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The Macroeconomics of Labor, Credit and Financial Market Imperfections*

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Abstract

An increasing share of corporate loans, a critical source of firm credit, are sold off banks' balance sheets and actively traded in a secondary over-the-counter market. We develop a microfounded equilibrium search-theoretic model with labor, credit, and financial markets to explore how this secondary loan market affects the real economy, highlighting a trade-off: while the market reduces the steady-state level of unemployment by 0.6pp, it amplifies its response to a 1% productivity drop from 3.6% to 4.3%. Secondary market frictions matter significantly: eliminating them would not only reduce unemployment by 1.2pp, but also dampen its volatility down to 2.7%.

JEL Classification: E24, E44, E51, G11, G12, G21, J64

Keywords: Search frictions, labor market, credit market, over-the-counter markets, real-financial linkages, secondary loan market

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1 Introduction

Loans from commercial banks constitute one of the most common avenues for firms to finance their borrowing needs.[1] Over the last two decades, an active secondary market for these corporate loans has developed both in the United States and in Europe, where loans are traded over-the-counter like debt securities. This financial innovation may have important macroeconomic implications for at least two reasons. First, the spreads in the secondary market for corporate loans are strongly correlated with various real macroeconomic variables like output and unemployment (Saunders et al., 2022). Second, corporate loans play a large role in recent policy conversations about corporate indebtedness, since their value has doubled in size in the last 15 years (Kaplan, 2019; IMF, 2018).[2] Despite their theoretical and policy importance, the linkages of the secondary corporate loan market with the real economy have not been studied in the macroeconomic literature.

We fill this gap by developing a microfounded general equilibrium framework that encompasses the following three markets: a credit market, in which banks give loans to new and existing firms to finance their borrowing needs; a labor market, in which new firms match with workers to produce output; and a secondary financial market, in which dealers securitize and sell to investors the loans acquired from commercial banks. We first study a parsimonious partial equilibrium model where the price of securitized loans in the secondary market is fixed. This allows us to highlight analytically that the introduction of a secondary loan market comes with a trade-off. On the one hand, it increases the profitability of the credit contract between banks and entrepreneurs, which leads to a lower level of unemployment. On the other hand, secondary loan trading makes credit contracts more sensitive to macroeconomic conditions, thereby increasing the sensitivity of unemployment to real disruptions. To assess the magnitude of these effects quantitatively, we then calibrate a richer version of the model to U.S. data. At this point, we endogenize the price at which banks can sell loans, allowing for general equilibrium feedback effects between the financial and

[1] In the fourth quarter of 2022, outstanding loan liabilities for non-financial corporate business in the U.S. were $5.4 trillion, amounting to more than two thirds of corporate debt securities outstanding and a fifth of GDP. In fact, Sufi (2007) reports that as early as 2005 the primary market issuance in the corporate loan market exceeded that of the primary corporate bonds market. Additionally, Saunders et al. (2022) report that the market for syndicated loans is one of the most important source of financing for firms. Of the publicly traded firms in Compustat, Saunders et al. (2022) report that 70% were syndicated loan issuers for the period 1999 to 2020. Moreover, half of the firms in their sample were private enterprises and thus had to rely on financing through bank loans.

[2] The Federal Reserve even included the secondary market for corporate loans in the announcement of the Primary Market Corporate Credit Facility as a target market for its interventions on the eve of the Covid recession; see Boyarchenko et al. (2022) for details.

real sides of the economy. We find that the introduction of a secondary loan market reduces the steady-state unemployment rate by 0.64 percentage points (pp). However, following a 1% decrease in productivity, the steady-state unemployment level increases by 4.3% in the presence of a secondary loan market, compared to only 3.6% in its absence. While these two results align with the theoretical predictions derived from the parsimonious, partial equilibrium model, our quantitative model allows us to provide some more nuance. We find that were trade between dealers and investors frictionless, secondary loan trading would dampen rather than exacerbate the response of unemployment to the productivity decline, down to 2.7%. In addition, it would reduce steady-state unemployment by an additional 1.2pp relative to the frictional secondary market. These results underscore that the impact of the secondary corporate loan market on real activity is highly dependent on the efficiency with which that market operates.

The modeling of each market follows an established path from the search and matching literature: the credit market builds upon Wasmer and Weil (2004), the labor market upon Diamond (1982) and Mortensen and Pissarides (1994), and the secondary market follows Duffie, Gârleanu, and Pedersen (2005). We henceforth refer to these models as WW, DMP, and OTC, respectively. The real side of the economy is populated by entrepreneurs, workers, and banks. Entrepreneurs have access to a production technology, but need workers in order to produce. Entrepreneurs and workers meet on the labor market, which is subject to frictions: finding a suitable counterparty takes time and resources. Moreover, entrepreneurs are liquidity constrained: they do not have the funds to finance the search for workers; thus, they first need to obtain financing from a bank. The entrepreneur and the bank participate in a credit market also subject to search frictions: it takes time and resources to find a suitable counterparty with which to form a credit partnership. Once the entrepreneur secures funding from a bank, the bank finances the labor market search costs until the entrepreneur finds a worker. At that point, production begins, and the entrepreneur starts repaying the loan. Banks have the option to securitize and sell loans in a secondary market. This secondary loan market has the OTC structure from Duffie et al. (2005): investors have heterogeneous valuations for an asset which periodically change due to preference shocks, generating trade incentives.[3] The asset traded in the OTC market consists in a securitized stream of repayments from the loans banks issue to entrepreneurs in the primary credit market. At an exogenous contact rate, investors/customers meet with dealers, who execute

[3]The OTC literature has provided multiple foundations for this preference structure. It captures investors with heterogeneous and time variant beliefs about the asset quality, hedging needs, or consumption opportunities.

buy and sell orders on their behalf in a perfectly competitive inter-dealer market.

An important departure from all three aforementioned frameworks is the introduction of a motive for banks to securitize loans. In particular, banks incur *loan-servicing costs*, which are strictly increasing in the amount of the loan the bank retains in its balance sheet. We choose to make this modeling innovation as previous literature has found strong empirical support that banks who offload some of their loans economize on the monitoring, servicing, and balance sheet costs related to these loans (see the discussion in Section 1.1). Moreover, some authors (see, for example, Simons (1993)) have put forth the hypothesis that sharing on the costs of the loan is precisely the reason why banks securitize loans in the first place.

Importantly, loan-servicing costs allow us to model banks facing a non-trivial decision of what fraction of the loans to keep on their balance sheet. Not only does this make our model consistent with key properties of the data, but it also generates several novel insights. Most notably, we show analytically that loan-servicing costs act as an automatic stabilizer: following a decrease in productivity, the economy with loan-servicing costs experiences business cycle fluctuations of a lower magnitude than a hypothetical economy where banks do not incur these costs. This is the case because loan-servicing costs affect the size of the fundamental surplus, the model object which determines the magnitude of the response of labor market tightness to productivity changes (Ljungqvist and Sargent, 2017). Intuitively, a productivity drop reduces the match surplus between a banker and an entrepreneur, which, in turn, lowers vacancy creation. As a result, there is less congestion in the labor market, vacancies are filled faster, and banks issue less credit to cover the entrepreneurs' search cost. In an economy with loan-servicing costs this means lower operating expenses for banks, which raises their profits and partially counteracts the negative effect of the drop in productivity.[4]

Turning to the impact of a secondary loan market, we find it has the opposite effect on the economy when asset prices are stable, amplifying the magnitude of business cycle fluctuations.[5] Intuitively, when there is a secondary loan market, banks solve a portfolio choice problem and securitize some of the loans on their books. This ties the equilibrium level of loan-servicing costs to the price of the asset on the secondary market. Under fixed

[4]This intuition develops an analogy to a progressive tax system in the baseline real business cycle model. In general, a negative output shock lowers wages, which tends to decrease labor supply. With progressive taxation, however, lower wages reduce income, hence the household's marginal tax rate decreases. This creates a counter effect which tends to push the labor supply up. As a result, business cycle fluctuations are dampened.

[5]Specifically, our analytical results are derived under partial equilibrium, where we fix the price of the asset. This allows us to study the direct effect of having access to a secondary market in a tractable way. We consider the full general equilibrium effects in our quantitative exercises. We find that asset prices do not change much in the comparative statics of the benchmark model, lending credence to our analytical results.

asset prices loan-servicing costs are constant, which eliminates their stabilizing effect. Hence, the existence of a frictional secondary loan market mitigates the ability of loan-servicing costs to serve as an automatic stabilizer.

In our quantitative model, we extend the baseline model to include credit for incumbent firms and endogenous secondary loan prices. The calibrated model matches a rich set of identified and unidentified moments, making it a good laboratory for our numerical experiments. Our first goal is to understand the effect of loan-servicing costs and secondary loan trading on the real economy. To this end, we calculate the steady-state unemployment levels in alternative models and compare them to the steady-state level in the benchmark economy. We find that in the absence of the secondary loan market, unemployment would be 0.64pp higher. Intuitively, when banks can sell the loans on their books, they optimally choose to securitize a fraction of them to save on loan-servicing costs. As a result, banks experience lower operating costs, which incentivizes larger credit provision and ultimately higher vacancy creation. Looking further into the importance of the secondary loan market for the real economy, we ask the question "what would unemployment have been if there were no frictions in that market?" Our calibration suggests that absent frictions in the OTC market, unemployment would be 1.21pp lower. Intuitively, reducing frictions in the secondary market leads to faster reallocation of the asset to high-value investors, which increases its price. This higher price, in turn, makes lending more profitable, which stimulates credit provision and vacancy creation. We also estimate that eliminating loan-servicing costs reduces steady-state unemployment by 3.42pp. Thus, the secondary loan market offsets almost a fifth of the drag that loan-servicing costs impose on employment. A frictionless market would eliminate more than half.

Our second goal is to study the propagation of shocks, which we investigate in a series of steady-state comparative statics exercises. We find that, following either a decrease in productivity or an increase in the costs banks incur to participate in the credit market, the benchmark model exhibits larger responses than an alternative economy without a secondary loan market. Both of these economies are, in turn, more responsive than an economy with a frictionless secondary loan market. For example, a 1% reduction in productivity leads to an unemployment increase of 4.3% in the benchmark model; 3.6% in the economy without a secondary market; and 2.7% in the economy with a frictionless secondary market. Intuitively, in our benchmark economy prices do not respond much to changes in supply due to the frictions on the secondary market. Consequently, an economy with a secondary loan market exhibits larger volatility than a hypothetical economy without. When the secondary market is frictionless, however, the asset price strongly responds to changes in asset supply. This makes loan-servicing costs even more volatile than in the economy without a secondary market, which boosts their ability to dampen fluctuations.

