers in Group 1A, or zero for firms in Group 3. Control variables are *Size =Log(AT–CHE), and Market-to-Book =(AT–BE+PRCC_F*CSHO–CHE)/(AT–CHE)*. Firms with non-cash assets smaller than $1 million are dropped. All variables are averaged for each firm in 2008-2009. All regressions use the robust standard error. Standard errors are reported in the parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Total Liquidity I

	Dependent variable: Total liquidity I			
	(1)	(2)	(3)	(4)
Access to CL	-0.349***	-0.114**	-0.131***	-0.024
	(0.036)	(0.047)	(0.044)	(0.082)
Size		-0.062***	-0.040***	-0.032***
		(0.014)	(0.013)	(0.012)
Market-to-Book			0.051***	0.045***
			(0.013)	(0.007)
Observations	1,208	1,208	1,208	1,208
Adj R-squared	0.020	0.042	0.087	0.137
Industry FE	No	No	No	Yes

Panel B. Total Liquidity II

	Dependent variable: Total liquidity II			
	(1)	(2)	(3)	(4)
Access to CL	-0.208***	0.037	0.020	0.126**
	(0.038)	(0.048)	(0.045)	(0.050)
Size		-0.064***	-0.042***	-0.034***
		(0.014)	(0.013)	(0.013)
Market-to-Book			0.051***	0.046***
			(0.014)	(0.014)
Observations	1,208	1,208	1,208	1,208
Adj, R-squared	0.007	0.030	0.077	0.126
Industry FE	No	No	No	Yes

Table X. Drawdown in crisis, regular borrowers, below the internal liquidity reference

This table reports regression results on the relationship between access to credit lines and total liquidity during the two-year crisis period. The sample includes regular credit line borrowers in Table II Panel B Group 1A and Group 3 below the internal liquidity reference. The dependent variable in Panel A is *Total liquidity I =(CHE + OIBDP+ drawdown CL)/(AT-CHE)*, and the dependent variable in Panel B is *Total liquidity II=(CHE+OIBDP + total CL)/(AT-CHE)*. The total CL and drawdown CL are collected from 10-Ks in 2008 and 2009. For firms in Group 3 without credit line access, the total CL and drawdown CL are equal to zero. The key independent variable Access to CL is a dummy variable equal to one for firms that are regular CL borrowers in Group 1A, or zero for firms in Group 3. Control variables are *Size =Log(AT–CHE), and Market-to-Book =(AT–BE+PRC_F*CSHO–CHE)/(AT–CHE)*. Firms with non-cash assets smaller than $1 million are dropped. All variables are averaged for each firm in 2008-2009. All regressions use the robust standard error. Standard errors are reported in the parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Total Liquidity I

	Dependent variable: Total liquidity I			
	(1)	(2)	(3)	(4)
Access to CL	0.254***	-0.147***	-0.040	-0.033
	(0.025)	(0.041)	(0.034)	(0.059)
Size		0.085***	0.044***	0.052***
		(0.011)	(0.009)	(0.010)
Market-to-Book			-0.047***	-0.050***
			(0.011)	(0.005)
Observations	1,025	1,025	1,025	1,025
Adj R-squared	0.034	0.104	0.188	0.209
Industry FE	No	No	No	Yes

Panel B. Total Liquidity II

	Dependent variable: Total liquidity II			
	(1)	(2)	(3)	(4)
Access to CL	0.383***	-0.003	0.106***	0.111***
	(0.026)	(0.042)	(0.035)	(0.035)
Size		0.082***	0.040***	0.047***
		(0.011)	(0.009)	(0.009)
Market-to-Book			-0.047***	-0.050***
			(0.011)	(0.010)
Observations	1,025	1,025	1,025	1,025
Adj, R-squared	0.073	0.134	0.216	0.235
Industry FE	No	No	No	Yes

Table XI. Drawdown in crisis, regular borrowers, above or below the internal liquidity reference

