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Technology, the Nature of Information, and FinTech Marketplace Lending

J. Christina Wang

Abstract:

The retail lending landscape has changed considerably over the past two decades, the most recent example being the rapid growth of online, or FinTech, lending to consumers and small businesses. This paper discusses how the boundary of the firm in the retail lending market is affected by advances in information technology that have turned what was previously soft information on borrower credit risk into encoded hard data that can be precisely transmitted across firms at a very low cost. The ability to collect and process information has become the critical resource for lending decisions, enabling entities with an advantage in producing information, such as technology firms, to compete in traditional retail lending activities. Efficiency can also be gained by relying more on hard data and firm specialization in a credit supply chain. Whether these changes favor hierarchical large banks or small start-up firms depends on their relative funding cost. In the aftermath of the financial crisis, an increase in banks' capital costs due to enhanced regulation is likely an important factor behind the faster growth of the new FinTech entrants. The need for funding to make loans means that the socially desirable objective of avoiding excessive credit contraction during economic downturns is better served in the current system by traditional banks, owing to their access to deposit insurance and the liquidity provided by the Federal Reserve. In sum, for the foreseeable future, banks will coexist as well as partner with FinTech lenders in the retail lending market. Banks' market share in loans to consumers and small businesses will likely fluctuate countercyclically.

JEL Classifications: G23, G12, G18, D24

Keywords: online marketplace lending, FinTech, soft and hard information, information technology, boundary of the firm

J. Christina Wang is a senior economist and policy advisor in the research department at the Federal Reserve Bank of Boston. Her email address is christina.wang@bos.frb.org.

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I. Introduction

Over the past two decades or so, the landscape of retail credit markets, especially for consumer loans, has evolved markedly. One notable aspect is that the volume and nature of information—in particular how it is produced, transmitted, and used—have changed profoundly. These changes are powered by advances in information and communication technology (IT). Information about borrower risk used to be "soft," meaning that it was often informal knowledge and mostly gleaned by loan officers through direct interactions with borrowers. But now the majority of such information, especially about individuals, has been digitized into hard data—numerical variables with fairly standard definitions—that can be accurately shared across agents, including across firm boundaries, at little cost.

The IT revolution over the 1980s and the 1990s has likely played a role in increasing the market share of large firms, which are more efficient at processing hard information (Stein 2002).[1] The IT-enabled lower relative cost of producing hard versus soft information can also affect the boundary of the firm (vis-à-vis the market), since a firm's communication with the market or other firms is subject to similar frictions, and thus can also benefit from the fall in the relative cost of obtaining hard information.

Specifically in the retail market for consumer lending, the process of creating and funding loans can be carried out by separate financial firms, with some specializing in originating or servicing loans, others specializing in the provision of funds, and these firms transacting via contracts to assemble a complete lending process.[2] This process is a form of a supply chain. Alternatively, these separate functions can all be carried out by a single bank, as in the traditional model of consumer lending. In fact, one can think of a bank as consisting of separate divisions that specialize in processing information or

[1] Stein (2002) shows that large, more hierarchical, firms can improve the efficiency of resource allocation with hard information more than can small firms. Stein (2002) recognizes, but does not analyze, how the change in the relative information cost can change firm boundaries.

[2] This process of different firms working to assemble a loan essentially describes how US households obtain mortgages to purchase homes.

raising funds (as modeled in Wang 2003a). Then the question boils down to what distinguishes interactions across divisions inside a firm from those across the firm's boundary. When information is hard, a non-integrated supply chain enabled by firms specializing in separate aspects of the lending process is likely to be more efficient than a single integrated traditional bank if the new entrants are better at applying new technology, all else being equal.[3] Importantly, when information is hard, the firm's mode of operation becomes a strategic choice. A company with internally produced hard data that enable it to more accurately assess borrowers' credit risk will choose the integrated lending model if the firm profits more from keeping its hard information proprietary.

This logic likely explains why, around 2007, a number of start-up firms emerged to provide the information services needed for lending to consumers and small businesses, while outside investors provided the funding. These new entrants to the retail credit market are referred to as online, marketplace, digital, or peer-to-peer (P2P) lenders. Each term emphasizes a particular aspect or phase of this new lending technology. These firms are collectively named FinTech lenders because they constitute an important category within the so-called FinTech industry, loosely defined as start-ups using more advanced applications of IT to provide financial services. These FinTech lenders share some common features: they develop online platforms for prospective borrowers to apply for loans and for (individual and institutional) investors to invest quickly and easily, and also develop algorithms that use mostly digitized data to swiftly process loan applications, matching credit demand (from borrowers) with supply (from investors). Most FinTech lenders also service the loans they originate.

It can be argued that the entry of new specialized firms into consumer loan markets had been delayed, even though the IT revolution made such entry technologically feasible beginning in the late 1990s. The reason is that banks used to

[3] This advantage can be further strengthened if we allow specialization to engender efficiency gains. Stein (2002), in contrast, concludes that an integrated firm is still favored because the firm's CEO is assumed to be better informed than market investors about each project's prospects, but this assumption seems at best weakly applicable to the market for retail consumer loans.

enjoy a competitive advantage in the cost of funds, the other key input into lending, owing to explicit and implicit government guarantees. Banks' lower funding cost used to more than offset their higher operational cost, discouraging entry of FinTech lenders. At the same time, large banks took advantage of IT advances and deregulation prior to the 2008 financial crisis to gain market share over small banks. Yet in segments of the consumer lending market where banks lack a funding cost advantage, such as the market for conforming residential mortgages given the presence of Fannie Mae and Freddie Mac, independent mortgage brokers had gained a noticeable market share in originations through the mid-2000s (as documented, for example, in Kim et al. 2018).

This same logic that underlies the evolution of mortgage lending can explain why a model of non-integrated operations is finally gaining prominence in the retail lending market in the post-crisis era: the 2008 financial crisis inflicted damage to bank capital which, combined with the enhanced capital requirements imposed on the largest banks, seriously eroded their funding cost advantage. Another factor that reduced banks' funding advantage in the decade since the 2008 financial crisis is the extended period of low interest rates. Banks, especially the largest ones, used to be able to pay deposit rates lower than maturity-matched Treasury yields, but the zero lower bound on nominal interest rates materially narrowed the deposit rate spread that banks can impose. Banks can expect to recover this spread somewhat as the Federal Reserve continues to raise the policy rate commensurate with the booming economy, although the equilibrium level of interest rates is expected to be lower than in the past.

This study seeks to shed light on the evolution of newer organizational forms in the consumer lending industry, with a focus on why stand-alone FinTech providers have emerged as major players only over the past five to ten years, even though the relevant technology became largely available by the early 2000s. In terms of this study's emphasis on information, it is most closely related to the analysis by Liberti and Petersen (2018), who offer an excellent review of the implications of the changing nature of information on the internal organization of banks. However, Liberti and Petersen (2018) only briefly mention the possibility of "moving decisions outside the traditional

boundaries of organization," an example of which is the development of online marketplace lenders. The subject under consideration in this paper is broader by comparison: what changes in the nature of the information used for lending decisions imply about the configuration of lending activity across financial firms more generally, which now extends beyond the hierarchy inside a traditional bank. Hence, this study uses FinTech lending as a case study to elucidate the technical nature of information production by financial intermediaries—what is the input, what is the output, and what is the nature of the transformation—and how advances in IT alter all three aspects of the production function. The study then considers how changes in the possibility frontier of hard versus soft information, interacting with the relative cost of funds faced by different types of financial firms, can alter the boundary of the financial firm, and what might be the resulting long-term implications for financial stability.

Unlike many existing studies, this study places more emphasis on the similarity between financial intermediaries and nonfinancial IT firms in terms of the production of data and services. This perspective has meaningful implications for making projections about future developments in retail credit markets. For instance, technology firms with expertise in collecting and processing information by running an e-commerce platform (such as Amazon) or a social media platform (such as Facebook) are more likely to be successful entrants into the credit market for consumers and small businesses if regulators allow such entry in the future.

The remainder of this study is organized as follows. Section II reviews the common patterns of online lending, largely analyzed through the theory of information production and the boundary of the firm, focusing on the activities and incentives of different parties. Section III discusses the legal and regulatory issues surrounding online lending and potential policy implications. Section IV concludes.

II. Online Marketplace Lending and Information Production

This section briefly describes the operation of online marketplace lending and its development over the past decade or so. This is not meant to be a broad survey of the

FinTech lending industry, just a discussion to highlight the empirical facts most pertinent for understanding how IT and the resulting changes in the nature of information influence the boundaries of firms operating in this market.[4] In distilling the common features of online lending, I first compare them with the digital operation of typical marketplace operators such as Amazon. Next, I compare online lenders with banks, highlighting three aspects that shape the comparative advantage of digital lending over the traditional bank lending model: 1) an operation that is principally powered by IT, 2) the mechanisms employed to assess borrowers' risk and promote equitable access to information, and 3) the funding model, which also helps provide the right incentives and satisfy investors' demand for financial claims with different attributes (such as whole loans versus structured products). Most of the discussion pertains to unsecured consumer installment loans made by US online lenders, which is the loan type with the longest history and still accounts for the highest share among online loans. Small business loans and foreign online lenders are covered briefly when they offer better examples for certain issues.

II.1 Rapid Growth of Online Marketplace Lending over the Past Decade

Online marketplace lending has grown rapidly in its first decade since its inception around 2007, although FinTech firms still account for only a minor share of the total balance of consumer loans outstanding.[5] These two facts together lead some to predict slower, but still robust, growth in online lending to continue for some years to come.[6] Figure 1 plots the total volume of originations by the top dozen or so online lenders.[7] It is clear that lenders specializing in consumer loans, the top two of which in

[4] The US Treasury (2016) and Morse (2015), for instance, provide more general reviews.

[5] Adams et al. (2017) report, using survey data, that only 25 percent of US consumers are aware of online lenders and only about 11 percent have ever applied for an online loan.

[6] For example, Turner's 2017 report on the Digital Lending Landscape, issued by S&P Global, projects that personal-focused lending will grow at an annual rate of 12.4 percent, and small business lending will grow at an annual rate of 21.5 percent by 2021.

[7] There are little official data on online lending. Most of available data are somewhat ad hoc and largely cover originations. Data on outstanding balances are more limited, especially for the marketplace lenders. This is hardly surprising since they do not retain exposure to the loans.

the United States are Lending Club and Prosper, dominate the volume.[8] According to TransUnion, online lenders' share in unsecured personal loan originations rose from just 1 percent in 2010 to nearly a third in 2017:Q2.[9] To the extent that FinTech firms consider their products to compete most directly with credit card loans, their market share is less than 3 percent of the sum of credit cards and personal installment loans outstanding, as reported in the Financial Accounts of the United States.[10]

Fixed-rate unsecured consumer installment loans (often referred to as personal loans) were the first product offered by online lenders. This type of loan still accounts for the bulk of online lending. Consumers use personal loans for a large number of purposes, the top two of which are debt consolidation and paying off credit cards. These two purposes account for 60 to 80 percent of the loan balance, according to borrowers' self-reported purposes from Lending Club, as shown in Figure 2.[11] The rest of the loan balances are used to finance home improvements, major purchases (appliances, vehicles, and so on), weddings, vacations, education, small businesses, and more. Online consumer loans for more specific and verified purposes have also emerged. Chief among these in terms of volume and growth are loans to consolidate or refinance student debt, dominated by SoFi, which reached up to 6 percent of total originations by 2016.[12] Student loan refinancing is a market segment where private lenders can easily target the

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[8] A very small fraction of borrowers of online personal loans state their purpose as business; on average these account for no more than 2 percent in the case of Lending Club for example.