Our paper bears interesting lessons for researchers and policy-makers alike. Firstly, we provide a theoretical framework to study the mechanisms through which the secondary loan market affects production and unemployment. Specifically, our model can rationalize the negative relationship between secondary market spreads and real macroeconomic variables established by Saunders et al. (2022). Secondly, our quantitative findings lend credence to the worries of policy-makers regarding the macroeconomic risks of turmoil in secondary financial markets. In particular, when we lower investors' valuations to engineer an asset price drop similar in magnitude to the one observed in the 2008 financial crisis, the model predicts a 10% increase in the unemployment rate. Thus, our model implies that a drop in the price of securitized loans *alone* can explain almost a sixth of the unemployment increase observed during the Great Recession. Importantly, the model with a frictionless secondary market delivers an even larger unemployment increase, of about 25%, following the same asset price drop. This highlights a challenging policy trade-off: eliminating frictions in the secondary market improves the steady-state level of macroeconomic aggregates and lowers the sensitivity of the economy to real disturbances, but raises its sensitivity to financial disturbances.

The rest of the paper is organized as follows. We continue this section with a review of the related literature, before detailing the institutional background of the secondary loan market and the importance of loan-servicing costs for loan securitization in Section 1.1. Section 2 develops a simplified model and highlights our main analytical results: loan-servicing costs act as an automatic stabilizer, but a secondary loan market with a stable price serves to mitigate their impact on the magnitude of business cycle fluctuations. Section 3 presents the richer model with incumbent firm financing and endogenous asset prices, while Section 4 explains the model's calibration strategy. In Section 5 we present the quantitative exercises and Section 6 concludes.

Related Literature. Our paper contributes to several strands of the macroeconomic literature. First, we focus on imperfections in the credit and labor markets. As such, our model is closely related to a vast search-theoretic literature on the labor market. Some of the early seminal papers include Diamond (1982), Pissarides (1985), Mortensen (1982), Mortensen and Pissarides (1994). Our work is more narrowly related to papers which investigate credit frictions within the Diamond-Mortensen-Pissarides class of models. Specifically, following the seminal work of Wasmer and Weil (2004) a large body of work has studied the macroeconomic impact of credit and labor market frictions.[6] For example, Petrosky-Nadeau and Wasmer (2013) provides a dynamic extension of the baseline model; Petrosky-Nadeau (2013) introduces firm heterogeneity to study the cyclical behavior of TFP; for a comprehensive list, see Chapters 5 and 6 in Petrosky-Nadeau and Wasmer (2017) and the papers cited therein. We contribute to that strand of literature by introducing a secondary loan market, a loan-servicing cost for banks, and credit needs for incumbent firms.

A central feature of our paper is the secondary loan market which we model as an OTC market with search frictions. Our paper is thus related to a large search-theoretic literature which studies OTC markets following the seminal work in Duffie et al. (2005, 2007). For recent surveys, see Lagos, Rocheteau, and Wright (2017) and Weill (2020). In particular, our OTC market closely follows the benchmark model surveyed in Weill (2020).[7] The only point of departure is that assets mature at some exogenous rate, and that the asset supply in our economy is endogenous. Our contribution to that literature is to study the linkages of a specific OTC financial market with the real economy. Other authors making this connection focus on different markets and study different linkages; see He and Milbradt (2014), Bethune, Sultanum, and Trachter (2019), Cui and Radde (2020), and Kozlowski (2021).

Another important ingredient of our theoretical framework is the cost of operating a loan that banks incur, and the related decision of what fraction of the loan a bank should keep on its books. Our paper is thus related to studies which have examined the importance of the ability of banks to sell their loans for measuring shock amplification through financial intermediaries (Buchak et al. 2023, 2024; Irani and Meisenzahl 2017). We motivate the loan-servicing costs through the observation that there are both balance sheet and monitoring costs associated with servicing a loan.[8] As such, our paper is related to an extensive literature

[6] A body of literature has used the alternative modeling approach found in New Monetarist papers to study the connection between credit frictions and unemployment. See, for example, Bethune et al. (2015), Branch and Silva (2021), and Bethune and Rocheteau (2023). Moreover, other approaches merge a DMP labor market with alternative mechanisms to connect financial markets with unemployment. See, among others, Monacelli et al. (2011), Rocheteau and Rodriguez-Lopez (2014), Buera et al. (2015), Eckstein et al. (2019), Shapiro and Olivero (2020), Dong (2022), and Kehoe et al. (2022).

[7] The literature has also studied models which have only some of these properties as well. For example, Lester (2010) studies a model with unconstrained asset holdings and directed search; Chang and Zhang (2015) study the interaction of OTC markets with network structures; Gabrovski and Kospentaris (2021) analyzes an economy with directed search and no competitive inter-dealer market; Chang (2018) builds a model with asymmetric information; Lagos and Rocheteau (2009) studies a model with unconstrained asset holdings and countably many investor types; Üslü (2019) studies unrestricted asset holdings; and Hugonnier, Lester, and Weill (2022) study a model without a perfectly competitive inter-dealer market.

[8] There are a number of costs associated with keeping a loan on one's balance sheet.. The empirical

on the importance of balance sheet costs which take the form of collateral constraints, funding liquidity, margin requirements, regulatory capital requirements, and leverage constraints among others. Specifically, we contribute to the line of studies examining the impact of balance sheet costs on asset prices and asset supply — see, among others, Kiyotaki and Moore (1997), Chowdhry and Nanda (1998), Gromb and Vayanos (2002), Krishnamurthy (2003), Brunnermeier and Pedersen (2009), Adrian and Shin (2010), He, Kelly, and Manela (2017), and Chang, Gomez, and Hong (2023). Also related is the literature on monitoring costs; seminal papers include Diamond (1984), Williamson (1987a), Aghion and Bolton (1992), Dewatripont et al. (1994), Holmstrom and Tirole (1997), and Kaplan and Strömberg (2003).[9] In particular, our paper falls within the strand of the literature that examines the macroeconomic implications of monitoring costs — see Chen (2001), Meh and Moran (2010), and Williamson (2012) among others. Unlike all of these papers, we study the aggregate implications of loan-servicing costs in the context of an economy which features frictional credit and a secondary loan markets.

Our paper studies the macroeconomic implications of frictions in a financial OTC market. As such, it is related to a growing literature which investigates the impact of financial frictions within New Monetarist economies. See, for example, Geromichalos and Herrenbrueck (2016), Geromichalos, Herrenbrueck, and Lee (2018), and Gabrovski, Geromichalos, Herrenbrueck, Kospentaris, and Lee (2023). In contrast to these papers, (i) we study the market for loans; (ii) our economy does not feature money; and (iii) our economy features a frictional labor market. To a lesser degree, our paper is related to the search-theoretic literature on the housing market, which operates over-the-counter, and where assets are discrete. See, for example, Wheaton (1990), Head, Lloyd-Ellis, and Sun (2014), Gabrovski and Ortego-Marti (2019, 2021a,b), Albrecht, Gautier, and Vroman (2016), and Garriga and Hedlund (2020). Within that strand of the literature, there are papers that have studied the linkages between frictional credit markets a la Wasmer and Weil (2004) and a frictional OTC housing market.

literature has provided evidence that capital requirements can have a negative effect on bank lending in the context of different regulatory regimes. See Haubrich et al. (1993); Berger and Udell (1994); Peek and Rosengren (1997); Bridges et al. (2014); Fratzscher et al. (2016); Bordo and Duca (2018); Koont and Walz (2021); Malovaná and Ehrenbergerová (2022) among others. Moreover, there is empirical evidence that the loan syndication market exists because of regulatory restrictions on banks such as capital requirements and lending limits (Simons, 1993), and that banks which are more capital-constrained retain smaller portions of the loan (Simons, 1993; Jones et al., 2005). The importance of monitoring and control rights of creditors has also been extensively documented: Chava and Roberts (2008); Roberts and Sufi (2009); Nini et al. (2012); Matvos (2013); Becker and Ivashina (2016); Green (2018); Berlin et al. (2020) among others.

[9]There is also a related empirical literature which examines the role of financial covenants for implementing creditor monitoring. See, for example, Chava and Roberts (2008), Roberts and Sufi (2009), Nini et al. (2012), Matvos (2013), Becker and Ivashina (2016), Green (2018), Berlin et al. (2020), and Kermani and Ma (2020).

For example, Gabrovski and Ortego-Marti (2021b) study the impact of credit frictions when buyers on an OTC (housing) market are liquidity constrained and Gabrovski and Ortego-Marti (2022) analyze an economy with credit frictions on the seller's side of an OTC (housing) market, where creating new homes is costly and housing developers are liquidity constrained. Lastly, our work is to a lesser extent connected to a voluminous literature which studies the impact of financial frictions on the real economy in models with nominal and credit frictions. See, for example, Williamson (1987b, 2012), Kiyotaki and Moore (1997), Bernanke et al. (1999), Gertler and Kiyotaki (2010), and Jermann and Quadrini (2012).

1.1 Institutional Background

The secondary loan market. A secondary market for loans emerged in the United States in the 1990s (Marsh and Virmani, 2022). The founding of the Loan Syndication and Trading Association (LSTA) in 1995, which standardized loan contracts and procedures, had a large positive impact on secondary market activity. Since then, the secondary market has been an active dealer-driven market, in which loans are traded similarly to debt securities (Saunders et al., 2022). Typically, loans traded in the secondary market are syndicated. A syndicated loan is a loan provided by a group of lenders who pool funds together ("syndicate") to provide them to a single borrower.[10] The syndicated loan market is one of the most important sources of private debt for corporations (Kaplan, 2019). For example, Chodorow-Reich (2014) reports that syndicated loans account for almost half of total commercial and industrial lending in the U.S., and two-thirds of lending with a maturity longer than a year, while Saunders et al. (2022) report that almost 70% of Compustat firms were syndicated loan issuers from 1999 to 2020. The market serves both publicly traded and private firms: in both Chodorow-Reich (2014) and Saunders et al. (2022) datasets, half of the borrowing firms are private. The vast majority of loans traded in the secondary market are "leveraged loans" (made to borrowers with high levels of debt), whose value recently peaked at almost 1.4 trillion (Marsh and Virmani, 2022) (see also Lee et al. 2019 and Bochner et al. 2020). The market's turnover rate is also high: annual secondary market trading volume reached $742 billion USD in 2019 (Saunders et al., 2022).