This table reports regression results on the relationship between CL drawdown and internal liquidity for regular borrowers during the two-year crisis period. The sample includes the regular credit line borrowers in Table II Panel A Group 1A and Panel B Group 1B. The dependent variable is *CL Drawdown =(Drawdown CL)/(AT-CHE)*. The drawdown CL is collected from 10-Ks in 2008 and 2009. The key independent variable *Above liquidity reference* is a dummy which is equal to one if a regular borrower is in the bucket of above the internal liquidity reference or zero otherwise. Control variables are *Size =Log(AT–CHE), and Market-to-Book =(AT–BE+PRC_F*CSHO–CHE)/(AT–CHE)*. Firms with non-cash assets smaller than $1 million are dropped. All variables are averaged for each firm in 2008-2009. All regressions use the robust standard error. Standard errors are reported in the parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	Dependent variable: CL Drawdown			
	(1)	(2)	(3)	(4)
Above liquidity reference	-0.013***	-0.013***	-0.013***	-0.013***
	(0.004)	(0.004)	(0.004)	(0.004)
Size		-0.017***	-0.017***	-0.018***
		(0.001)	(0.001)	(0.001)
Market-to-Book			0.001	0.003
			(0.003)	(0.003)
Observations	422	422	422	422
Adj R-squared	0.025	0.267	0.268	0.314
Industry FE	No	No	No	Yes

Appendices

A Great innovations with profit heterogeneity

We use two examples of Apple and 23andMe to demonstrate the main stylized facts of entrepreneurs: great innovations with heterogeneous profits. In the Merriam-Webster Unabridged dictionary, an entrepreneur is the *organizer* of an economic venture, especially one who organizes, owns, manages, and assumes the risks of a business. In this study, the corporate identity of Apple is the "entrepreneur" of Apple Inc. (formerly Apple Computer). In this study, we mention Steve Jobs and Tim Cook to link different products of Apple. Likewise, gender has zero input on entrepreneurs in this study.

As a partnership company, Apple was founded on April 1, 1976, by Stephen G. Wozniak with a 45% stake, Steven Paul Jobs with a 45% stake, and Ronald Wayne with a 10% stake[10]. The inaugural product was the Apple I, released in July 1976. To finance the costs of producing the Apple I, Wozniak sold his HP-65 calculator and Jobs sold his Volkswagen minibus. The Apple I was priced at $666.66, and the sales number in 1976 was 200 units.

On January 3, 1977, Apple Inc. was incorporated under Mike Markkula's guidance, with a personal funding of $\$80,000 - 92,000$ and a $\$170,000 - \$250,000$ line of credit from Bank of America. The Apple II was released in April 1977 with a base price of $1,298 with millions of units sold in the next decade.

Apple Computer went public (IPO) on December 12, 1980. The product line of Macintosh was released in 1984. In the first quarter of 2025, Apple's Mac product line generated around $9 billion in revenue.

23andMe Holding Co. was founded in 2006 by two entrepreneurs and a businessman[11]. The company is best known for its genetic testing service directly to consumers. *Time* magazine

[10] Apple Inc. by Britannica; Mike Markkula by Wikipedia.
[11] 23andMe by Wikipedia; Reuters: 23andMe's journey from DNA testing pioneer to bankruptcy

named the product “Invention of the Year" in 2008. From 2007 to 2020, the company has raised $850 million through F series venture capital funding.

The company went public through a merger with a special purpose acquisition company (SPAC) in a $3.5 billion deal in June 2021. After the IPO, the company achieved a market capitalization of $6 billion. However, the company’s valuation fell to 2% of its peak in 2024. In March 2025, the company filed for Chapter 11 bankruptcy.

Here is the similarity between the two. Both entrepreneurs are great in terms of innovation. Profits are the main difference. Apple can constantly generate profits through project replacements. However, 23andMe was unable to generate profits.

However, the bankruptcy of 23andMe has shown an example of the missing dots between innovation and profits. 23andMe is not unusual. The competition of videotape format between Sony’s Betamax and JVC’s VHS was an example in the 1970s and 80s.