[9] See https://www.transunion.com/blog/fact-or-fiction-are-fintechs-different-than-other-lenders. Earlier TransUnion data show that FinTech lenders had already reached nearly a one-third share in 2015.

[10] Assuming Lending Club's share is the same in originations as in outstanding balances, total online personal loans outstanding as of 2017:Q4 is estimated to be under $7 billion, while the outstanding balance of credit card debt and other consumer credit is just over $1 trillion and $200 billion, respectively. Behind installment loans, credit card debt is arguably the second closest substitute for online loans, as over 60 percent of Lending Club borrowers' stated purpose is to replace credit card debt.

[11] Debt consolidation is presumably broader than credit card debt. But applicants seem to treat these two purposes as interchangeable, likely because the distinction between them appears fuzzy, even according to the lender's website.

[12] Total student loan origination data are from the Consumer Finance Protection Bureau; the SoFi data are all loans, which include a small amount of mortgages since 2014, from https://lending-times.com/2017/10/04/sofis-ipo-will-the-time-ever-be-right/

best borrowers, as 90-plus percent of student loans after the financial crisis were originated by the federal government (the College Board), which for each loan program sets a uniform interest rate that is unrelated to an individual borrower's credit risk. Online lenders' cost advantage enables them to offer high-quality borrowers better terms than those offered on their government loans.

It should be noted that online lending is no longer solely the domain of startup firms. Marcus, a recent FinTech entrant, is owned by Goldman Sachs, a large established financial firm. Compared with the major earlier entrants to online lending, Marcus has grown more rapidly: it reached $1 billion in origination volume within eight months of its launch in October 2016, compared with 65 and 98 months, respectively, for Lending Club and Prosper.[13] Marcus has likely benefited from Goldman Sachs's brand capital. Its product features also stand out: it charges no origination fee or late payment fee; Marcus gives borrowers the flexibility to choose any maturity between 36 and 72 months; it allows borrowers to skip one payment after 12 consecutive on-time monthly payments. In terms of the business fit, it can be argued that online consumer lending may be more suitable for established financial firms whose primary income source is investment banking (such as Goldman Sachs), since it would not cannibalize existing lending revenue sources, as would be the case for traditional commercial banks.

FinTech lenders have also made substantial inroads into small business loans (SBL). By the end of 2017, the two major US players in this market, OnDeck and Kabbage, have cumulatively extended over $8 billion and $4 billion to more than 80,000 and 130,000 small businesses, respectively.[14] This amount is still miniscule compared with the volume of SBL by banks: according to the regulatory filing (at the holding company level), the top 10 bank lenders to small businesses had over $120 billion of SBL outstanding at the end of 2017. So the growth potential for online lenders is promising.

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[13] https://www.lendacademy.com/consumer-lenders-1-billion-originations/

[14] Kabbage's statistics: http://www.prweb.com/releases/2017/12/prweb14975809.htm; OnDeck's statistics come from its 2017 Annual Report.

One important trend to note is that, over time, every FinTech lender that has grown in volume has also expanded its variety of product offerings in terms of the loan type as well as the features within each type (such as maturity and loan amount). For example, to help individuals pay medical and dental bills, Lending Club added Patient Solutions in 2007, which offers more maturity options than their standard personal loans. SoFi offers loans to parents to finance their children's education. The major personal loan lenders have also started to offer auto loans and mortgage loans (Lending Club and Sofi, respectively). The greater presence of established nonbank lenders in the markets for auto loans and mortgages is likely a main reason for the delayed entry by FinTech lenders. These firms have even expanded beyond credit products to become a one-stop shop for all personal finance needs. SoFi, for instance, offers term insurance and wealth management. In the other direction, payment processers, such as Square, may have a special advantage in entering lending, as they are able to deduct repayment from borrower sales directly, and the sales records offer valuable data. The nature of IT, especially the economies of scope in operating a digital marketplace, which confers FinTech lenders' key technical advantage, likely makes this trend of one-stop shopping inevitable.

II.2 What Makes Online Marketplace Lenders Special among Online Marketplace Operators?

Among the features that are common to all online lending operations, the foremost is probably that all operate an online platform, where most of the customer-facing transactions are conducted, obviating the need for brick-and-mortar retail offices. Prospective borrowers can use the platform to check relevant information and apply for credit. For most lenders, the platform is also where investors select the loans in which they want to invest. This is likely why these firms are referred to as "marketplace" lenders: they operate a digital market that brings together buyers and sellers (of a financial product). During the first few years of operation, the two earliest US lenders, Prosper and Lending Club, used their platforms mostly to facilitate individuals lending to individuals; the two lenders thus are often referred to as P2P lenders. Nowadays,

most funding comes from institutional investors and wealthy individuals, as will be discussed further later.

Online marketplaces are made possible by an extensive IT infrastructure in the background: equipment (hardware and software) and technology (including standards and protocols) that collect and digitize the relevant information, and then store, process, and transmit the generated data.[15] In providing a virtual marketplace that connects buyers and sellers, and thus reduces search costs, online lenders are similar to the typical e-commerce firms such as Amazon or eBay. There are some minor differences: there is no direct matching and thus no relationship between individual borrowers and lenders, unlike the purchases facilitated by e-commerce firms; FinTech lenders only rate borrowers, since they are the only side of the trade that can default on the contract.[16]

The need to comply with financial regulations clearly distinguishes online lenders from standard marketplace firms such as eBay, and this requirement will be discussed at length in Section III. Another feature that sets online lenders apart from eBay and the like is the IT-powered algorithm used to assess credit risk. As has been well-established in economics research (see, for example, Diamond 1984), mitigating the information asymmetry between borrowers and investors (that is, borrowers know more about their financial situation, and hence credit risk, than investors) is a key function of financial intermediaries.[17] To this end, online lenders use their model of risk evaluation to first decide whether to list an application, and then assign a credit grade to each application to be listed. At any point in time, the risk rating fully determines the loan's interest rate (price), although the interest rate for a given rating changes over time. The interest rate is then posted along with the loan amount being sought. Investors then

[15] Oliner and Sichel (2000) provide an overview of how the increasing presence of IT in the economy explains the growth acceleration in the late 1990s. Brynjolfsson and Hitt (2000) present evidence that IT has enabled considerable innovations in products and services, as surveys and case studies show that the most important reasons for investing in IT are product quality improvements, notably customer service, timeliness, and convenience.

[16] Individual investors, who constituted a larger share of the investor base before 2010, used to be able to pose questions to specific applicants under the auction format run by Prosper.

[17] Pioneer studies include Leland and Pyle (1977) and Diamond (1984).

select the loans and the amount they want to fund.

To verify an applicant's identity and then evaluate her creditworthiness, online lenders can draw on an existing extensive infrastructure of consumer data. First, these lenders make use of government and bank data in the critical but fairly uniform process of identity verification: all applicants must first register with a platform, providing proof of US citizenship or legal residence status, a social security number, proof of being at least 18 years old and having a valid bank account. After establishing a user's identity, online consumer lenders (especially the major ones that mostly lend to prime borrowers) rely heavily on the credit bureau data to assess credit risk.[18] This data system, exemplified by the three credit bureaus and credit scores, became widely adopted in the United States by the mid-1990s. For example, in 1995 Fannie Mae and Freddie Mac recommended the FICO credit score for use in mortgage lending.

Given the breadth and depth of the credit bureau data, it is not surprising that the online lenders relied almost entirely on credit bureau data early on in developing their credit rating technology. Lending Club, for example, appears to have only used the credit bureau data to form a borrower's base credit grade until at least late 2012. Exhibit 1 in the Appendix presents the risk scoring rules that Lending Club posted on October 20, 2012. An applicant's credit score determines her initial credit grade, which is then adjusted up or (mostly) down by several other indicators (such as her revolving credit utilization rate). For every indicator, there is a threshold beyond which an application is declined, while some cutoffs combine two indicators. These rules are largely verified using Lending Club's data: Figure 3 shows a small absolute difference (of one subgrade on average, out of a total of 35 subgrades) between the actual subgrade and the one replicated using the rules posted publicly from April 2011 to November 2012. Lending Club clearly switched to different scoring models since late 2012 (as can be seen in Figure 3), the performance of which kept improving over the years. As shown in Figure

[18] These data include some version of a credit score along with the underlying data used to estimate the score—mainly payment history on credit products, length of credit history, utilization rate on credit lines, number and type of accounts, and recent credit inquiries.

4, the borrowers' risk subgrade became increasingly accurate as a measure of the relative credit risk, as evidenced by its rising and now high correlation with the average ex post default loss rate.

Similarly, Prosper's earliest archived credit score model (from 2006) lists only credit bureau data, such as the number and balance of delinquent accounts, as inputs.[19] In a later 2009 post, Prosper even explicitly listed the coefficients of the logistic regression used to estimate the probability of a loan becoming 61-plus days past due (Exhibit 2 of the Appendix). Such explicit information is no longer available, although the number of delinquent accounts, recent inquiries, recently opened trade lines, and credit card utilization rate are still listed as the key inputs into the Prosper score model.[20]

In addition to an applicant's existing credit data, online lenders also use contract terms as a screening device, as this helps to reveal a borrower's private information about default probability. In its posted policy, Lending Club charged a higher interest rate on the longer-maturity loan (five-year versus three-year) by adjusting down a borrower's initial risk grade (see Exhibit 1 of the Appendix).[21] There is evidence that, conditional on the observed attributes, borrowers choosing the longer maturity are more likely to default (see Hertzberg, Liberman, and Paravisini 2017). By a similar logic, the interest rate is also weakly increasing in loan size (again see Exhibit 1 of the Appendix).[22]

Another practice that can be used to mitigate borrower risk is to allow borrowers who stated that the loan's purpose is to consolidate debt or pay down credit cards to have the loan proceeds sent directly to the intended existing lenders.[23] This is a

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[19] https://web.archive.org/web/20090506101713/http://www.prosper.com:80/help/topics/general-prosper_score.aspx

[20] https://www.prosper.com/plp/general-prosper_score/.

[21] Note that at a point in time, a borrower's risk subgrade fully decides her interest rate. So Lending Club must adjust a borrower's grade in order to charge her a higher rate. This then means that a five-year loan does not necessarily carry a higher interest rate than a three-year loan for a given risk subgrade eventually assigned, since the former is made to borrowers with safer observed attributes. The downward grade adjustments for a longer maturity ranged between four to eight subgrades.

[22] This is consistent with the costly state verification model of debt (as in Froot and Stein 1998).

[23] This is analogous to a balance transfer, which has long been offered by credit card lenders.

revelation mechanism: it gives borrowers who truly want to reduce their borrowing a way to credibly convey their intent and receive a lower interest rate, as their default risk is lower than it would have been otherwise. This practice is easy and inexpensive to implement with the existing payment system, which the lenders already use to send payments to and receive payments from borrowers and investors. It seems that more lenders (beyond Lending Club and banks Wells Fargo and Discover) will find it profitable to offer this service.

The credit bureau data clearly qualify as hard information—digital with fairly standard definitions. These data are also valuable to lenders because the information is accurate for the most part and is easily accessible to all (for a fee in general). The credit bureau data underscore an often implicit quality of what are defined as data: the information must be truthful. Variables that are inherently numeric but have dubious veracity cannot serve as data inputs for credit evaluation. As an example of digital data being excluded due to uncertain quality, Lending Club's risk grading rules posted during 2011 and 2012 (discussed above) made virtually no use of the few variables (income, employment status and length) supplied by the applicants themselves.[24] This example also underscores the limitations of credit bureau data: reliable hard data on income and employment already exist, but they are not readily available to lenders. Constraints on data access can be due to legal restrictions, but more often due to incompatible systems or firms' desire to profit from their proprietary data.