[10] Typically, the syndication process is led by a "lead arranger," a commercial or investment bank that arranges the loan details with the borrower and recruits other participant intermediaries (which include banks and institutional investors). Although both the lead arrangers and the other participants sign the loan contract with the borrower, the lead arranger retains a larger share of the loan than the participants (Chodorow-Reich, 2014). See FSB (2019), Lee et al. (2019), Kundu (2020), and Marsh and Virmani (2022), along with the other references in this section, for detailed market descriptions.

The importance of loan-servicing costs for loan securitization. One might wonder what incentives do banks have to syndicate loans and/or trade them on a secondary market. The literature has identified several reasons for it, some obvious and some subtle. When several banks hold parts of a single loan, each of them has a smaller exposure to the loan, which serves to share the risk between banks (Wilson, 1968; Chowdhry and Nanda, 1996). Another reason for the existence of syndication might be because such a loan arrangement is the most efficient one to deal with moral hazard and adverse selection issues (Pichler and Wilhelm, 2001). Indeed, when several banks co-manage a loan, they can monitor the lead arranger to ensure that it does not systematically syndicate the most risky loans and that it does not shirk on its monitoring functions. A related hypothesis is that banks syndicate loans because that helps them specialize and therefore save on loan-servicing costs. In particular, Das and Nanda (1999) put forth that hypothesis by showing that syndication is an efficient way for banks to specialize optimally. Lastly, the literature has speculated that banks engage in syndication because of capital and regulatory requirements, as pointed out by Simons (1993).

Empirically, there is much support for the latter two hypotheses, according to which banks securitize loans to save on loan-servicing costs such as balance sheets and monitoring costs. For example, Simons (1993) and Jones et al. (2005) show that more capital constrained banks retain smaller portions of the loan; Buchak et al. (2024) find that banks shift their lending activities towards loans they can sell when their capitalization declines; François and Missonier-Piera (2007) find evidence that banks share the cost of managing the syndicate.[11] Following the seminal works of Diamond (1984) and Fama (1985), there are ample examples in the literature that emphasize the role of banks as monitors. Most closely related to our research question are papers which have examined the monitoring role of banks in the context of loan syndication. For instance, Berlin et al. (2020) find that borrowers in the leveraged loan market are still subject to financial covenants and monitoring; Plosser and Santos (2016) find that both the lead originator and syndicate participants engage in monitoring and that more economically significant loans are associated with more monitoring; Sufi (2007) finds that

[11] These findings are in accordance with the extensive empirical support that balance sheet costs impose a significant burden for banks in practice. For example, Koont and Walz (2021) show that relaxing the Supplementary Leverage Ratio in 2020 led to a shift in banks' loan supply schedule; Bordo and Duca (2018) show that the Dodd-Frank Act has negatively impacted small business lending; Kovner and Van Tassel (2022) empirically establish a link between the regulatory requirements in the Dodd-Frank Act, the cost of capital for banks, and ultimately the supply and pricing of loans; Berger and Udell (1994) find that more stringent leverage requirements and tighter loan portfolio examination criteria negatively impacted the supply of commercial loans; Bridges et al. (2014) find than an increase in capital requirements leads to a decrease in supply of commercial loans in the UK.

the lead bank retains higher share of the loan and forms more concentrated syndicate when the borrower requires more intense monitoring and due diligence; Wang and Xia (2014) find that banks exert less ex-post monitoring effort on securitized loans; Gustafson et al. (2021) find a positive correlation between the portion retained by the lead arranger and monitoring activity, as well as that about half of syndicated loan borrowers provide information to the lender at least on a monthly basis and about a fifth of loans involve active monitoring.[12]

Taken as a whole, the empirical evidence suggests that the bank's function as a monitor is important whether or not the loan is syndicated. All syndicate participants share in on the monitoring, servicing, and balance sheet costs of the loan (Plosser and Santos, 2016); however, the larger the portion of the loan retained by a bank the more effort on monitoring it exerts. Moreover, as some authors have pointed out, sharing in on the costs of the loan is the reason why banks syndicate loans in the first place (Simons, 1993). Thus, in order to capture a realistic motive for banks to participate in the secondary loan market in our theoretical framework we introduce loan-servicing costs for banks which are strictly increasing in the portion of the loan the bank retains on its balance sheet.[13]

2 Simplified Model and Theoretical Mechanisms

We begin by laying out a simple model which we employ to study the main theoretical channels connecting financial and real variables analytically. The model is essentially the economy of Wasmer and Weil (2004) (WW henceforth) with two extensions: i) banks face loan-servicing costs when they provide loans to entrepreneurs and ii) banks have the option to securitize and sell part of the loan in a secondary market at an exogenous price.[14] We also derive the steady-state elasticity of labor market tightness with respect to productivity shocks and show how it is affected by the inclusion of loan-servicing costs and the option to sell part of the loan in the secondary market. This derivation extends the approach of Ljungqvist and Sargent (2017) to our economy and places our model in the context of the labor search and matching literature. The model of this section is a stripped down version of

[12]Active monitoring is a costly action taken by the bank or third-party appraisers that includes regular borrower site visits.

[13]In our model agents are risk neutral, so we do not take into account the motive for banks to share in on the risk of managing the loan. In this regard, we follow the vast majority of the search literature, which abstracts its discussion from risk.

[14]We abstract away from general equilibrium effects in this section because it allows us to derive a series of analytical results in closed form. We study the complete general equilibrium effects numerically in Section 5.

the richer model which we introduce in Section 3 and then calibrate and use for quantitative analysis in Sections 4 and 5.

2.1 Environment

Time, agents, and preferences. Time is continuous and runs forever. The economy is populated by continuums of three types of agents: workers, entrepreneurs, and bankers. The mass of workers is exogenously fixed, while the masses of entrepreneurs and bankers are determined endogenously through free entry. All agents discount the future at rate r and enjoy linear utility over the numeraire good, with marginal utility normalized to one.

Job creation and production. Each entrepreneur has access to a productive project, i.e., a technology that produces a flow output $y > 0$. The technology requires one worker in order to be used. Workers can be hired in a frictional labor market à la DMP, where entrepreneurs must spend time and resources to open a vacancy and search for a suitable job candidate. Specifically, an entrepreneur attempting to find a worker faces a pecuniary flow search cost χ. Following Pissarides (2000), we assume that matching is random and occurs through the means of a matching function $M^L(\mathcal{U}, \mathcal{V})$, where $\mathcal{U}$ is the number of unemployed workers and $\mathcal{V}$ is the number of vacancies. We further follow the literature and assume that the matching technology exhibits constant returns to scale and is strictly increasing in both arguments (see, e.g., Petrongolo and Pissarides 2001). The matching rate for entrepreneurs is $q(\theta) \equiv M^L(\mathcal{U}, \mathcal{V})/\mathcal{V} = M^L(\mathcal{U}/\mathcal{V}, 1)$, where $\theta \equiv \mathcal{V}/\mathcal{U}$ represents the labor market tightness. Symmetrically, this implies that the job-finding rate for a worker is $\theta q(\theta)$. The wage paid by an entrepreneur to a worker, w, is fixed exogenously.[15] Operating projects are terminated at Poisson rate s, in which case the entrepreneur and the worker separate.

Financing. As in WW, entrepreneurs are liquidity constrained and cannot self-finance the costly job-filling search activities. Each banker has deep pockets and the ability to issue exactly one loan to an entrepreneur. The credit market is subject to search and

[15] Although wages are often determined by bilateral bargaining in search-theoretic models of the labor market, we prefer to abstract from this mechanism here. Indeed, as shown by Wasmer and Weil (2004) and Petrosky-Nadeau and Wasmer (2013), this assumption facilitates the identification and analysis of the theoretical mechanisms of the model in a clean and intuitive way. Highlighting the theoretical mechanisms between secondary financial markets and real economic variables is one of our main goals, hence this approach seems appropriate. In addition, even if wages were bargained over, the resulting general equilibrium effects would be unlikely to alter our numerical results significantly. The equilibrium wage would be an increasing function of labor market tightness operating through exactly the same channels as the tightness does.

matching frictions similar to the frictions present in the labor market: it takes time and effort for entrepreneurs to secure financing and for banks to find and screen suitable projects to finance.[16] Entrepreneurs searching for financing incur a non-pecuniary flow search cost c. Bankers searching for a worthwhile project to finance incur flow costs κ, which can be interpreted as the cost of screening applicants and keeping liquidity idle.[17] Matching between bankers and entrepreneurs occurs randomly and is represented by the matching function $M^C(\mathcal{B}, \mathcal{E})$, where $\mathcal{B}$ and $\mathcal{E}$ are the mass of banks and the mass of entrepreneurs respectively. The matching function satisfies the usual properties: it is increasing, concave in both arguments, and exhibits constant returns to scale. We denote the matching rate for entrepreneurs by $p(\phi) \equiv M^C(\mathcal{B}, \mathcal{E})/\mathcal{E} = M^C(1/\phi, 1)$, where $\phi \equiv \mathcal{E}/\mathcal{B}$ is the credit market tightness. Symmetrically, the matching rate for banks is given by $\phi p(\phi)$. When a banker and an entrepreneur match, they bargain bilaterally over the terms of the loan, where the contract specifies the flow repayment R that the entrepreneur will owe once production begins.[18] Finally, when the separation shock s hits, the credit relationship is also terminated.[19]

Loan-servicing costs and securitization. A bank which carries a loan with principal L on its books incurs loan-servicing costs equal to $\xi(L)$ per unit of the loan, with $\xi(L) = \tilde{\xi} L^{\epsilon}$ and $\tilde{\xi}, \epsilon > 0$.[20] Moreover, banks have the ability to securitize the loans: they split the original asset, which promises a flow repayment R until maturity, into R units of a new asset that repays a flow unit of the numeraire good until maturity. The bank optimally chooses what fraction of these securities to sell and keeps the remaining on its books, trading off the opportunity cost of the foregone yield and the benefit of saving on the loan-servicing costs. In the full model, we model the secondary loan market as an OTC market in the spirit of Duffie et al. (2005). For this section, however, we assume that the unit price of loan securities, P, is exogenously fixed and bounded above by $1/(r+s)$.

[16] Indeed, there is much empirical evidence that bank lending to firms is subject to credit frictions. For a discussion see Gabrovski and Ortego-Marti (2022).

[17] See Gabrovski and Ortego-Marti (2021b) for a review of the findings from the literature on the connection between banks' liquid asset holdings and their ability to extend loans.

[18] Note that R can be interpreted as encompassing both the principal and the interest.