B Choosing a higher return project may be counterproductive to the long-term growth

Apple and Compaq are innovators in technology. However, different business strategies set growth apart in the period 1983 to 1999 and after. By legally cloning the IBM PC, Compaq became the first successful IBM-compatible PC maker. Compaq’s strategy is an example of Romer (1986) to explain economic growth contrary to the neoclassical approach; knowledge is characterized as a nonrival, partially excludable good.

During the same period, Apple has been persistent in building a closed system with its own hardware and software. The Apple strategy is an example of endogenous growth in Romer (1990). The creation of knowledge by Apple creates a stage of imperfect competition in which Apple can earn monopoly profits.

Although both companies reported significant growth after the IPO, Compaq was in an

advantageous position before 2000. In 1983, Compaq became the youngest company to make the Fortune 500 list. Compaq's stock prices were much higher than Apple's stock prices from 1990 to 1999. However, the growth of the two companies changes after 2000. Compaq was acquired by Hewlett-Packard in 2002. Apple has achieved significant growth since 2007 in its iPhone projects.

C Profit continuity determines an entrepreneur's lifespan

The apple's growth model features a progressive growth of product lines. Start with the first small project. With successful sales revenue, an entrepreneur can invest in a second, larger project that requires more investment. Such iterative operations are exactly how Apple Inc. has grown its product lines. Of the Macintosh product family, the Macintosh LC is a low-cost entry-level Macintosh family personal computer for education and home markets. Its lifespan was from 1990 to 1997. Power Macintosh is Apple's main workstation family with an emphasis on performance. The product lifespan is from March 1994 to August 2006.

The first mobile phone by Nokia was the Mobira Senator car phone in 1982[12]. Lumia 920 is the last Windows Phone developed and sold by Nokia, and the company is in financial losses. Selling the mobile and device division to Microsoft helps Nokia avoid a cash crisis. Therefore, I will be the last product number for Lumia 920. The tenor of Lumia 920 as a product is from 2012 to 2014[13], $m_I = 2$ years. The lifespan of Nokia as a mobile phone entrepreneur is from 1982 to 2014. $T_I = 32$ years.

[12] Nokia
[13] Nokia Lumia 920

D 10-K questionnaire for liquidity on regular borrowers of lines of credit

We design a six-question questionnaire. The questions are about corporate liquidity, including internal liquidity and lines of credit. We survey 10-Ks for 655 regular borrowers of lines of credit in the years 2008 and 2009. Sample answers that we have collected are summarized below.

[1] What are the top sources of liquidity for your company?

(a) Operation cash, cash on hand, or marketable securities.

(b) Revolving lines of credit

(c) Commercial paper.

(d) (Long-term) Debt issuance.

(e) Asset sales.

(f) Other.

[2] How would you describe your company's overall liquidity condition in 2008/2009?

(a) Some sample wordings for sufficient liquidity are "sufficient" or "adequate liquidity" or "liquidity could satisfy investment needs" or "we are comfortable with our ability to finance our operation . . . ".

(b) Some sample wordings for constrained liquidity are "negatively affected", "insufficient", "put significant pressure on liquidity".

[3] Did you find it difficult to access external credit markets in 2008/2009?

(a) Some sample wordings for not difficult to access external credit are "not materially impacted", "sufficient borrowing capacity".

(b) ome sample wordings for difficult to access external credit are "Because the current market for A3 commercial paper is very limited, it would be very difficult to rely on the use of this market as a meaningful source of liquidity."

[4] Did the major negative shock to your business come from the supply side or demand side?

(a) Some sample wordings for supply shock are that the insufficient liquidity is caused by "bank failure".

(b) Some sample wordings for demand shocks, "executing strategic "trough" plans", "reducing planned capital expenditures". We code a supply shock if the problem is because banks cut lending. It is a demand shock if the borrowers reduce borrowing activities because of their own problems or lower-than-expected business opportunities.

[5] Did your company have specific relationship bank(s) that was(were) in trouble? If so, did you search for a replacement?

[6] What is your company's total lines of credit? How much did your company draw down?

(a) We follow total credit line = drawdown credit line + undrawn credit line.

(b) In case that any two of the three numbers are available in 10-K, we calculate the third one.