On the other hand, some information remains "soft" because it is still too costly to collect digitally. For instance, someone could miss a few loan payments because of large expenses due to a car accident, even though she is in fact responsible and tries her best to pay on time. Absent a long history of payment records, records of the accident

[24] This is despite the fact that, during that period, Lending Club verified the income source of 20 to 30 percent of the borrowers by contacting the employer, and verified the amount of income for 40 percent of the borrowers by requesting pay stubs, tax returns, or bank statements. Moreover, Lending Club warns in its member-notes prospectus (the current version can be found at https://www.lendingclub.com/legal/prospectus) that: "Investors should not rely on a borrower's stated employment or income, except when such income has been verified as indicated on the Loan details page, or on our ability to perform income and employment verifications."

and the repair would help make the correct inference about her true credit risk. Such information, or any quantifiable indicators deemed useful in predicting credit outcomes, will likely be digitized into hard data eventually. After all, the soft versus hard label depends on the available technology for handling information. Until then, however, established lenders still have an advantage over the new entrants in terms of information on their existing customers. This advantage, however, vanishes or even reverses regarding prospective new customers.

Intuitively, the smaller the sample (such as due to a short history), the greater the risk of a loss of context due to missing data adversely affecting the outcome of a loan application. For this reason, online lenders specializing in non-prime consumers or young individuals, who tend to have a limited formal credit history, purport to make greater use of unconventional or alternative sources of data to expand credit access to such consumers, who might otherwise be denied credit. LendUp, for example, supplements credit bureau data with data gleaned from social media, such as Facebook or LinkedIn profiles and posts, and Twitter feeds.[25] The obvious use is to mine hard data (with advanced methods such as machine learning models) from these sources to verify data supplied in a loan application, such as job title or employer.

The more advanced, and presumably more valuable, use of social media data lies in the soft indicators that may help lenders infer a potential borrower's "character."[26] There is no universal definition of character, but when making lending decisions, character is generally interpreted as a borrower's willingness to pay her debts, which would be reflected in her past payment records. It can be mapped to a borrower's type in game theory models, or the fixed effects in regression analysis. Modeled either way, character or reputation carries significant explanatory and predictive power for a borrower's credit performance. Social media data can help achieve a more precise inference of this underlying type to the extent that such data represent a large number of

[25] https://www.wsj.com/articles/borrowers-hit-socialmedia-hurdles-1389224469.

[26] The borrower attributes deemed relevant are often referred to as the four or five c's of credit: character, capacity, capital, conditions, and collateral. In the context of lending to businesses, see, for example, https://iupdate.dnb.com/iUpdate/whatAre4Cs.htm by Dun & Bradstreet.

indicators correlated to varying degrees with character.

Using statistical analysis of the soft indicators in social media data to replace subjective human assessment of qualities such as "responsible" or "honest" should in principle also reduce biases often embedded in human judgment. Several studies (Barasinska and Schäfer 2014; Gonzalez and Loureiro 2014; Pope and Sydnor 2011; and Ravina 2018) find that soft information such as a borrower's photo, which reveals gender, age, ethnicity, perceived attractiveness, and so on, influences some individual investors' lending decisions, but the loans' outcomes do not support their preference. [27]

In terms of the variety of data used to support lending decisions, small business loans are likely the category experiencing the most innovation. Online SBL lenders certainly require standard financial data in the form of balance sheets, income statements, tax returns, and bank accounts.[28] But, in addition, and in some cases, as substitutes, online lenders make use of novel data such as real-time data on borrowing firms' sales, payment, and online customer reviews.[29] Such data likely contain more and/or better forward-looking signals, which should improve the accuracy of performance predictions.[30]

Many such data are produced by technology firms such as Amazon and Google. These firms have amassed volumes of data on many activities by a large number of consumers and (small) businesses, not only as a natural by-product of their digital operations, but also due to their strategic recognition of data as a critical form of intangible capital. They also apply more powerful quantitative methods (such as

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[27] Liberti and Petersen (2018) discuss at length the nature of soft versus hard information and the role of human judgment in lending. Barberis and Thaler (2003) review a host of cognitive biases studied in behavioral economics, many of which influence even important financial decisions.

[28] FundingCircle, for instance. demands the two most recent years of business tax returns, one year of personal tax returns, etc.; see https://www.fundingcircle.com/us/about/support/.

[29] Jagtiani and Lemieux (2018) provide a more detailed account of the alternative data sources.

[30] The real-time nature of the data also allows more flexible repayments, often directly deducted as a fixed fraction of a borrower's monthly sales, which can be a valuable benefit to a new business when compared to the fixed monetary repayment of a standard debt contract. This feature is offered by advances from Square, for example, and is typical for merchant capital advances used to fund working capital.

machine learning models) to mine all these data. Technology firms, including FinTech firms, moreover, excel over the incumbent financial firms in delivering digital services with an intuitive interface, speed, security and functionality. All these make technology firms serious contenders for the retail lending business. Some have already entered the market. Amazon Lending, which launched in 2011, has made over $3 billion of loans to small businesses selling products on its platform. Amazon collects and uses real-time data on sales, customer ratings, and so on to assess each small business's prospects and credit risk. It then offers credit to those small firms deemed promising. Owing to its superior information, Amazon Lending likely offers better terms than what the firms could obtain from other lenders.[31]

Interestingly, some of these online SBL lenders emphasize the value of a "human touch" alongside data-driven models.[32] Under the assumption that humans are better at handling soft information, theories of financial intermediation suggest that a human touch can add value in at least two ways: 1) using soft signals at the screening stage to improve prediction accuracy in the absence of more detailed quantitative data ex ante, and 2) engendering reciprocity—an implicit sense of mutual obligation that tends to arise in human interactions (also discussed in Liberti and Petersen 2018)—to motivate borrowers to repay their loans. Whatever may be the exact mechanism, the human touch is unlikely to be the comparative advantage of online lenders as a whole, although some of them may use it as a dimension of product differentiation. On the other hand, online lenders may be better at using data-driven methods to assess the specific mechanisms through which the human touch confers a benefit on net; that is, the higher cost of human intervention is more than offset by a lower default rate than would exist absent the human interaction.

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[31] https://www.cnbc.com/2017/06/16/amazon-plans-to-crush-small-business-lending.html

[32] For example, FundingCircle stated that "We have numerous methods of building statistical models that guide our underwriting… Yet, we also understand the limitations of models in evaluating loans. This is where our team of experienced underwriters contribute their knowledge and bring the human touch that we consider so crucial to making sound credit decisions." See https://web.archive.org/web/20150606020730/https://www.fundingcircle.com/us/blog/2014/07/future-underwriting-will-algorithms-robots-replace-human-touch/

The various issues discussed above, taken together, argue for using care when developing artificial intelligence (AI) applications for credit underwriting. Foremost, it is clear that the AI system should not be built to exactly emulate how humans make decisions. Instead, biases afflicting the human decision-making process should be identified and corrected in the AI system. Second, it should also be recognized that some data inputs (such as a dearth of a past credit history) may be the result of past discrimination. Additional data and modeling should be explored to improve these applicants' prospects of accessing credit.

II.3 What Makes Online Marketplace Lenders Special Relative to Traditional Lenders?

One chief advantage that online lenders have over traditional lenders is the quality and the digital nature of their services, which deliver speed, ease of use, and convenience. The application form can be completed online in minutes, although lenders may later request additional documents to verify certain information submitted online (as discussed above). The digital format of the data also enables the use of statistical and machine learning methods to automate the assessment of applicants' credit risk, enabling the online lenders to make credit decisions mostly within 36 to 72 hours. The decision, and any other information that needs to be exchanged, can be transmitted instantaneously.

Marketplace lenders offer greater data transparency than traditional banks, that disclose neither information about their credit models nor loan-level data to investors. Early on, the major online lenders used to disclose even their (admittedly simple) credit scoring algorithms (as shown above), which are regarded as their "core competency" and would normally be kept secret. It is likely that when the lenders did not yet have a track record of good performance, transparency helped establish credibility, contributing on net positively to firm value. Moreover, since almost all the investors on these platforms early on were individuals, the lenders likely had little concern about investors cherry-picking loans based on the revealed algorithms. Over time, as the lenders established a record of competence, they stopped posting algorithms. They have

also reduced the amount of data that is revealed even to direct investors (for example, Lending Club removed 50 out of 100-plus variables in late 2014). This benefits the platforms, at least in the near term, by enhancing the value added of their rating service. In addition, as some studies have shown (such as Dang et al. 2013), full transparency may not be optimal for all purposes. So it remains an open question what degree of data transparency is optimal for these online lenders who rely on private investors for funding versus what is optimal for the society as a whole.

The digital nature of online lenders' operations lowers cost in multiple ways. Offering a platform for buyers and sellers to interact remotely on the Internet obviates the need for brick-and-mortar retail spaces. This lowers the entry barrier into retail lending, as a new online lender needs little upfront investment in structures. It also lowers the per period fixed cost of operation for online lenders relative to banks, which must maintain a branch network. While all lenders must spend to develop and maintain their IT systems (such as routinely updating software to prevent data loss due to cyber attacks), online lenders avoid the fixed cost of also having to maintain a legacy system.[33]

In addition to their lower fixed operating cost, online lenders' digital transactions also enjoy a near-zero marginal cost and start with a high degree of returns to scale. These lenders thus set fees in ways that encourage digital transactions, such as imposing a large fee on payments made by check instead of electronically (for example, $7 per check as listed in Lending Club's May 22, 2017 prospectus, versus $15 in 2014). The lower marginal cost enables online lenders to offer smaller loans than traditional lenders, as the per loan average processing cost falls rapidly with the higher origination volume. The low marginal processing cost also makes it economical for these lenders to encourage prospective demand by offering to treat the initial rate check as a soft inquiry, which has little or no adverse impact on the applicant's credit scores.[34]

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[33] Legacy systems generally mean they are built using the old IT (prior to the late 1990s). They can contain incompatible subsystems, and are costly to interface with new IT. According to Celent (2012), three-quarters of banks' technology budgets are spent on legacy system maintenance.

[34] On the other hand, online lenders also adopt (higher marginal cost) conventional marketing methods that have proved effective. In particular, they send a large volume of direct mail to pre-

The marginal cost of online lenders' digital operations is not only low but also fairly constant over the short run up to the system capacity. A flat marginal cost means that online lenders can quickly ramp up volume without needing to raise the origination fee, and vice versa. This suggests that if and when a secondary market develops for the loans by online lenders, the spread of the rate paid by borrowers over the secondary market rate will likely be insensitive to fluctuations in origination volume, unless only a few lenders remain, who are thus able to set rates at any profit-maximizing level.[35]

II.4 Mechanisms to Mitigate Information Asymmetry Among Investors

Akerlof's (1970) seminal work employs the example of the used car market to demonstrate that markets can break down when sellers have more knowledge than buyers—in the used-car market, sellers have better information about which cars are "lemons." This unequal knowledge is referred to as the asymmetric information problem, which is regarded as the raison d'être of financial intermediaries. However,, asymmetric information can also exist across agents on the same side of the market. Moreover, asymmetry can also stem from disparate abilities (including technology) to process information. Institutional or "accredited" investors (which generally include banks, finance companies, insurance companies, hedge funds, foundations, pension plans, university endowments and high-net-worth individuals) have an advantage over the average consumer who wants to invest, as the accredited investors have the resources and operational scale to support buying or developing IT systems to automate routine tasks, such as to spread the purchases across loans to achieve diversification, and

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screened consumers to try to attract applicants most likely to be approved. See, for example, https://www.cnbc.com/2018/06/27/loan-companies-are-pulling-out-all-the-stops-to-get-people-to-borrow-m.html.