[19] This is obviously an unrealistic assumption, since it perfectly ties the life of the loan with the life of the job. However, it simplifies the exposition considerably without substantially altering the qualitative results and the underlying economic intuition. We relax this assumption in Section 3, where we consider job termination and loan maturity shocks separately.

[20] As in the data, the existence of loan-servicing costs in the model creates an incentive for banks to syndicate loans; see the literature surveyed in the "Market Background" paragraph of Section 1.

Value functions. The life of a project begins with an entrepreneur searching for financing in the credit market. The discounted lifetime value of doing so is denoted by E_C and is given by

$$rE_C = -c + p(\phi)(E_V - E_C). \tag{1}$$

The entrepreneur pays the flow search cost c for every instant spent searching in the credit market. At a rate $p(\phi)$, she finds financing and transitions to the labor market to search for a worker. The lifetime discounted value of searching for a worker is given by E_V, which satisfies

$$rE_V = q(\theta)[E_J(R) - E_V]. \tag{2}$$

Since the entrepreneur does not pay for any of the search costs in the labor market, E_V is comprised of the matching rate $q(\theta)$ and the capital gain the entrepreneur can expect after matching with a worker. This capital gain corresponds to the value of having a newly created job and being liable for a flow loan repayment R, $E_J(R)$, net of the value of having an open vacancy, E_V. The notation $E_J(R)$ makes explicit that the value of an operating job depends on the negotiated repayment. Specifically, it is given by

$$rE_J(R) = y - w - R - sE_J(R). \tag{3}$$

The flow profits that the entrepreneur enjoys are given by the output y net of the wages w and the loan repayment R. At a rate s the project is permanently terminated, the value of the job is lost, and the entrepreneur leaves the market.

The life of a loan begins with a bank looking to finance a new project. The value for a bank of being in this stage is denoted by B_C and is given by

$$rB_C = -\kappa + \phi p(\phi)(B_V - B_C). \tag{4}$$

At a rate $\phi p(\phi)$, the bank meets an entrepreneur and extends credit to her. In that event, the bank has to fund the labor market recruitment costs for a vacancy, which has a value B_V. The lifetime discounted value of financing a vacancy B_V is given by

$$rB_V = -\chi + q(\theta)\left[\max_{\tau\in[0,1]}\{B_J(\tau) + P(1-\tau)R\} - B_V\right]. \tag{5}$$

The bank has to finance the vacancy's search activities, hence it experiences a flow cost $-\chi$. At a rate $q(\theta)$, the entrepreneur finds a worker and production begins. In that event, the bank experiences a capital gain due to being owed the loan repayment. The bank can securitize the repayment she is owed, R, optimally choosing the fraction $\tau \in [0,1]$ to keep on the books, while selling the fraction $(1-\tau)$ to investors in the secondary loan market at a price P per unit. The bank's lifetime discounted value of keeping a fraction τ of the asset on the balance sheet, $B_J(\tau)$, is given by

$$rB_J(\tau) = [1-\xi(\tau L)]\tau R - sB_J(\tau). \tag{6}$$

For a fraction τ of the asset kept on the books, the bank receives the flow repayment net of the loan-servicing costs until the underlying project is terminated at Poisson rate s.

Bargaining. The negotiated repayments the entrepreneur makes to the banker solve

$$R = \arg\max \left[B_V - B_C\right]^{\alpha_C} \left[E_V - E_C\right]^{1-\alpha_C}, \tag{7}$$

where $\alpha_C \in [0,1]$ is the bargaining power of the bank.

The evolution of unemployment. Unemployment evolves in our economy in the same way it does in the baseline DMP model. The flow into the pool of unemployed is simply all employed workers $(1-\mathcal{U})$ times the separation rate s; the flow out of unemployment is the mass of unemployed $\mathcal{U}$ times the job-finding rate $\theta q(\theta)$. Formally,

$$\dot{\mathcal{U}} = s(1-\mathcal{U}) - \mathcal{U}\theta q(\theta). \tag{8}$$

2.2 Mechanisms

Banks' optimal portfolio choice. To begin with, we derive the optimal fraction of the loan banks choose to securitize, taking the size of the loan L and the repayment R as given. Substituting (6) into (5) leads to the following problem:

$$B_V = -\frac{\chi}{r+q(\theta)} + \frac{q(\theta)}{r+q(\theta)} R \left\{ \max_{\tau\in[0,1]} \{\tau \frac{1-\xi(\tau L)}{r+s} + P(1-\tau)\} \right\}.$$

The solution for the optimal fraction of the asset the bank will keep on its books, τ^*, is given by the following expression and depicted graphically in Figure 1a:

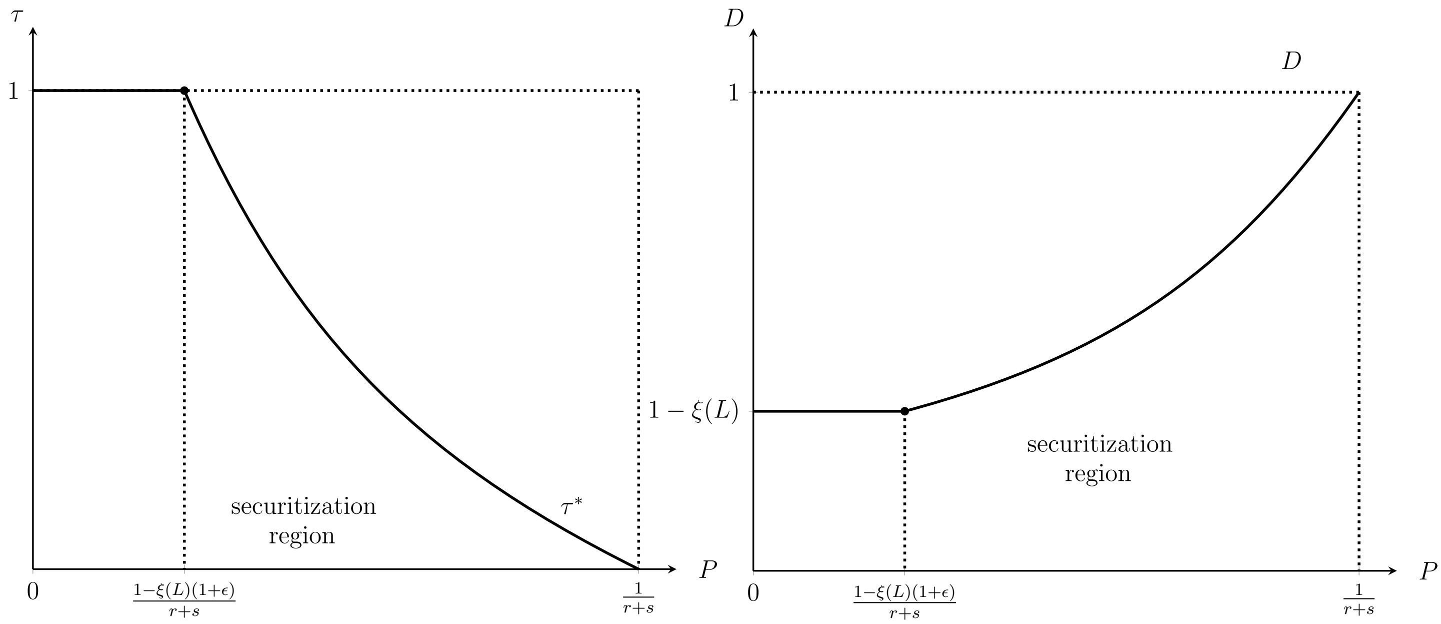
$$\tau^* = \begin{cases} 1 & \text{if } P \leq [1 - \xi(L)(1+\epsilon)]/(r+s), \\ \left[\frac{1-(r+s)P}{(1+\epsilon)\tilde{\xi}L^\epsilon}\right]^{\frac{1}{\epsilon}} & \text{if } [1 - \xi(L)(1+\epsilon)]/(r+s) < P < 1/(r+s), \\ 0 & \text{if } P = 1/(r+s). \end{cases} \tag{9}$$

In words, if the secondary market price is too low compared to the loan-servicing costs, the bank keeps the whole asset on its books ($\tau^* = 1$). Symmetrically, if the securitization price is high enough, the bank securitizes the whole loan and does not keep any on its balance sheet ($\tau^* = 0$). In the intermediate case, the fraction τ^* is a decreasing function of both the secondary market asset price and the size of the loan. Substituting the intermediate τ^* in the cost function yields:

$$\xi(\tau^* L) = [1 - (r+s)P]/(1+\epsilon). \tag{10}$$

That is, banks adjust their portfolios such that the asset price is the main determinant of loan-servicing costs at the optimum.

A complementary way to understand banks' behavior is to focus on the additional flow utility the bank would receive from a marginal increase in repayment R. We denote this object by D and, from the envelope theorem, we can express it as: $D \equiv \tau^*[1 - \xi(\tau^* L)] + (1-\tau^*)P(r+s)$. Intuitively, the existence of a secondary market allows banks to save on loan-servicing costs which affects the marginal utility of an additional unit of repayment. To see this, we graph in Figure 1b the bank's marginal utility D for different price levels, keeping the size of the loan fixed. When the price is too low, the bank keeps all of the loan on its books ($\tau^* = 1$) and, as a result, an increase in P does not affect the bank's loan-servicing costs, nor its marginal utility. Observe that in this non-securitization region, D attains its lowest value. At the securitization cut off $P = [1 - \xi(L)(1+\epsilon)]/(r+s)$, the marginal utility of keeping a unit of the loan on its books versus selling it to the secondary market are exactly equal. At that point, an increase in the price induces the bank to offload more of the loan, which lowers the loan-servicing costs: the slope $dD/dP = (1-\tau^*)(r+s)$ is positive, since $\tau^* \leq 1$. In the securitization region ($\tau^* < 1$), a higher price in the secondary market induces banks to securitize a larger fraction of the loan which, in turn, leads to a greater marginal utility D due to the lower loan-servicing costs. D attains its largest value of 1 when the bank securitizes the whole loan and eliminates the loan-servicing costs ($\tau^* = 0$). Overall, the existence of a secondary OTC market mitigates the size of loan-servicing costs and increases



(a) Optimal portfolio choice

(b) Marginal utility

Figure 1: Bank optimal portfolio choice and marginal utility.
Panel (a) shows banks' optimal portfolio choice, τ^* as a function of the asset price P. For low levels of P the bank chooses to keep all of the asset on its books. As P increases, it enters the securitization region where some of the asset is offloaded. The higher the price the less of the asset is kept on the banks' balance sheet. When the price reaches $1/(r+s)$, the bank chooses to securitize all of the asset. Panel (b) depicts the resulting additional flow utility, D, from a marginal increase in repayment, R, as a function of the secondary market price, P. In the securitization region, as the price increases banks choose to off-load more of the asset which allows them to save on loan-servicing costs. This leads to an increase in the marginal utility flow D. At $P = 1/(r+s)$ the bank securitizes all of the asset and its marginal utility flow from an extra unit of repayment R is 1.

the surplus of the joint entrepreneur-bank venture.