[35] For comparison, Fuster et al. (2013) argue that capacity constraints likely played a major role in the widening of the primary-secondary mortgage rate spread during refinancing waves in the first few years after the financial crisis. Going forward, the rising share of FinTech mortgage originators suggests that the primary-secondary spread may well become less sensitive to (refinancing) volume, unless the market becomes sufficiently concentrated to allow strategic pricing.

more advanced risk rating and management.[36] Online lenders that serve both accredited and individual investors offer services to help make diversification easier for retail investors. Lending Club and Prosper both offer automated investing, meaning that the platform automatically picks loans following investors' pre-set criteria for a borrower's risk, maximum amount per loan, maximum debt-to-income ratio, and so on (see Lending Clubs's 2012 10-K for a discussion).[37]

In the context of online lending, the mechanism for price discovery can also affect the degrees of information asymmetry across investors. One mechanism, present early on in P2P lending (such as used by Prosper), is the auction format. Each borrower posted the maximum interest rate she was willing to accept and each investor listed the rate and amount she would fund each loan, or indicated the minimum rate she would accept for a specified category of risk. All investors had access to the same listing page. But more sophisticated investors are better equipped to make use of the information.

It should be noted that the P2P auction format is not consistent with the standard theory of financial intermediation. In the auction format, investors conduct much of the screening themselves, based on which they decide which loans to fund and at what interest rate. This effort is expended separately by every investor on each loan, which contradicts the standard theory of financial intermediation (such as Diamond 1984) that shows that screening and monitoring should be delegated to intermediaries. There are a few plausible explanations for the (brief) presence of the P2P format. First, a rational explanation is that the online platforms offer the lowest cost way for some individual investors to access this class of risky debt. There may not be alternative investment assets with sufficiently similar risk-return profiles before, or these individual investors

[36] Vallee and Zeng (2018) also make this point. The presence of multiple lending platforms that often provide data in inconsistent formats exacerbates the cross-investor inequality due to data processing capability. More generally, Dang et al. (2013) show that absolute symmetry can be achieved only with the absence of any information.

[37] In addition, investors can pay LendingRobot, a robo-advisor in the alternative lending space, to diversify their investment across platforms. Regarded as a case of inevitable consolidation as an industry matures, LendingRobot merged with competitor NSR in August 2017 to become the largest robo-advisor in marketplace lending.

may not have enough net worth to access the close substitutes (high-yield bond funds, for example). Other reasons are likely more due to cognitive biases. One is that individuals may regard the credit rating exercise as akin to a game and thus derive utility from it. They may also derive utility from sharing the experience (such as swapping tips) with friends or even bragging about their success in social media. Moreover, some individuals may be over-confident and believe that they can do better than banks in assessing the potential risks and returns of a specific investment.

More consistent with the standard theory of financial intermediation is the other listing mechanism used by FinTech firms, in which the online lender evaluates each applicant's credit risk and, accordingly, decides whether to list the request with investors as well as the interest rate to charge if listed. Investors then select the amount of each loan they are willing to fund. For this and a number of additional reasons, most online lenders started with this lender-set-price mechanism, and it has entirely replaced the auction format.[38] This listing mechanism mitigates the asymmetry across investors of different abilities since the online lender sets the loan terms. To the extent that some accredited investors perceive a disadvantage in their capabilities to assess credit risk, this set-price mechanism should encourage the participation of these investors, as well as the even more disadvantaged retail investors.[39, 40]

Moreover, on average the set-price format results in faster originations, a feature likely more valuable to institutional investors, and certainly to the online platform itself, since it earns a fee of 1 to 6 percent for each loan originated. With a set price, any listing is closed as soon as the requested amount is subscribed, instead of waiting till the end of

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[38] Wei and Lin (2017) argue that there is a downside to the lender-set-price format, as the lender sets a higher rate in the equilibrium than what a borrower would have chosen, and this not only reduces borrowers' welfare but also raises default. However, Wei and Lin (2017) ignore the potential harm to less skilled investors due to information asymmetry, as they model the cross-investor heterogeneity in interest rates solely as a result of preference and not difference in skill.

[39] Investors who can still "beat the market" by being better than the FinTech lender in evaluating or pricing credit risk should be a small set, since FinTech lenders specialize in risk rating.

[40] Another way to reduce cross-investor asymmetry is to disclose less data. Vallee and Zeng (2013) present empirical evidence that the asymmetry across investors is lessened after Lending Club removed 50 out of 100-plus variables supplied to investors in November 2014.

a fixed listing auction period.[41] Institutional investors likely have more to lose than retail investors by leaving funds idle and thus want their funds deployed as fast as possible.

II.5 Evolution of the Funding Models and Funding Sources for FinTech Loans

The funding models and funding sources for loans originated by online lenders have evolved over time. While individuals funded most P2P loans in the early years after FinTech firms emerged, now "accredited investors" have become the dominant source of funding.[42] Most later FinTech entrants thus opted to fund loans entirely with accredited investors. Marketplace lenders, who do not fund the loans themselves, tend to serve prime borrowers. In contrast, lenders to small businesses and to consumers with blemished records tend to fund the loans themselves for a period of time, and some then offload the loans through securitization and other channels. These different funding models are meant to minimize the asymmetric information problem.

As noted above, Lending Club and Prosper, early entrants into the personal loan segment, operate as marketplace lenders and fund only a miniscule share of the loans they originate. Their loans were funded almost entirely by retail investors in the first few years of operation.[43] To make online investing more attractive, these FinTech lenders started offering individual retirement accounts in 2011 and 2012, where the investment is tax-deferred. And yet retail investors' share in outstanding loan balances declined rapidly. For example, it fell to just 49 percent in 2012 for Lending Club (10-K filings) (Table 1). This share continued falling, reaching only 15 percent for loans originated in 2016, while the share of institutional investors grew commensurately.[44]

The evolution of the funding mix for online loans indicates that institutional investors have come to recognize that online consumer loans offer competitive risk-

[41] Until August 2010, four months before ending its auction format, Prosper offered applicants the option to close the auction early or wait till the end of the listing period (in hopes of a lower rate).
[42] As defined in Rule 506 of Regulation D under the Securities Act of 1933.
[43] Time to funding was thus longer and more variable for these marketplace lenders as investors' demand varies across loans.
[44] Likewise, this share fell to 11 percent in 2014 for Prosper, even though in 2012 it still claimed that "It is people that are the drivers of credit formation … not institutions."

adjusted returns. And their capacity to fund online loans is much greater than retail investors'. This is consistent with the considerable rise in wealth concentration since the 1980s.[45] Further tilting the funding model in favor of institutional investors is the costly regulatory burden associated with raising funds from retail sources.[46] These factors led almost all later entrants to online lending to raise funds entirely through private placements with accredited investors. This means that, despite the early promise, small investors no longer have direct access to many online loans, including small business loans as a class. Individual investors can gain indirect access to online loans (likely for a higher fee) through mutual funds that invest in loans made by FinTech firms.[47]

Unlike the early entrants, many subsequent FinTech lenders directly fund the loans on their own balance sheet. This is more prevalent with small-business FinTech lenders, such as OnDeck and Kabbage. This is consistent with the notion that it is more difficult to assess the risk of small businesses than consumers, since many more factors matter for the former than for the latter. This results in more severe informational problems between the lender and investors. One way to mitigate the problem is for investors to have direct control over the intermediation functions (of loan screening and so on), by integrating with the lender and funding the loans on the joint balance sheet.

Funding loans on the balance sheet is also easier and less costly to arrange with a small group of accredited investors than with a large number of small investors. The debt contracts can be privately negotiated with accredited investors, whereas selling debt to retail investors would require a separate costly registration for such debt securities. Funding loans initially on their own balance sheet does not mean that FinTech

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[45] According to Saez and Zucman (2016), the top 0.1percent wealth share has risen from 7percent in 1978 to 22 percent in 2012, while the bottom 90 percent wealth share fell steadily from the mid-1980s.

[46] Platform lenders must register the notes (representing fractional interest in underlying loans) issued to retail investors with the SEC under the Securities Act of 1933 because the SEC deems these notes as securities. This registration process is time consuming and costly. Lending Club, for example, had to cease operating the platform between April 7 and October 12, 2008, in order to complete registration for $600 million notes (see its 2012 10-K filing, for example).

[47] Two online-loan mutual funds open to the public registered with the SEC in later 2016; see https://www.wsj.com/articles/fintechs-struggling-lenders-want-your-help-1478093871

lenders intend to hold the loans to maturity. Instead, many of them make use of the growing securitization market to sell the loans from their balance sheet after a period of time in order to originate more loans. This is a funding model similar to that used for issuing credit card loans and residential mortgage loans.

With the increasing dominance of institutional investors as the primary funding source for online lenders, the lack of secondary market liquidity for online loans is felt more acutely.[48] This is likely an additional impetus for the growing role of securitization in funding these loans. The resulting asset-backed securities can be traded over the counter (with large broker-dealers). Moreover, securitization, which divides claims on the cash flow from loan pools into separate slices corresponding to debt claims with different default risks or prepayment risks, offers securities with risk profiles that are better customized to different professional investors' specific needs.

Online lenders' funding models are inherently tied to the question of how they earn their keep, which in turn shapes their incentives. It is no surprise that marketplace lenders are essentially compensated with explicit fees, mostly consisting of origination fees (typically from 1 to 6 percent of the loan principal) paid by borrowers and service fees (typically 1 percent of the installment payment, meaning principal plus interest) paid by investors. It is, however, interesting that many FinTech lenders do not charge explicit fees, even though they could, but instead simply earn the net interest margin, just like traditional banks.

Why do these more recent entrants to the online lending market choose to adopt the same pricing scheme as traditional lenders? One answer lies in the same problem that the balance-sheet lenders by design try to mitigate: by making their entire revenue stream subject to borrower default risk, their incentive to screen and monitor borrowers is maximized. In contrast, the origination fee is taken out of the loan principal upfront, although the lender typically still chooses to bear any collection fee beyond the

[48] Currently, resale of platform notes is available only through the trading venues offered by the broker-dealers affiliated with Lending Club and Prosper.

maximum chargeable to the investors.[49] This can explain why the origination fee is higher for riskier borrowers, who are more likely to default and thus impose the collection costs. The upfront fee can weaken the lender's incentive to screen and monitor, since she no longer bears the full expected default loss, if the firm's reputational capital is inadequate. By comparison, the service fee charged to investors is fully subject to the default risk in that the fee stops once a borrower stops paying. In fact, Lending Club has made the service fee more subject to prepayment risk as well since sometime in 2015.[50]

Not imposing an upfront origination fee offers one, perhaps minor, tangible benefit to online borrowers: they can request the exact amount needed without being subject to the uncertainty of receiving less or more net of the origination fee. Apart from familiarity, there may be a deeper rationale to the old approach: what borrowers truly want is just the credit, whereas the origination process is of no direct utility to them. Such activities are a "necessary evil" to enable lending, and borrowers prefer not to pay explicitly for them.

Besides receiving funding directly, FinTech lenders increasingly collaborate with banks and community development financial institutions (CDFIs) in other ways to utilize each party´s comparative advantage in order to maximize credit creation. Online lenders have established referral relationships with banks and CDFIs in which banks refer borrowers who do not qualify for their loans to online lenders, while online lenders refer borrowers to CDFIs.[51] Both types of referral arrangements benefit borrowers and lenders by reducing search cost. Some more recent entrants to online lending choose to

[49] Lending Club, for example, caps the collection fee 1) up to 35 percent of the amount recovered if no litigation is involved, or 2) 30 percent of hourly attorneys' fees, plus costs, up to the amount recovered, if litigation is involved. No collection fee will be charged if no payments are recovered. See https://www.lendingclub.com/public/rates-and-fees.action

[50] If a borrower pays off her loan within the first 12 months, an investor pays no more than 1 percent of the contractual installment amount for the actual months paid, not the entire prepaid loan principal.

[51] See Northrup, Hangen, and Swack (2016) for more detail on specific cases of collaboration.

become the technology provider to banks instead of making loans themselves.[52] This combination offers the potential benefit of lowering the cost on existing products and offering new products to existing customers, who save on the search cost.

This subsection closes with a brief discussion of the funding sources for the online lenders themselves, which are distinct from the funding for the loans originated by FinTech firms, except in the early start-up stage for some online lenders. Consistent with their perceived status of technology startups, venture capital is the primary funding source for FinTech firms, especially for those that have not gone through an initial public offering (IPO). According to S&P Global Intelligence (2017), venture funding for digital lending peaked in 2015, topping $2.2 billion. Along with the stock market retreat in 2016, venture funding fell precipitously. In 2017, it recovered to about half of the level in 2015. These swings indicate that investment in FinTech lending firms themselves may be highly susceptible to market risk sentiment. This points to the danger of at least some of these firms being unable to sustain their operations during the next economic downturn, exacerbating cyclical fluctuations in credit supply. As will be discussed later, regulatory measures may be needed to mitigate this risk.

II.6 Theory of the Nature of Information and the Organization of Lending: A Brief Discussion

As already suggested above, data may have overtaken funding to become the critical resource in lending, especially under normal economic conditions. When enough credit-relevant information is digitized and processed with algorithms so that data disclosure can mostly resolve the asymmetric information problem, the firm carrying out the credit screening can operate separately from the agents supplying loanable funds. Moreover, economies of scale and scope in producing information services are not per se reasons to integrate information production with funding.

A more structured perspective can be gained by comparing these facts with some

[52] LendKey, for example, builds platforms that enable credit unions and smaller banks to lend online. See https://www.prnewswire.com/news-releases/lending-as-a-service-platform-lendkey-deploys-800m-in-capital-300089990.html

important theories of financial intermediation. These comparisons are all predicated on financial intermediaries playing a special role in mitigating the information asymmetry between borrowers and investors. Frictions that hamper information sharing across agents exacerbate this problem, an argument for integrating functions if information can be more precisely or more cheaply shared within the firm. However, the benefit of integration must be traded off against the loss of incentives, and hence efficiency.[53] On the other hand, one potential downside to separate firms operating along a supply chain is that inter-firm interactions are more likely than intra-firm ones to be characterized by contracts featuring precisely defined monetary incentives. Such incentives can cause too much effort to be spent on easy-to-measure tasks at the expense of hard-to-measure, but important, tasks.[54] The quality of data verification or services can suffer as a result, as exemplified by the Wells Fargo scandals (see Holmström's Nobel Prize interviews).

Most of the notable models of financial intermediation traditionally assume (often implicitly) a state of the technology such that information can be obtained only through direct lending by the intermediary and, once created, has to remain private because it is infeasible to convey, let alone verify.[55] Owning (part of) the loans is in turn used as a means for the intermediary to signal the borrower's quality (as in Leland and Pyle 1977). Together, these explanations amount to assuming implicitly that funds are a more critical resource than credit evaluation capabilities, since an entity with funds but no expertise in assessing credit risk can still lend (as the arm's-length investors in Rajan 1992), but not vice versa. In reality, however, even the investors buying loans on an online platform need to be informed, perhaps to a lesser extent than the inside bank.

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[53] The idea is that, with integrated firms, many workers do not have direct control over their activities and are thus less motivated to perform at their maximal efficiency. This is a basic insight of models of the firm and the make-or-buy decision, as pioneered by Grossman and Hart (1986) and Hart and Moore (1990), among others. See Gibbons (2005) for a systematic review. Stein (2002), on the other hand, shows that the incentive can be restored, even heightened, if information can be "hardened" and thus transmitted more precisely through the hierarchy.

[54] See Holmström and Milgrom (1991).

[55] Diamond (1984), for example, shows that by pooling funds, banks obviate the need to divulge information, which may not be feasible. Allen (1990) and Millon and Thakor (1985) are among the minority of exceptions that model how a market for information itself can be sustained.

Investors gain information on borrower risk partly by buying from marketplace lenders.

Stein (2002) is arguably the most direct study of how the structure of a firm interacts with the nature of information: More (less) hierarchical firms are better at using hard (soft) information. Stein (2002) also recognizes that changes in information from soft to hard may alter the boundary of firm as well, although he justifies a hierarchical firm even under hard information, instead of a chain of stand-alone firms, by assuming that chief executives have better knowledge about the projects than outside investors. This assumption seems hardly applicable to personal loans or even some small business loans.

Economies of scale (and scope) in the automated processing of digitized data likely favor an industry structure with a few large firms. However, economies of scale in information production per se does not imply that this financial service function should be integrated with funding supply.[56] A firm specializing in credit evaluation can sell its services to many investors. Marketplace lenders do this; rating agencies and credit bureaus have done so for years. Even when funding and data services are integrated, now/today the data producers are as likely to initiate the joint ownership, since data have become the more critical resource than funds. This data-centric model helps explain Amazon's foray into small business lending. Amazon has superior information on those small firms that sell on its platform, and it prefers to fund the loans on its balance sheet in order to protect its proprietary data. At the same time, Amazon can fund the loans easily with its own cash holdings or by issuing debt. As a leading technology firm, Amazon has been able to raise funds easily and cheaply.

Amazon's case illustrates the forces that favor integrating the supply of funds with the production of even hard information. If, for some reason, a firm can raise funds more cheaply than other investors for making loans with comparable risk profiles, then an integrated operation can be optimal if the volume of lending justifies an integrated

[56] Wang (2003b) finds increasing returns to scale in the production of services by banks, after separating out the effect of loanable funds in banks' cost function. Mester (2008) reviews studies estimating returns to scale in banking, most of which do not distinguish between information production and funding, and these studies find mixed evidence for scale economies in banking.

operation. Compared with other lenders, traditional banks used to have a funding advantage owing to deposit insurance and their market power in offering depositor services.[57] The largest banks also expanded their use of short-term wholesale funds in the mid-2000s, which are cheaper than longer-term funds because of their "money" premium.[58] Alternatively, if the expected profit to be gained by keeping the data private exceeds the profit the firm may expect from selling its data services, then an integrated lending model may be preferred. This rationale applies more to firms that produce new and better data themselves, such as Amazon, than to lenders that use existing data.

III. Implications for Financial Regulation and Financial Stability

The legal and regulatory framework, which affects what contracts are feasible, are especially important for the provision of lending services, or even financial services in general. After the Great Depression, the United States developed an extensive system of banking regulations to mitigate the potential moral hazard induced by deposit insurance and to ensure each bank's safety and soundness. This regulatory system was rolled back substantially beginning in the early 1980s, a policy decision that some view as the main contributing factor to the 2008 financial crisis.[59] After the crisis, enhanced regulations (chiefly higher capital and liquidity requirements) were introduced for the largest banking organizations, not only to further ensure their solvency, but also to tackle systemic risk and thus the safety of the financial system as a whole.[60] The post-crisis regulations have raised the cost for these systemically important banks to fund

[57] Basu, Inklaar, and Wang (2011), for example, show that the average interest rate on bank retail deposits is almost always lower than the maturity-matched Treasury yield.
[58] See, for example, Stein (2012) for a model of the premium on money-like assets.
[59] Berger, Kashyap, and Scalise (1995) offer a select review of deregulation enacted from 1979 through 1994. For a few years after the 1980s savings and loan crisis, there was a brief reversal as exemplified in the Financial Institutions Reform, Recovery and Enforcement Act of 1989.
[60] The Federal Reserve Bank of St. Louis publishes a complete list of the significant rules issued by federal agencies from June 2010 through April 2014 to implement the Dodd-Frank Act: see https://www.stlouisfed.org/federal-banking-regulations/.

their balance sheets.[61] This section discusses how the post-crisis legal and regulatory environment has helped shape the online lending industry thus far, including the regulations and laws already faced by online lenders, and the direction for future evolution.[62]

III.1 Do Online Marketplace Lenders Have Regulatory and Legal Advantages?

Online lenders already must comply with a number of legal and regulatory requirements in regard to borrowers and investors in the retail lending market. On the borrower side, FinTech lenders are subject to a number of statutes aimed at protecting consumers, including the Truth in Lending Act, the Electronic Funds Transfer Act, the Fair Credit Reporting Act, and the Telephone Consumer Protection Act. On the investor side, if a lender issues platform notes to small investors, the firm is subject to statutes aimed at protecting retail investors.[63] However, the regulations to protect investors have been more actively enforced than those to protect consumers. Some would argue that enforcement generally has not been as vigorous and consistent with FinTech lenders as with traditional lenders.

In fact, it is possible that it takes banks more time to originate loans because they must ensure that all the relevant rules are followed. But this argument should be much less applicable to banks not subject to the enhanced regulatory requirements after the crisis. Moreover, Fuster et al. (2018) show that FinTech lenders are more efficient even in originating mortgage loans that comply with fairly standard underwriting rules.

Some concerns about consumer protection are more specific to online lenders. In particular, many have voiced the need to apply extra care in using alternative data (such as from social media) for loan underwriting. Care must be taken to minimize the risk of

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[61] For example, this is regarded by the Committee on the Global Financial System as a main reason why liquidity in money markets has declined after the crisis in a report issued in 2015.

[62] The Basel Committee's consultative document (2017) discusses the implications of FinTech developments for banks and for bank supervision.

[63] Manbeck, Franson, and Henry (2018) present an in-depth analysis of the regulation facing marketplace lenders.

using variables that are highly correlated with protected attributes (such as ethnicity) or discriminating against those with little social media presence. Explicit consumer consent should be required and disclosure standards set sufficiently high to help consumers fully recognize the ramifications of sharing social media data (see discussions of the European Union's data protection rules later).

Requiring lenders to protect the safety, security and privacy of consumer data is clearly important. How the property rights of data pertaining to an individual or a firm are assigned is likely also critical in influencing competition in the consumer credit market. If individuals and firms have the rights to their own data and can easily "transport" the data, this in general should encourage competition across service providers, as customers can easily switch to other service providers rather than remain locked in to one provider because the cost of changing providers is too onrerous.

Being a lender that is not organized as a bank incurs some disadvantages. In particular, nonbank lenders are subject to the interest rate ceilings imposed by state usury laws, if present. In contrast, the National Bank Act preempts state usury ceilings for nationally chartered banks, which can charge nationwide interest rates that may be above the ceilings in some states. The 1980 Depository Institution Deregulation and Monetary Control Act grants a similar preemption to FDIC-insured state-chartered banks so that they can charge interest rates up to the limit imposed by their home state, which may be above the limits in other states, as long as the home state did not countermand the preemption. This is likely the main reason that many online lenders (both Lending Club and Prosper, for example) partner with a bank to originate the loans, as this avoids the need to be licensed separately in each state. The bank then quickly sells the loans back to the lender.