Credit and labor market tightness. Given the bank's optimal choice τ^*, one can then derive the equilibrium conditions which determine the credit and labor market tightness, θ and ϕ respectively, following the analysis in WW. We find this approach useful because our environment extends the economy of WW. Comparing the two economies highlights the economic implications of the novel features of our model in a transparent way. The first step is to properly manipulate the entrepreneurs' and banks' value functions. Using (3), the firm's flow value when it has a loan with repayment R is given by the discounted expected revenue net of wages and future loan repayments, i.e. $E_J(R) = (y-w-R)/(r+s)$. We can substitute this expression into (2) and substitute the optimal bank portfolio choice into (5) to derive:

$$E_V = \frac{q(\theta)}{r+q(\theta)} \frac{y-w-R}{r+s}, \tag{11}$$

$$B_V = \frac{q(\theta)}{r+q(\theta)} \left[\frac{R}{r+s} D - \frac{\chi}{q(\theta)} \right]. \tag{12}$$

Adding (11) and (12) yields the joint surplus of an entrepreneur-bank match (which also coincides with the value of a vacancy), denoted by Σ:

$$\Sigma = \underbrace{\frac{q(\theta)}{r+q(\theta)} \left[\frac{y-w}{r+s} - \frac{\chi}{q(\theta)} \right]}_{\text{surplus in WW}} - \underbrace{\frac{q(\theta)}{r+q(\theta)} (1-D) \frac{R}{r+s}}_{\text{discounted loan-servicing cost}}. \tag{13}$$

Equation (13) allows for a direct comparison with the corresponding surplus equation (17) in Wasmer and Weil (2004). In both models, the principal of the loan just covers the discounted vacancy cost: $L = \chi/q(\theta)$. In WW, the surplus is a discounted value of the expected firm profits $(y-w)/(r+s)$ net of the labor search costs $\chi/q(\theta)$. In our economy, the surplus also includes the bank's loss of utility due to loan-servicing costs, as captured by the last term in the equation. Every unit of repayment R that is negotiated lowers the entrepreneur's utility by a unit. At the same time, however, the bank only receives $D \leq 1$ units of extra utility. Hence, each negotiated unit of repayment leads to a $1-D$ units of loss in the joint entrepreneur-bank surplus. Over the lifetime of the loan this amounts to $(1-D)R/(r+s)$ units of cumulative surplus loss. In contrast, the repayment R is a pure transfer from the entrepreneur to the bank in the WW economy, thus it does not affect the joint surplus. The surplus in our model converges to that in the WW economy when the price in the secondary market becomes high enough to incentivize the bank to securitize the entire loan (in which case $\tau^* = 0$ and $D = 1$). Again, access to a secondary market with a favorable price allows banks to mitigate the loan-servicing costs and increases the bank-entrepreneur surplus (i.e., the value of a vacancy).

Next, we characterize the repayment R as a function of the labor market tightness. Solving for the Nash Bargaining problem in (7) implies the following split of the surplus:

$$E_V = \frac{1-\alpha_C}{1-\alpha_C(1-D)} \Sigma, \tag{14}$$

$$B_V = \frac{D\alpha_C}{1-\alpha_C(1-D)} \Sigma, \tag{15}$$

where E_V and B_V represent the surpluses of the entrepreneur and the bank, since $E_C = B_C = 0$ due to of free entry. In the WW economy $D = 1$, hence the two parties split the surplus according to their respective bargaining powers. Once loan-servicing costs are introduced, the effective bargaining strengths of both the entrepreneur and the bank change to reflect this new feature. As D decreases, the bank keeps a larger part of the loan on its books and receives a smaller part of the surplus: the higher loan-servicing costs put a larger burden on the match surplus from each additional unit of repayment and the bank has to settle for less.[21]

Plugging in the expressions for E_V and B_V from (2) and (5) yields the equilibrium solution for the loan repayment:

$$R = \alpha_C(y - w) + \frac{(1 - \alpha_C)(r + s)}{D} \frac{\chi}{q(\theta)}. \tag{16}$$

The equilibrium loan repayment is the weighted average of two terms. The first is the firm's net revenue minus the entrepreneur's outside option (recall that free entry drives the entrepreneur's search value E_C to zero). This term represents the maximum repayment the entrepreneur could make while keeping a non-negative surplus. The second term is the principal of the loan, $\chi/q(\theta)$, divided by the bank's marginal utility. That term can be interpreted as the minimum repayment the entrepreneur could make to leave the banker whole. Because both the banker and the entrepreneur have positive bargaining power, the negotiated repayment falls in between the minimum and the maximum values it could take. When $D < 1$, the repayment is higher than that in the WW economy for a given labor market tightness θ: intuitively, bargaining imposes that the entrepreneur and the bank share the burden of the loan-servicing costs, effectively akin to a lower interest rate.

The last step of the WW methodology consists of deriving the EE and BB locii, which operate in a similar fashion as the job-creation condition in the benchmark DMP model (Pissarides, 2000) to determine equilibrium labor and credit market tightness. The EE locus equalizes the entrepreneur's cost of searching for credit with the expected value of obtaining such credit. Free entry of entrepreneurs ensures this condition holds: were search costs less than their expected value, more entrepreneurs would enter the market, increasing competition for banks, and thereby driving the cost of credit up until the net value of entering is zero. Similarly, the BB locus equalizes the cost for a bank to finance a project with the expected value of providing such financing—and the free entry of bankers ensures that this

[21] In other words, for a given principal, the bank is not able to negotiate as high an interest rate on the loan.

condition holds in equilibrium.

Algebraically, free entry applied on the Bellman equations (2) and (5) yields expressions for E_V and B_V as functions of credit market tightness:

$$E_V = c/p(\phi), \tag{17}$$

$$B_V = \kappa/[\phi p(\phi)]. \tag{18}$$

We substitute R into (11) and (12) and equate them with the expressions in (17) and (18) to derive the EE and BB locii:

$$\text{EE}: \quad \frac{c}{p(\phi)} = (1-\alpha_C)\frac{q(\theta)}{r+q(\theta)}\left[\frac{y-w}{r+s} - \frac{1}{D}\frac{\chi}{q(\theta)}\right], \tag{19}$$

$$\text{BB}: \quad \frac{\kappa}{\phi p(\phi)} = D\alpha_C\frac{q(\theta)}{r+q(\theta)}\left[\frac{y-w}{r+s} - \frac{1}{D}\frac{\chi}{q(\theta)}\right]. \tag{20}$$

These two equations jointly determine θ and ϕ in equilibrium conditional on P. Using the language of Wasmer and Weil (2004), BB represents a credit creation condition and EE a job creation condition. Moreover, we follow WW and represent the system of equations (19) and (20) graphically as a pair of contour lines in the (θ, ϕ) plane along which banks and entrepreneurs make zero profit due to free entry (Figure 1 in their paper). As Figure 2 shows, both in the WW model and our model, EE has a positive and BB has a negative slope: as ϕ decreases, θ has to increase to keep the bank's profit constant (BB curve) or, symmetrically, θ has to decrease to keep the entrepreneur's profit constant (EE curve). The equilibrium of the model is given by the intersection of the two curves. We now proceed to study the differences in equilibrium credit and labor market tightness between the two models.

The impact of loan-servicing costs and secondary loan trading on the market tightness. Having solved for the model equilibrium, we now compare the levels of credit and labor market tightness in our economy with their corresponding levels in the WW economy. Again, this is a useful exercise because the WW economy corresponds to our economy with neither loan-servicing costs nor a secondary loan market. To do so, we compare the equilibrium conditions (19) and (20) to those in the WW economy (equations (15) and (16) in their paper): the only difference is the term D, the marginal utility the bank receives from an extra unit of repayment. This marginal utility reflects the novel elements of our model with respect to the WW model, namely the loan-servicing costs and the banks' ability to securitize loans. On the one hand, the loan-servicing cost tends to lower D because it makes it relatively more expensive for the entrepreneur to compensate the bank for the credit it has extended, which, in turn, reduces the joint surplus of the bank-entrepreneur venture. On the other hand, a higher secondary market price tends to increase D because it allows banks to offload part of the loan and save on loan-servicing costs. In total, the existence of a secondary market brings our model closer to the WW economy because it helps banks alleviate the effects of the loan-servicing costs. The two economies coincide when the secondary market price is large enough for the entire loan to be securitized, in which case loan-servicing costs are zero.

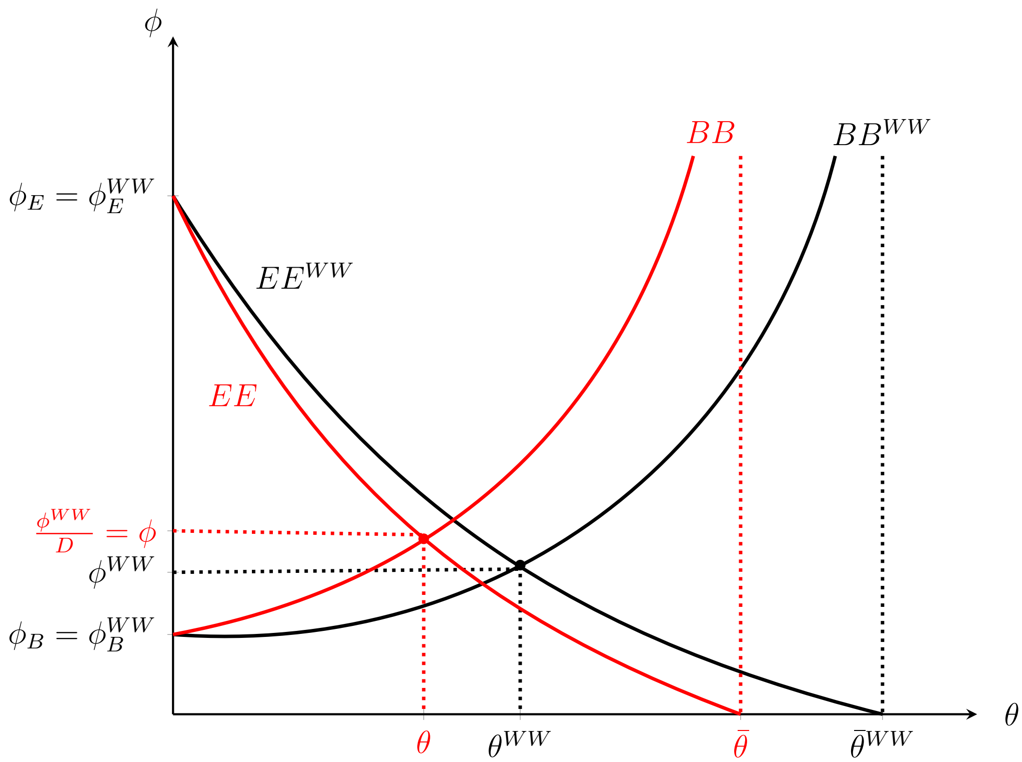


Figure 2: Equilibrium labor and credit market tightnesses.