Such arrangements can be regarded as a regulatory arbitrage, and thus have been challenged in court in recent years. The New York Southern District Court ruled in 2017 in the case of Madden v. Midland Funding, LLC, that a nonbank assignee of loans originated by a national bank was not entitled to the federal preemption afforded to the bank. In its 2014 decision on the case against CashCall, an Internet lender using a South

Dakota bank to fund loans, the West Virginia district court ruled that CashCall is the true lender and thus is not exempted from the state's usury limit. In part because of this ruling, in 2016 WebBank revised its agreement with borrowers and its contract with Lending Club to retain more of an interest in the lifetime performance of the loans in order to mitigate the risk of being found the "true lender" and thus subject to the usury restrictions.

In the cases where FinTech firms become service providers to banks, the existing regulatory rules over banks afford a degree of safeguard by requiring banks to conduct due diligence over third-party service providers. In the context of lending, the funding bank is responsible for its credit policy and compliance, and thus is expected to take an active role in approving and monitoring the lending program where online lenders are contracted to provide the underwriting services. Banks must also be responsible for the online loans they purchase, although that can still leave many online loans unchecked.

Owing to the nature of IT, which is at the core of FinTech operations, there can be regulatory spillovers across jurisdictions. The idea is that if a firm must update its system to comply with a rule for customers from one jurisdiction, then the firm may well choose to make the system compliant for customers in all regions if the marginal cost is sufficiently low relative to the expected cost of violating the rule because of errors in identifying some customers' jurisdictions. The rule for one jurisdiction thus spills over to others. A recent example pertains to data protection. The European Union's (EU) General Data Protection Regulation, effective on May 25, 2018, stipulates a variety of protections for the personal data of EU citizens, regardless of where the data reside and where a firm is domiciled. Anecdotal evidence suggests that data service providers that are able to comply have chosen to update their systems to apply to all customers.

Nevertheless, on the whole, online lenders do face fewer regulatory constraints than banks, which some argue confers an unfair (cost) advantage to online lenders. In particular, FinTech lenders are not required to maintain a minimum capital buffer, whereas banks are, and thus banks face a higher cost of funding. To the extent that some online lenders do not supply funding, the issue becomes the cost-of-capital advantage

that nonbank investors have over banks. This is basically a specific case of the broader post-crisis debate about whether it is consistent with macro-prudential principles to regulate nonbanks less, or not at all, just because nonbank financial firms enjoy no explicit US government guarantee. The uneven playing field inevitably pushes activities outside of the regulated banking industry to nonbanks.

On the other hand, to the extent that FinTech lending, and other FinTech services more generally, are regarded as an innovation that can potentially create sizable consumer benefits in the future, it may be socially optimal to allow FinTech firms greater latitude to experiment and innovate, as long as they put in place sound corporate governance. This is one rationale expressed in the Office of the Comptroller of the Currency's paper titled "Exploring Special Purpose National Bank Charters for Fintech Companies."[64] The Internet-based nature of how FinTech firms operate means that a national charter is more efficient and effective in terms of cost and enforcement. Some states may want to impose additional rules for consumer or investor protection. The tradeoff between protection and efficiency needs to be assessed rigorously. In principle, the degree of special treatment should be tied to the industry's stage of development: as a FinTech segment grows or the underlying technology matures, exemptions should be gradually removed.

More generally, the banking deregulation experience offers some lessons. It is recognized that the deposit rate ceilings (under the old Regulation Q) severely limited banks' ability to offer higher interest rates despite the much higher market interest rates in the 1970s and the early 1980s. The IT advances at the time enabled money market mutual funds to offer a more competitive product and rapidly squeezed banks' market share. Banking deregulation ensued, which some argue was largely regulators' attempt to help stem the IT-induced erosion of traditional banks' comparative advantage. There is a reasonable consensus after the financial crisis that bank deregulation from the early 1980s to the mid-2000s went too far. It is possible that if bank regulations are relaxed to

[64] The report was published in December 2016. The Office also published all the comments online; see https://www.occ.treas.gov/topics/responsible-innovation/fintech-charter-comments.html.

help restore banks' competitiveness, future financial instability may arise. Even if the regulations are not loosened, to the extent that enough activity migrates away from banks to the less regulated financial firms due to persistent uneven treatment, this development may still sow the seeds for financial instability in the future.

III.2 Financial Stability—Cyclicality of Credit Supply and Liquidity Risk

Regulators responsible for the overall financial system's stability should be mindful of the risk that the growth of the online lending industry may exacerbate the cyclicality of credit supply to consumers and small businesses. Most institutional investors in FinTech loans are not banks and thus do not have access to stable deposit funding. And they are not subject to capital requirements, so their capital cushion may well become too thin should loan performance be hit by a negative shock, constraining their ability to borrow and invest during an episode of adverse economic conditions. The binding capital constraint may even lead to fire-sale dynamics: some investors sell loans in order to reduce their leverage, and this action may by itself lower the loan prices, further eroding these investors' capital and thus leading to even more loan sales. Such a downward spiral can result in a market collapse. Moreover, at least some of the nonbank investors likely have short-term performance objectives that compel them to "de-risk" during market downturns. In fact, even the banks investing in online loans may choose to cut back on these loans first during downturns to preserve lending to their core customers or to simply invest in safe assets.

There is suggestive evidence of a positive correlation between online lending volume and market sentiment. As shown in Figure 5, growth in the aggregate amount of online consumer loan originations slowed substantially in early 2016, and even turned negative through 2017:Q1.[65] In terms of timing, it followed a noticeable correction in the Standard & Poor's (S&P) 500 Index outside of recessions. In contrast, the aggregate outstanding balance of credit card debt continued growing at a moderate pace.

[65] Thanks to Orchard Platform for sharing aggregate data.

Likewise, consumer credit (including credit cards and other revolving accounts, auto loans and student loans) held on bank balance sheets also exhibited steady growth over that time period. These facts suggest that FinTech lending activity may be especially susceptible to swings in market sentiment.[66] A further implication is that banks' share in lending to small businesses and consumers is likely to be countercyclical, since deposit funding is more stable and banks, especially the largest ones, have increased the share of deposits in their overall liabilities (Figure 6). Moreover, the largest banks have substantially boosted their capital ratio to comply with the enhanced capital requirements after the financial crisis.

The capital buffer that online lenders maintain may prove too thin as well, and if negative shocks push these lenders into bankruptcy, operations may be disrupted, possibly throwing the online lending sector into chaos, even if only temporarily. The major lenders all have backup servicers, but the robustness of such arrangements has yet to be tested. Lending Club, for example, states in each prospectus that they "have made arrangements for only limited backup servicing."[67] Technically, the high degree of digitization of these lenders' operations should make it feasible for them to transfer data and processing accurately and at low cost. So it may be more a question of whether the level of operation continuity that is privately optimal to FinTech firms is also socially optimal. FinTech lenders, along with their investors, may not have adequately accounted for the probability of major disruptions or internalized the related costs.

To the extent that some investors in online loans have incentive contracts tied more to short-term returns through trading, better liquidity in this market may in fact amplify fluctuations by attracting more investors targeting short-term gains. The emergence of mutual funds that invest in online loans can also lead to liquidity

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[66] I am conducting additional analysis using loan-level data to better identify and quantify the effect of investors' risk attitudes on FinTech consumer loans.

[67] See, for example, http://ir.lendingclub.com/Cache/c2000698265.html, which also discusses possible delay and increased cost due to the limited and untested backup servicing. Public firms such as Lending Club also provide details on the backup servicing arrangement in their financial reports and discuss it as a risk factor.

mismatch. To the extent that the liquidity promised to shareholders by these funds exceeds the liquidity available in the underlying whole loan or structured product market, there is a risk that the shareholders may run on the funds if the online loan market or the consumer credit market in general suffers an adverse shock. This is analogous to the risk facing high-yield bond mutual funds, although online loan funds will not have the scale in the foreseeable future to pose systemic risk.

IV. Concluding Thoughts

Much of the efficiency gain achieved by FinTech marketplace lenders vis-à-vis traditional lenders stems from their superior systems of information technology, which enable them to gather more data and make more efficient as well as more effective use of the data. The rapid growth of FinTech lending is perhaps best regarded as a continuation of the credit market's evolution enabled by advances in IT rather than a revolution. IT has changed the nature of financial information from "soft" to "hard," which then can be cheaply and precisely transmitted across individuals and firms. This development, along with financial engineering, has moved the provision of consumer credit from the traditional bank lending model, where funding and the production of services and information are integrated inside the same firm, to a model of nonintegration where these functions are performed by separate entities along a supply chain.

In accordance, information has become the critical resource, more than funding, in the retail lending industry. IT-powered services, characterized by speed, convenience and ubiquitous access, have come to be expected by consumers. All this can have profound implications for the future evolution of the industry. Nonfinancial technology firms that excel in both information production and digital service delivery have a natural stock of intangible capital that makes them competitive potential entrants to the retail lending market. The increasing returns to scale and scope characteristic of information production also suggest consolidation as FinTech lending matures, likely

even across segments with FinTech suppliers of other financial services, such as wealth management. This does not, however, imply that the production of information services will necessarily be integrated with holding the loans.

The exponential growth of the volume and variety of data being collected and the algorithm-based processing of these data also pose legal and regulatory challenges. How the property rights of data pertaining to an individual or a firm are assigned and what protections are conferred influence competition in the consumer credit market and may alter its evolution. Granting individuals the rights to their own data in general should encourage competition across service providers. Both the novel data, some of which are proprietary, and the more extensive use of algorithms to process data have the potential to attain a more accurate and objective assessment of a credit applicant's risk, which is particularly valuable to those with less credit history, such as young or low-income individuals. But care is needed to minimize the chance of bias against those with less of a digital presence, or bias against protected populations being inherited by, let alone built into, the system.

It should also be recognized that the rapid growth of FinTech lending since the 2008 financial crisis is partly the result of online lenders' regulatory advantage: they face lighter regulations than traditional lenders. In principle, this uneven playing field should not be perpetuated. Capital losses suffered by banks during the crisis coupled with the resulting enhanced regulation of the largest banks have raised their cost of capital and curtailed their ability to grow. This has enabled nonbank investors to compete with banks in lending. The increased share of funding managed by nonbank investors has created a demand for nonbank firms to carry out the information services needed to channel this pool of funds. This helps explain the entry and rapid growth of the FinTech lenders. Conversely, banks' (arguably unfair) funding cost advantage before the crisis can explain why IT advances used to encourage consolidations in the banking industry that had resulted in massive global banks.

Although lagging in some technology compared to FinTech lenders, banks still possess a large stock of intangible capital—a large volume of data on their existing

customer base. By providing an array of services, banks have built "sticky" relationships with many customers. Moreover, banks enjoy the advantage of more stable funding, owing to deposit insurance and their access to the liquidity facilities operated by the lender of last resort (that is, the Federal Reserve). This means that banks can in principle help stabilize credit supply during downturns, barring shocks to their capital and liquidity, or perceived regulatory constraints. Coupled with their expert knowledge of the regulatory system, banks can remain viable and even regain market share if they can update their operations using the new technology, such as by partnering with FinTech firms.

In sum, the entry into lending by FinTech firms in recent years should ultimately make credit faster, easier and cheaper to obtain for consumers and small businesses, even though there are risks that need to be monitored and managed through judicious regulation. The same underlying factors, chiefly advances in IT, should bring about similar changes in other financial services more generally.