The figure shows the equilibrium credit and labor market tightnesses in our economy (black) and in the Wasmer and Weil (2004) economy (red). Equilibrium in our economy occurs at the the intersection of the EE and BB locii given by (19) and (20). A higher labor market tightness implies a longer time to recruit a worker, which in turn translates to a higher loan principal. Thus, it is more expensive for banks to finance the joint bank-entrepreneur venture. They need to be compensated with a higher matching rate in the credit market, resulting in an upward-sloping BB locus. The entrepreneur also endures part of the higher funding costs (through Nash bargaining), so they require a higher match rate as well, and the EE locus is downward sloping. The EE^{WW} and BB^{WW} are the locii in the Wasmer and Weil (2004) economy, which can be derived by plugging in $D = 1$ in (19) and (20) in our model.

Graphically, the existence of loan-servicing costs in our model shifts both the EE and BB locii to the left compared to the WW model. To explain these shifts, let us begin with the EE locus, as defined by (19). The relative bargaining power of the entrepreneur remains unaffected by the existence of loan-servicing costs, hence the only change in this locus compared to the WW model comes from the higher burden of the search costs (the $1/D$ term in the bracket). For positive values of θ, the larger search costs translate into larger loans to entrepreneurs, since these costs are financed by bank credit. As the principal of the loan $(\chi/q(\theta))$ increases, the bank faces higher loan-servicing costs $(1-D)R$ which shift the EE locus to the left of that of the WW economy, denoted with EE^{WW}. Notice that for $\theta \to 0$, the search costs approach 0 as well, hence the EE locus converges to EE^{WW}. Similarly, as $\theta \to 0$, the BB locus converges to that of the WW economy, denoted with BB^{WW}. For positive values of θ, the total match surplus Σ decreases faster than that in the WW economy (equation (13)) and the bank's relative bargaining power, $D\alpha_C$, decreases as well. This shifts the BB locus to the left of BB^{WW}. In total, this graphical analysis implies that labor market tightness in our economy is smaller than in the WW economy, $\theta \leq \theta^{WW}$. The inequality is strict as long as the secondary market price is not large enough to incentivize banks to securitize loans in their entirety. We provide an analytical proof of that result in Appendix A.

The graphical analysis does not allow for a clear-cut comparison between the magnitude of credit market tightness in our model vis-a-vis the WW model. However, we can easily show that ϕ is larger in our model than in the WW economy (as depicted in Figure 2). To begin with, plugging (17) and (18) in the Nash bargaining protocol yields the following expression for the credit market tightness:

$$\phi = \frac{1}{D}\frac{(1-\alpha_C)}{\alpha_C}\frac{\kappa}{c} = \frac{\phi^{WW}}{D}, \tag{21}$$

where we have substituted in the expression for credit market tightness in the WW model, ϕ^{WW} (Proposition 1 in their paper). Because of loan-servicing costs, the marginal utility D is less or equal to one in our economy contingent upon the magnitude of the secondary market price P. Consequently, the equilibrium tightness in the credit market is larger (or equal for a large P) in our model than in the WW model. As (13) shows, the surplus of a bank-entrepreneur match in our economy is lower than in the WW economy due to the existence of loan-servicing costs. This lowers entry for both banks and entrepreneurs. However, the less-than-unit marginal utility also lowers the bank's effective bargaining power (equations

(14) and (15)). Thus, banks have an even lower incentive to enter, which results in a greater credit market tightness relative to the WW economy. To sum up, $\phi \geq \phi^{WW}$, with a strict inequality as long as the secondary market price is not large enough to incentivize banks to securitize the entire loan.

In summary, loan-servicing costs tend to depress the labor market tightness because they reduce the joint entrepreneur-bank venture surplus. Moreover, the bank tends to carry a higher fraction of the loan-servicing cost burden, thus loan-servicing costs tighten credit, i.e. ϕ is higher. The existence of a secondary loan market offers banks the option to securitize some (or all) of the loan. If the asset price P is high enough, banks sell part of the loan off their books, which allows them to save on loan-servicing costs. This tends to increase the joint entrepreneur-bank surplus by mitigating the impact of loan-servicing costs, and subsequently loosen credit conditions for firms. As a result, the secondary loan market increases the labor market tightness θ. Just like in the DMP model, equilibrium unemployment in our model is given by the Beveridge curve $u = s/[s + \theta q(\theta)]$, and thus decreasing in θ. Hence, the steady-state unemployment level in our economy is lower than that in a hypothetical economy without a secondary loan market.[22]

2.3 Loan-servicing costs as an automatic stabilizer

Finally, we study how the existence of loan-servicing costs and a secondary loan market affect the propagation of labor productivity shocks in our economy. As Wasmer and Weil (2004) show, credit frictions generate a financial accelerator that amplifies the impact of productivity shocks. The presence of loan-servicing costs and a secondary loan market in our model has important implications for the model's response to real shocks. On one hand, loan-servicing costs dampen the financial accelerator, thereby acting as an automatic stabilizer that reduces the economy's response to real shocks in comparison to the WW model. On the other hand, access to a secondary loan market mitigates this stabilizing effect. Hence, the simplified model economy with a secondary market exhibits *smaller* responses to productivity shocks than the WW economy but *larger* responses than a hypothetical economy without loan securitization.

To provide an analytically tractable proof of these results, we follow the methodology of Ljungqvist and Sargent (2017) to derive the elasticity of labor market tightness with respect

[22] At the limit when the secondary loan price is exactly high enough for loans to be entirely securitized, $P(r + s) = 1$, the unemployment rate converges to the same level as in an economy without loan-servicing costs (i.e., the WW economy).

to labor productivity. As shown by Ljungqvist and Sargent (2017) (equation (44) in their paper), the elasticity of θ with respect to y in the WW economy is given by

$$\varepsilon_{\theta,y}^{WW} = \frac{1}{\eta_L} \frac{y}{y - w - s\frac{c}{(1-\alpha_C)p(\phi)}}, \tag{22}$$

where η_L is the elasticity of the matching function with respect to unemployment, and we set $r = 0$ as in Wasmer and Weil (2004) to facilitate an easier comparison between the two models.[23] In the language of Ljungqvist and Sargent (2017), the elasticity is equal to the inverse of the elasticity of the labor market matching function $1/\eta_L$ times the inverse of the fundamental surplus. The smaller the fundamental surplus, the larger the response of the market tightness to changes in labor productivity. In the WW model, the fundamental surplus is the worker output net of wages and the annualized search costs faced by the entrepreneur. These search costs reduce the fundamental surplus (as they lower the surplus of a bank-entrepreneur match) and amplify the impact of productivity shocks; that is, search costs in the credit market generate a financial accelerator.

The calculation of the corresponding $\varepsilon_{\theta,y}$ elasticity in our model is more involved because the marginal utility D is also a function of labor market tightness θ (as θ affects the loan principal through hiring costs). Importantly, the elasticity of D with respect to θ is negative: a tighter labor market increases hiring costs, which, in turn, raise the loan principal and the loan-servicing costs. The higher loan-servicing costs lower the bank's marginal utility D, which implies that $\varepsilon_{D,\theta} < 0$. To calculate $\varepsilon_{\theta,y}$ in our model, we totally differentiate (19) and (21) with respect to y:

$$\varepsilon_{\theta,y} = \frac{1}{\eta_L} \frac{y}{y - w - \frac{sc}{(1-\alpha_C)p(\phi)} - \frac{\varepsilon_{D,\theta}}{\eta_L}[y - w - (1-\eta_C)\frac{sc}{(1-\alpha_C)p(\phi)}]}. \tag{23}$$

Given that $\varepsilon_{D,\theta} < 0$, the last term in the fundamental surplus is positive. Thus, the fundamental surplus is higher than that of the WW model, which implies that the impact of real shocks is smaller in our model than in the WW economy. The last term in the fundamental surplus represents the automatic stabilizer, whose magnitude determines the difference in the responses between the two models.

It is instructive to dig deeper into the elasticity $\varepsilon_{D,\theta}$ and provide its algebraic expression.

[23] It is straightforward to derive this equation by substituting $D = 1$ and $r = 0$ into (19), totally differentiating with respect to y, and using the expression for ϕ from (21). Alternatively, setting $D = 1$, $r = 0$, and using (21) implies that the k term in equation (44) of Ljungqvist and Sargent (2017) is equal to $sc/[p(\phi)(1 - \alpha_c)]$.

Let us begin with the case when the secondary loan market price is too low and banks do not securitize any loans. Then, $D = 1 - \xi(L)$ and $\varepsilon_{D,\theta} = -\eta_L \xi(L)\epsilon/(1 - \xi(L))$. In this case, the elasticity $\varepsilon_{D,\theta}$ reaches its maximum (in absolute value) and the impact of the automatic stabilizer is maximized. Next, assume that the secondary market price is high enough that at least a fraction of the loans are securitized. Since P is fixed, the impact of an increase in θ on D is captured by $\varepsilon_{D,\theta} = -\eta_L \tau\xi(\tau L)\epsilon/[\tau(1 - \xi(\tau L)) + (1 - \tau)P(r + s)]$. This expression is analogous to the no securitization case but of a smaller magnitude since $\tau\xi(\tau L)\epsilon/[\tau(1 - \xi(\tau L)) + (1 - \tau)P(r + s)] < \tau\xi(\tau L)\epsilon/[\tau(1 - \xi(\tau L))] < \xi(L)\epsilon/(1 - \xi(L))$. Intuitively, following an increase in labor productivity, the principal amount of the loan increases and raises the banks' loan-servicing costs. Since banks sell a part of the loan to the secondary market, however, they have a tool at their disposal to mitigate the increase in loan-servicing costs. Hence, for a given loan amount, D does not decrease as much as in the no securitization case and the impact of the automatic stabilizer is smaller. That is, an economy with loan-servicing costs but without a secondary loan market features smaller responses to productivity shocks (larger automatic stabilizers) than an economy with loan-servicing costs and a secondary loan market. In sum, the presence of a secondary loan market amplifies the economy's response to productivity shocks.