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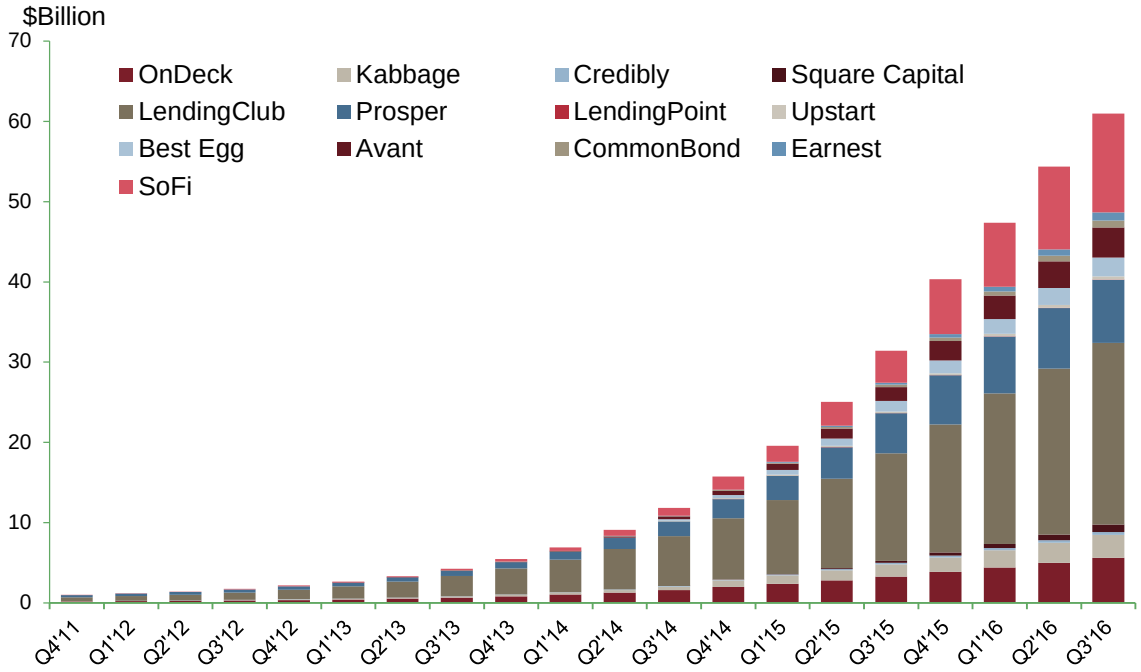
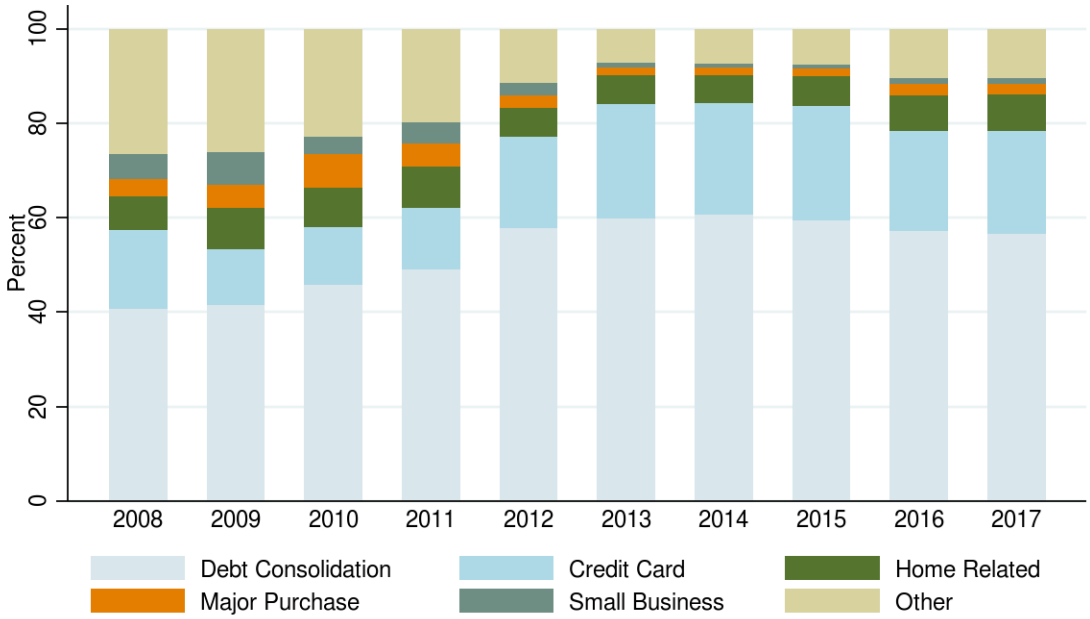
Figure 1. Growth of Online FinTech Lending in the United States



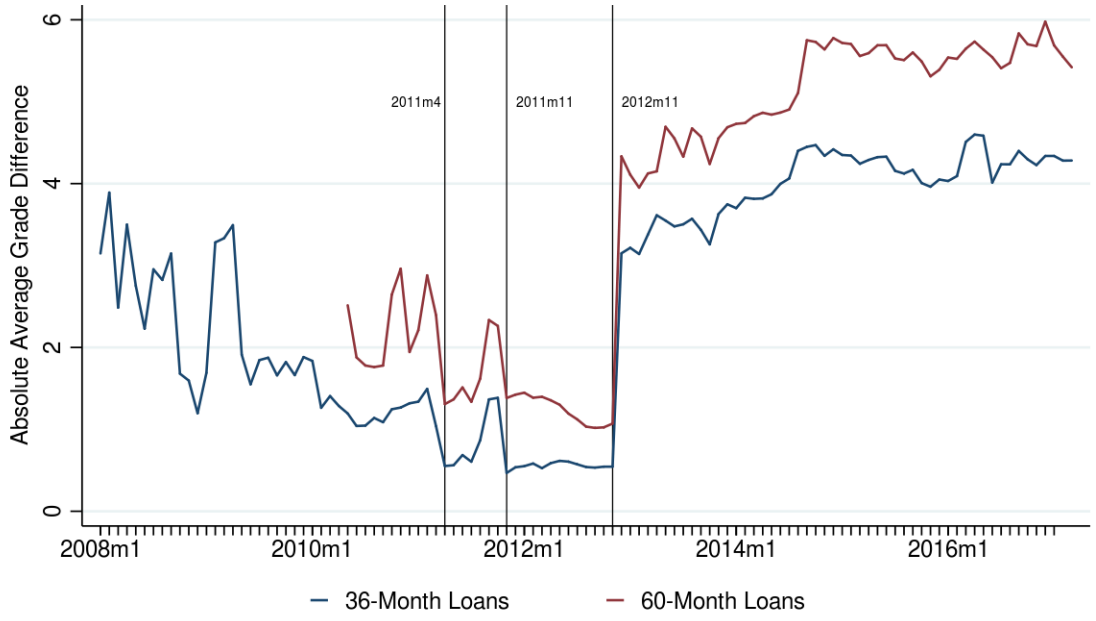
Notes: This figure shows cumulative origination volume from 2011:Q4 to 2016:Q3.
Source: S&P Global Market Intelligence.

Figure 2. Purposes of Borrowing, Lending Club



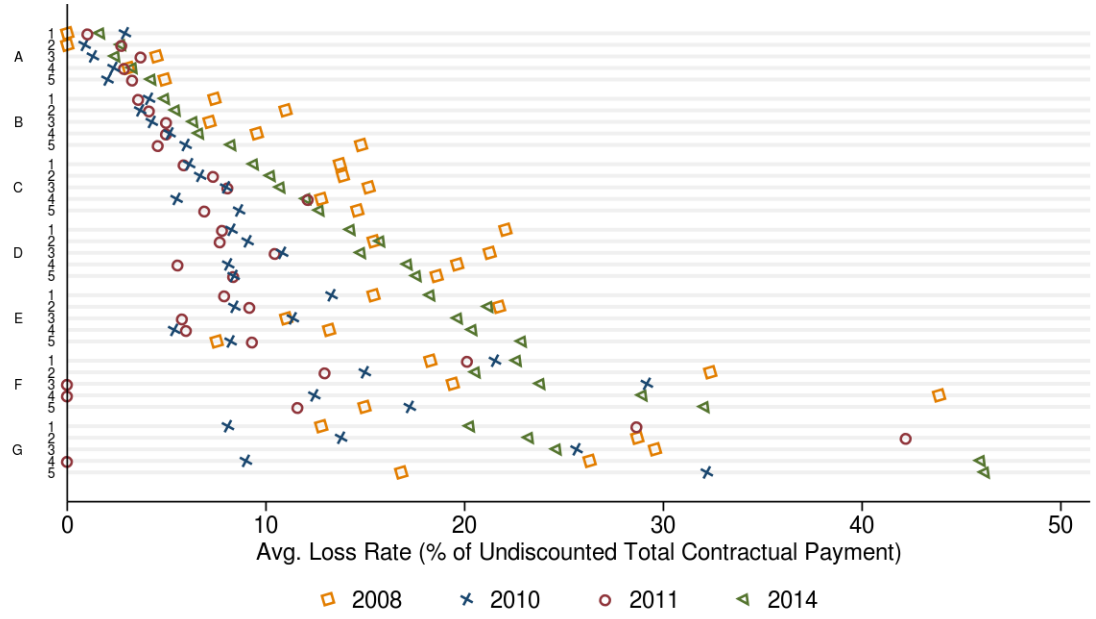
Notes: This figure plots the percent of loan purposes as stated by the borrowers.
Source: Lending Club and author's calculations.

Figure 3. Replication of Lending Club's Risk Scoring Rules: Absolute Subgrade Difference between the Actual Grades and the Replicated Grades



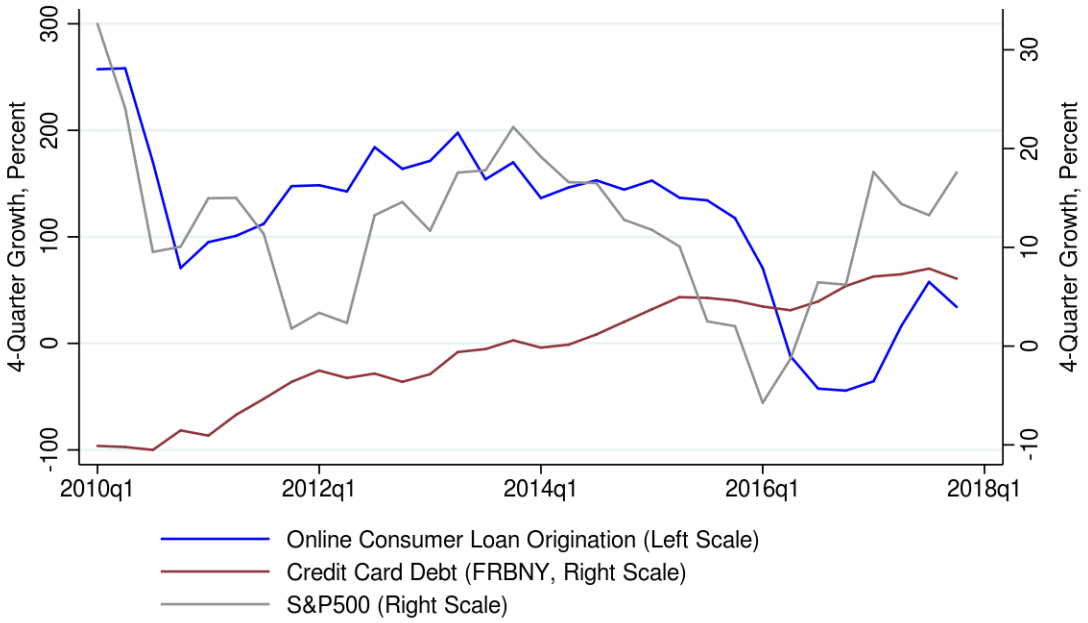
Notes: The replicated subgrades use scoring rules posted by Lending Club in April 2011 to November 2012. For known reasons, the match rates are much lower in 2011 months 9 and 10.
Source: Lending Club and author's calculations.