We stress that the preceding analysis applies to a partial equilibrium setting. When one analyzes the general equilibrium effects of a productivity shock on the economy there are two additional effects at play. First, for a given set of parameter values, the credit market tightness ϕ in our economy is larger than that in the WW world. Thus, in our economy the annualized credit search costs for the entrepreneur are larger, which tends to amplify the magnitude of business cycle fluctuations. Moreover, the presence of a secondary loan market mitigates this effect as it helps loosen credit conditions for entrepreneurs. Second, we have kept the asset price P fixed, even though a productivity shock will affect the asset supply, which will have an impact on prices. As we show in Section 5, this is a good approximation to a frictional secondary market where prices do not respond much to changes in supply. However, in a hypothetical economy with a frictionless secondary market prices adjust much more following a productivity shock. As a result, the banks' marginal utility D is more volatile than under a no-securitization economy, which ultimately leads to a lower magnitude of business cycle fluctuations. We explore the relative size of these effects quantitatively in Section 5.

3 Full Model

To gauge the quantitative importance of loan-servicing costs and banks' ability to securitize and sell loans on a secondary market, we develop a richer model that incorporates several key extensions of the environment presented in Section 2. First, we fully model the secondary loan market in the spirit of Duffie et al. (2005). This allows us to study the quantitative properties of a general equilibrium model where the price of loans on the secondary market and the supply of assets on said secondary market are both endogenous. Moreover, it allows us to quantitatively study the impact of financial frictions on the real economy. Second, we introduce the need for financing capital expenditures. Both newly-formed firms and existing firm-worker pairs require capital to produce, hence incumbent firms require external financing as well. Thus, in our richer model newly-created firms require vacancy loans to fund both labor search and capital expenditures, whereas incumbent firms require capital replacement loans to fund capital expenditures only. These features are both realistic and potentially relevant to capture quantitatively when calibrating the model to the data. In the remainder of this section, we detail the environment. In Appendix B, we derive the steady-state equilibrium of the model.

3.1 The markets for credit and labor

Capital and the need for financing for incumbents. Most of the environment relating to the labor and credit markets is the same as in Section 2. A point of departure is the introduction of capital. In this richer economy, entrepreneurs must hire a worker *and* purchase a unit of capital, costing F, in order to produce. The capital is embodied in the job: if the worker and the firm separate, the capital is destroyed. The rate of separations occurs at rate s_J. This rate is different that the rate at which loans mature, which we denote by s_C. Thus, it is possible for the entrepreneur to pay off the loan while she is still attached to the worker.

Provided that the firm does not already have an existing loan, its capital is hit by a negative depreciation shock with an exogenous Poisson rate σ. If the firm does have an existing loan, its capital is not subject to depreciation. This assumption keeps the model tractable — firms can have at most one active loan. Moreover, it is also consistent with the view of banks as monitors — as we have detailed in Section 1.1 banks exert a considerable effort ensuring that firms are maintaining their collateral and good business practices in general — which would incentivize firms to maintain their capital and/or protect it with

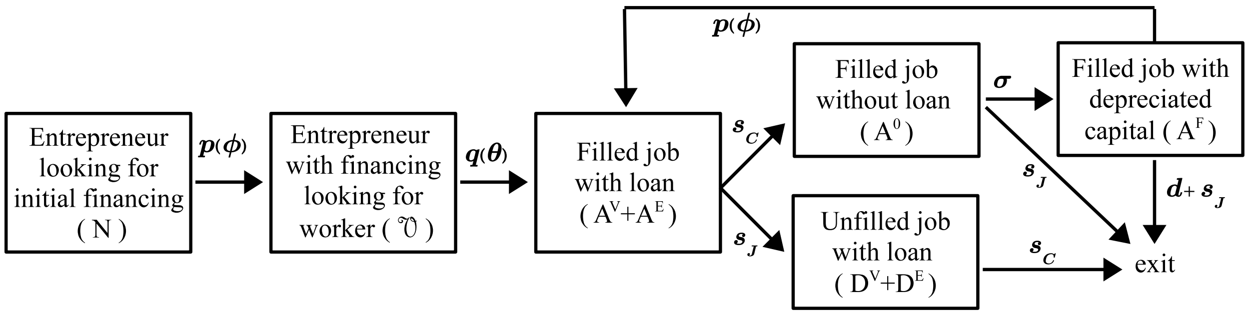


Figure 3: Life of a project.

The figure details the life of a project. New projects (N) begin their life as entrepreneurs looking for financing. At a rate $p(\phi)$ they obtain a loan and transition to labor market vacancies ($\mathcal{V}$). At a rate $q(\theta)$ the vacancy is filled and transition to a filled job with a vacancy loan (A^V). The firm and worker separate at rate s_J, resulting in a "dead" firm with a vacancy loan D^V. Once the loan matures, the firm exits. Alternatively, if the firm's loan matures before it separated with a worker, the firm transitions to a filled job without a loan (A^0). This firm is subject to depreciation shocks: at a rate σ it transitions to a firm looking for financing (A^F). If the firm manages to find financing before its worker separates or before its capital becomes completely inoperable, it transitions to a firm with an incumbent loan (A^E).

insurance.[24] Once a firm's capital experiences a depreciation shock, the firm must purchase a new unit or it risks its capital becoming completely inoperable, which happens at a Poisson rate d. If the firm fails to take a new loan to replace its capital, production stops and the match is destroyed. If the firm can secure financing, on the other hand, it continues production while repaying the new loan. The life of a project now takes a more involved form, depicted in Figure 3.

Value functions. The Bellman equations for entrepreneurs who are looking for financing, E_C, and looking for a worker, E_V, are still given by (1) and (2). However, once production starts, the firm may suffer either a loan maturity shock or a worker separation shock. Hence, the Bellman equation for E_J is now given by

$$rE_J(R_i) = y - w - R_i + s_C[E_J^0 - E_J(R_i)] - s_J\left[E_J(R_i) - E_N(R_i)\right], \tag{24}$$

where E_J^0 denotes the value of a firm that is matched with a worker but has no existing loan, $E_N(R)$ is the value of a firm that has separated with a worker but has an existing loan, and $R_i \in \{R_V, R_E\}$. We use the notation R_V to denote the repayment a bank negotiates with an entrepreneur looking to fill a vacancy and R_E the repayment it negotiates with an entrepreneur in an existing match. In equilibrium, the two will be different, reflecting

[24]For example, Gustafson et al. (2021) highlight that direct monitoring costs include collateral appraisals, field examinations, and collateral protection.

the heterogeneity in loan principals and outside options for incumbent versus newly-formed firms. The lifetime discounted value of operating the job after having repaid the original loan is given by

$$rE_J^0 = y - w + \sigma(E_J^F - E_J^0) - s_J E_J^0. \tag{25}$$

The entrepreneur still enjoys the flow profits $y - w$. The project is terminated at a rate s_J. In that event the value of the job is lost and the entrepreneur leaves the market. However, the firm's capital may depreciate at a rate σ. In that event the firm loses its value E_J^0 and transitions to the state of a filled job looking for financing with value E_J^F. That value is in turn given by the Bellman equation:

$$rE_J^F = y - w + p(\phi)[E_J(R_E) - E_J^F] - (s_J + d)E_J^F. \tag{26}$$

The firm can still produce output, but the capital is in a depreciated state and the project faces the risk of being terminated at the higher rate $s_J + d$. At a rate $p(\phi)$ the firm is matched with a bank that is willing to extend credit. In that event the firm transitions to producing with non-depreciated capital, but is burdened by the loan repayment R_E. Lastly, if the project and the worker separate before the entrepreneur has repaid the loan, the value of the project is given by

$$rE_N(R_i) = -R_i - s_C E_N(R_i). \tag{27}$$

Next, we turn to the Bellman equations for the value of the bank at different stages. Let us first focus on the stage at which the bank has an existing loan. Since loans can mature at a time different than the worker and the firm separate, the Bellman equation for $B_J(\tau)$ is given by

$$rB_J(\tau_i) = (1 - \xi(L_i))\tau_i R_i - s_C B_J(\tau_i), \tag{28}$$

with the only differences, as compared to (6) from the simplified model, being in the rate at which the loan matures, s_C, and the fact that the loan amount, L_i, and the fraction which the bank will choose to keep on its books, τ_i, will both depend on whether this is a vacancy creation loan or a loan to an existing firm.

We proceed to the value of a bank that is matched with an entrepreneur looking for a worker. Since firms need capital to operate, the bank has to extend a larger line of credit.

Thus, its value is now given by

$$rB_V = -\chi + q(\theta) \left[\max_{\tau \in [0,1]} \{ B_L(\tau_V L_V) + P(1-\tau_V) R_V \} - F - B_V \right]. \tag{29}$$

Lastly, we turn to the first stage of the matching process: banks looking for credit opportunities. In our extension incumbent firms are looking for financing as well, so the bank may match with either a new firm looking for a vacancy loan, or an existing firm looking for a capital financing loan. Thus,

$$rB_C = -\kappa + \phi p(\phi) \left\{ (1-\pi)(B_V - B_C) + \pi \left[\max_{\tau_E \in [0,1]} \{ B_L(\tau_E R_E) + P(1-\tau_E) R_E \} - F - B_C \right] \right\}. \tag{30}$$

At a rate $\phi p(\phi)$ the bank meets with an entrepreneur and extends credit to her. With probability π the entrepreneur is a new entrant, so the bank has to fund the labor market recruitment costs in addition to capital, which has a value B_V. With the complement probability, the bank meets with an entrepreneur who already has a worker but needs financing to replenish her depreciated capital. In that event the banker finances the costs of capital acquisition F and gets to securitize the loan into R_E pieces.