Figure 4. Default Rate of Lending Club's Three-Year Loans by Risk Subgrade



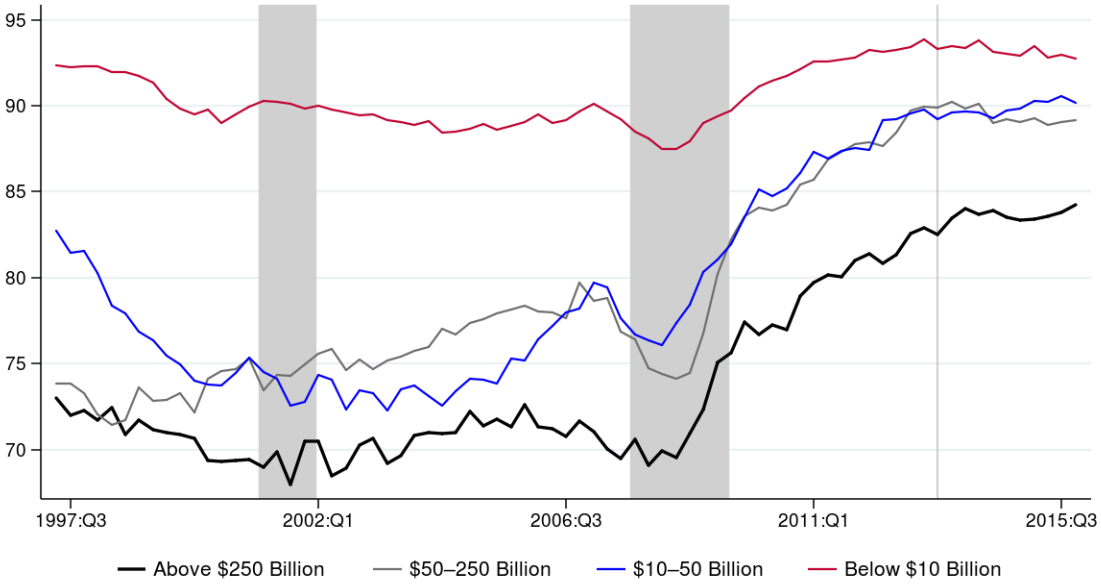
Source: Lending Club and author's calculations.

Figure 5. Aggregate Online Consumer Loan Origination versus Market Condition



Notes: This figure plots the four-quarter growth rate of aggregate amount of online consumer loan originations versus S&P 500 Index.
Source: Orchard Platform, Haver Analytics and author's calculations.

Figure 6. Share of Deposits in Total Bank Liabilities



Notes: This figure plots the share of deposits funding by bank size class.
Source: Bank Call Reports, and author's calculations.

Table 1. Share of Funding Sources, Individual versus Institutional Investors

Year	Lending Club			Prosper	
	Individuals	Institutions		Individuals	Institutions
	Notes	Certificates	Whole Loans		Whole Loans
	(%)	(%)	(%)	(%)	(%)
2007	100.0	--		100.0	--
2012	49.3	49.4	1.2		
2013	29.7	52.2	18.1		
2014	18.2	29.5	52.3	11	89
2015	15.5	31.0	53.6	5	95
2016	14.9	16.1	69.0	10	90

Source: 10-Ks of Lending Club (LC) and Prosper, and author's calculations. Institutional investors on LC's platform can invest in either certificates or whole loans (introduced in 2011 and 2012 respectively, see 2013 10-K). Certificates are a debt instrument issued by a bankruptcy-remote Trust that holds LC's loans. Many whole loan investors are banks.

Appendix. Examples of Credit Grading Rules Used by Online Lenders

Exhibit 1. Lending Club's Typical Risk Scoring Rules: July 11, 2011 to October 31, 2012[68, 69]

Loan Grades and Risk Modifiers
Using the credit score as the basis of historical credit performance, we first assign each loan into a base sub-grade. We then modify the sub-grade using the following credit risk indicators:

- Requested loan amount
- Number of recent credit inquiries
- Credit history length
- Total and currently open credit accounts
- Revolving credit utilization
- Loan maturity: 36 or 60 months

By adding the modifiers to the base sub-grade, we arrive at the final sub-grade.

Table 2. Initial Loan Sub-Grade Assignment

FICO® Score	Loan Grade
780+	A1
750-779	A2
734-749	A3
723-733	A4
714-722	A5
707-713	B1
700-706	B2
693-699	B3
686-692	B4
679-685	B5
675-678	C1
671-674	C2
668-670	C3
664-667	C4
660-663	C5

Table 3. Guidance Limits by Loan Grade

Loan Grade	Guidance Limit
A1	$35,000
A2	$30,000

[68] The exact rules were posted on October 20, 2012, copied from the archived webpage https://web.archive.org/web/20121020205505/http://www.lendingclub.com/public/how-we-set-interest-rates.action

[69] These two dates are pinned down by the first and the last dated pages containing the explicit grading rules, which remained virtually unchanged, as archived by the Internet Archive. The Internet Archive crawler, however, only samples any given webpage periodically. Judging by the match rate from the replication results shown in Figure 3, the exact earliest (latest) date of this risk grade regime, however, appear a few months before (one month after) the archive date.

A3	$25,000
A4	$20,000
A5 - B5	$15,000
C	$12,500

Table 4. Loan Amount vs. Guidance Limit Risk Modifier

Loan Amount/Guidance Limit Ratio	Risk Modifier
0-24%	0
25-49%	0
50-74%	-2
75-99%	-2
100-124%	-4
125-149%	-4
150-174%	-6
175%-199%	-8
200% or more	-10

Table 5. Recent Inquiries Risk Modifier

# Inquiries in the Last 6 Months	Risk Modifier
0	A +1, B +2, C +3
1-3	0
4	-1
5	-2
6	-4
7	-6
8	-10
9 or more	Decline

Borrowers with 4 or more credit inquiries in the last 6 months and a credit score below 740 will be declined.

Table 6. Credit History Length Risk Modifier

Credit History Length (months)	Risk Modifier
61 or more	0
55-60	-1
49-54	-2
43-48	-3
37-42	-4
36 or less	Decline

Table 7. Total and Open Accounts Risk Modifier

Open Accounts	Sub-Grade Modifier
0-1	Decline
2-3	-4
4	-2
5	-1

6-21	0
22	-2
23	-3
24	-4
25	-8
26 or more	-12

Table 8. Revolving Credit Utilization Risk Modifier

Utilization	Risk Modifier
<5%	-1
5-84.99%	0
85-89.99%	-1
90-94.99%	-2
95-97.99%	-4
98% or more	Decline

Borrowers with a total revolving balance of $0 and a credit score of less than 714 will be declined.

Table 9. Loan Term Modifier

Loan Term (Maturity)	Loan Grade	Risk Modifier
36 months	A - G	0
60 months	A - B	-5
60 months	C - G	-6

As an example, let's assume a borrower member requests a 60-month $20,000 car financing loan, showing the following credit data points:

- FICO score of 700
- 10 open accounts
- 3 credit inquiries in the last six months
- 50% utilization of credit limit, and
- First credit line opened 7 and a half years ago.

We start by assigning this borrower a B2 sub-grade (11.14% interest rate) based on the borrower's FICO score of 700. Next, we make no sub-grade modification for open accounts, because 10 open accounts is greater than 6 and less than 21 and because borrower has had only three credit inquiries in the last six months. We make no sub-grade modification for 50% utilization of credit limit, since it is greater than 5% but lower than 85%, and we make no sub-grade modification for length of credit history, because the borrower member shows more than 60 months of credit experience.

Now, let's look at the requested loan amount: since $20,000 is between 125-149% of the guidance limit of $15,000 for B loan grades, the borrower's credit grade is reduced by an additional four sub-grades to C1. Finally, we lower the sub-grade six more levels to a D2 based on the loan term of 60 months resulting in an APR of 20.93% for the borrower and an interest rate of 18.49% (before fees) for the investor.

Exhibit 2. Prosper score model posted on July 21, 2009[70]

Prosper Score

A custom risk model was built using historical Prosper data to assess the risk of Prosper borrower listings. The output of the model is a Prosper score which is used in conjunction with a credit reporting agency score to estimate expected loss rates on Prosper borrower listings. The Prosper score was built specifically on the Prosper population, so it incorporates behavior that is unique and inherent to this population. In contrast, the credit score obtained from a credit reporting agency is based on a much broader population, of which Prosper borrowers are just a small subset. As such, the credit reporting agency score should, and does, rank order risk on the Prosper population, but is not as discriminating as a custom score. Prosper uses both the custom score and the credit reporting agency score together to assess the borrower's level of risk and determine estimated loss rates, which is more powerful than using just one score. The loss estimates are based on the historical performance of Prosper loans to borrowers with similar characteristics. They are not a guarantee and actual performance may differ from expected performance.

Model Development

A logistic regression model was built to predict the probability of a loan going "bad," where "bad" is the probability of going 61+ days past due. All loans booked from April, 2007 through June, 2007 were used to build the model, with the performance measured through December, 2008. The score was then validated using all loans booked from July, 2007 through September, 2007 with the performance measured through December, 2008. The output of the model to Prosper users is a Prosper score, which ranges from 1 to 10, with 10 being the best, or lowest risk score. The worst, or highest risk score is a 1.

All potential variables available at the time of listing, including those from the identification authorization process, the credit report and listing details provided by the borrower were analyzed for potential inclusion in the final model. For example, variables such as authorization score (used during identity verification), income, debt-to-income ratio, total revolving balance and delinquencies were reviewed. Transformations such as log and square root and ratios were performed on most of the variables during the development process. Several iterations of stepwise linear regression were used to select significant variables from the pool of customer bureau variables and listing characteristics. Variables were dropped or kept in the final model based on their significance and interaction with other variables. Many model iterations were completed and analyzed in order to determine the final model.

Key variables in the model are:

- number of delinquent accounts
- delinquent balance
- number of inquiries in the past six months
- number of recently opened trades
- amount of available credit on bankcards

[70] Content copied from the following archived webpage: https://web.archive.org/web/20090721215108/http://www.prosper.com:80/help/topics/general-prosper_score.aspx

The model was validated on loans booked from July, 2007 through March, 2008 to ensure that it ranks risk in this more recent population.

The score is calculated using the logistic function:

$f(z) = 1/(1 + \exp(-z))$

where z is a regression equation with the following variables and coefficients:

Intercept	-3.642
Amount Delinquent (dummy variable)	0.576
Trades with delinquent balance	0.198
Available credit on bankcards (log)	-0.547
Inquiries <= 6 months	0.194
Trades opened <= 6 months	0.150
Loan Amount (log)	1.557
Monthly Income (log)	-0.774
Automatic Funding	0.559

The output of these equations is a raw score that is then mapped to a Prosper score, which is displayed on each borrower listing. The Prosper score ranges from 1 to 10, with 10 being the best, or lowest risk value. The raw score ranges from the Prosper score are shown on the estimated loss rates page. For example, a raw score = 3 equates to a Prosper score = 10.