Bargaining. The bargaining problem faced by the bank and a new entrant and the one faced by the bank and the existing firm are given by:

$$R_V = \arg\max_R \left[B_V - B_C \right]^{\alpha_C} \left[E_V - E_C \right]^{1-\alpha_C}, \tag{31}$$

$$R_E = \arg\max_R \left[\max_{\tau_E \in [0,1]} \{ B_L(\tau_E R) + P(1-\tau_E) R \} - F - B_C \right]^{\alpha_C} \left[E_J(R) - E_J^F \right]^{1-\alpha_C}. \tag{32}$$

Laws of motion. The laws of motion for projects in different states are straightforward to describe. Let A^V denote filled jobs which are repaying their initial loan; A^F filled jobs looking for financing, i.e. with depreciated capital; A^E filled jobs which are repaying an incumbent loan; D^V firms that have separated from the worker but are still repaying their initial loan, and D^E those repaying an incumbent loan. Let N denote the number of new projects looking for financing and $\mathcal{V}$ the number of vacancies. Then, the laws of motion are given by:

$$\dot{\mathcal{V}} = p(\phi)N - q(\theta)\mathcal{V}, \tag{33}$$

$$\dot{A}^V = q(\theta)\mathcal{V} - (s_J + s_C)A^V, \tag{34}$$

$$\dot{A}^0 = s_C(A^V + A^E) - (\sigma + s_J)A^0, \tag{35}$$

$$\dot{A}^F = \sigma A^0 - (s_J + d + p(\phi))A^F, \tag{36}$$

$$\dot{A}^E = p(\phi)A^F - (s_C + s_J)A^E, \tag{37}$$

$$\dot{D}^E = s_J A^E - s_C D^E, \tag{38}$$

$$\dot{D}^V = s_J A^V - s_C D^V. \tag{39}$$

The laws of motion for the masses of projects in any given state of their life equate the flows in and out of any given state. For example, looking at (36), the mass of filled jobs looking for financing increases by σ, the rate at which capital depreciates, times the mass of producing jobs without a loan, A^0. It decreases by an amount corresponding to all those firms that have found financing $p(\phi)A^F$ plus all those firms who have exited the market due to separation with a worker, $s_J A^F$, or due to their capital becoming unproductive, dA^F. The other laws of motion are interpreted analogously, so we omit their interpretation for succinctness.

The law of motion for unemployment takes the familiar form:

$$\dot{\mathcal{U}} = s_J(A^V + A^0 + A^F + A^E) + dA^F - \theta q(\theta)\mathcal{U}. \tag{40}$$

The flow into unemployment is given by all those workers who are employed by a firm, regardless of whether or not the firm has a loan, times the separation rate, s_J, plus all those workers employed at firms that need financing times the rate with which depreciated capital becomes completely inoperable. The flow out of unemployment is simply the number of unemployed workers times the job-finding rate, $\theta q(\theta)$.

3.2 The secondary loan market

As in the simplified model from Section 2, banks securitize their loans and optimally choose what fraction of them to keep on their books and what fraction of them to sell at price P. In our richer environment, this price is endogenously determined in a secondary loan market. We model this market as an OTC market in the spirit of Duffie et al. (2005). There is an exogenously fixed mass of investors denoted by $\mathcal{L}$ who can either hold 0 or 1 unit of the asset.

Trade takes place through the help of dealers: at a rate λ, an investor meets with a dealer who has access to a perfectly competitive inter-dealer market. The dealer can execute buy and sell orders for the investor in exchange for a fee which the two parties bargain over. The dealer executes these orders by trading in the inter-dealer market. In that market, the price of the asset is P and it is set such that the order flows for buy and sell orders are equated. Thus, the inter-dealer market is the same as the market for newly-securitized loans. One departure we make from Duffie et al. (2005) is that we allow for infinitely many investor types distributed according to a continuous CDF $G(\delta)$. This description of an OTC market is standard in the search-theoretic literature.[25]

Value of an investor. The lifetime discounted value of holding one unit of asset, for an investor of type δ, is denoted $V_1(\delta)$ and is given by

$$rV_1(\delta) = \delta + \gamma \int [V_1(\delta') - V_1(\delta)]\mathrm{d}G(\delta') + \lambda \max\{B(\delta) - \Delta V(\delta), 0\} - s_C \Delta V(\delta). \tag{41}$$

When the investor has the asset, she enjoys the utility flow δ. At a rate γ, the investor experiences a utility shock and draws a new utility level δ' from the type distribution. If an investor meets a dealer, she has the option to trade the asset at the negotiated bid price, $B(\delta)$. She will do so if the bid price is higher than her reservation value $\Delta V(\delta) \equiv V_1(\delta) - V_0(\delta)$. In that event she receives the transfer, but loses her reservation value, i.e. she becomes an investor with no asset. This can also happen if the loan matures, an event that occurs at a rate s_C. The lifetime discounted value of having no asset is $V_0(\delta)$, which satisfies

$$rV_0(\delta) = \gamma \int [V_0(\delta') - V_0(\delta)]\mathrm{d}G(\delta') + \lambda \max\{\Delta V(\delta) - A(\delta), 0\}. \tag{42}$$

The interpretation is similar: the investor can experience a preference shock or she can meet a dealer. When the latter event happens she can purchase the asset at the negotiated ask price, $A(\delta)$, or choose to remain with zero asset holdings.

Laws of motion. Next we turn to the laws of motion for the investor types. Given the structure of the secondary market, it is straightforward to show that there exists a reservation type δ^* such that investors of type δ^* are indifferent between holding the asset or

[25] Alternative characterizations of the market include, among others, competitive search instead of random search (Lester, 2010), a frictional inter-dealer market (Hugonnier et al., 2020), a combination of the two (Gabrovski and Kospentaris, 2021), as well as unrestricted asset holdings (Lagos and Rocheteau, 2009). See Weill (2020) for a recent survey.

not, investors of type $\delta > \delta^*$ who do not hold the asset buy it when they meet a dealer, and investors of type $\delta < \delta^*$ who hold the asset sell it when they meet a dealer. Let $g(\delta)$ denote the density of customers of type δ, and $\psi_0(\delta)$ and $\psi_1(\delta)$ denote the densities of investors with type δ that respectively do and do not have the asset. Then the following two equations hold:

$$g(\delta) = \psi_0(\delta) + \psi_1(\delta), \tag{43}$$

$$\dot{\psi_1}(\delta) = \lambda\psi_0(\delta)\mathbb{I}_{\delta\geq\delta^*} + \gamma\left[\int \psi_1(\delta')d\delta'\right] g(\delta) - \lambda\psi_1(\delta)\mathbb{I}_{\delta<\delta^*} - \gamma\psi_1(\delta). \tag{44}$$

The first equation simply formalizes that any investor either holds or does not hold the asset. The second equation is the law of motion for the density of investors of type δ holding the asset. For any δ, there is a positive flow into that state from investors who already held the asset with a different preference type and switched to type δ following a preference shock (second term). There is a corresponding negative flow from investors holding the asset who used to be of type δ but now have a different preference type δ' (fourth term). When $\delta \geq \delta^*$ there is an additional positive flow from investors of type δ who previously did not hold the asset but matched with a dealer, allowing them to purchase it (first term). Conversely, when $\delta < \delta^*$, there is a negative flow from investors of type δ who previously had the asset and met with a dealer, allowing them to offload it (third term). Lastly, all of the asset supply, $\mathcal{A}$, must be held by some investor, adding the constraint $\int \psi_1(\delta)\mathrm{d}\delta = \mathcal{A}$. Combining these equations yields the following investor density functions in steady state:

$$\frac{\psi_1(\delta)}{g(\delta)} = \begin{cases} \frac{\gamma}{\lambda+\gamma+s_C}\mathcal{A} & \text{if } \delta < \delta^*, \\ \frac{\gamma}{\lambda+\gamma+s_C}\mathcal{A} + \frac{\lambda}{\lambda+\gamma+s_C} & \text{if } \delta \geq \delta^*. \end{cases} \tag{45}$$

Bargaining. The bid and ask prices in the secondary loan market as well as the repayments in the credit market are determined by Nash Bargaining. Let the dealer's bargaining power be α_D. Then, the bid and ask prices solve the Nash products given below:

$$B(\delta) = \arg\max\left[B - \Delta V(\delta)\right]^{1-\alpha_D}\left[P - B\right]^{\alpha_D}, \tag{46}$$

$$A(\delta) = \arg\max\left[\Delta V(\delta) - A\right]^{1-\alpha_D}\left[A - P\right]^{\alpha_D}. \tag{47}$$

The description of the secondary loan market closes the model. Since our interest is in the quantitative properties of the model, we do not characterize the equilibrium here. Instead,

Parameter	Description	Value
r	Discount Rate	0.0042
$\bar{w}$	Wage	0.667
s_C	Maturity Rate	0.0181
η_L	Labor Market Matching Elasticity	0.72
η_C	Credit Market Matching Elasticity	0.5
α_D	Dealer's Bargaining Power	0.97
$G(\delta)$	Distribution of Investor Valuations	$\mathcal{U}[\underline{\delta}, \overline{\delta}]$
y	Firm-Worker Match Output	1
$\mathcal{L}$	Measure of Investors	1
$\underline{\delta}$	Lower Bound of Investors' Valuations	0

Table 1: Externally Calibrated Parameters

we proceed by calibrating the model to the data and examining its numerical properties in Sections 4 and 5. A full characterization of the equilibrium is provided in Appendix B.

4 Calibration

We calibrate the model at a monthly frequency. Several parameters are calibrated externally to their direct empirical counterparts or by following the literature. We set the discount rate r to 0.0042, consistent with an annual interest rate of 5%. The exogenous wage $\bar{w}$ is set to 0.667 to match a labor share of two thirds (Gollin, 2002). Next, the maturity rate for loans, s_C, is set to 0.0181 to match an average maturity of 4.6 years for loans traded in the secondary market (Saunders et al., 2022). Regarding matching functions, we follow Shimer (2005) for the labor market and Petrosky-Nadeau and Wasmer (2013) for the credit market. In both papers, the matching function takes a Cobb-Douglas functional form: $M^L(\mathcal{U}, \mathcal{V}) = \mu_L \mathcal{U}^{\eta_L} \mathcal{V}^{1-\eta_L}$ and $M^C(\mathcal{B}, \mathcal{E}) = \mu_C \mathcal{B}^{\eta_C} \mathcal{E}^{1-\eta_C}$. Shimer (2005) calibrates the elasticity $\eta_L = 0.72$, while Petrosky-Nadeau and Wasmer (2013) work with a symmetric elasticity of $\eta_C = 0.5$. Turning to the OTC parameters, Feldhütter (2012) and Hugonnier et al. (2020) estimate the bargaining power of dealers to be 0.97 in the corporate and municipal bond markets, respectively. In lack of direct evidence for corporate loans and given that these markets share a similar over-the-counter structure, we set α_D to this value. Next, we impose that the distribution of asset valuations in the OTC market, G, is uniform, as in Hugonnier

Parameter	Description	Value
μ_L	Labor Market Matching Efficiency	0.4782
χ	Cost of Vacancy Creation	0.5000
μ_C	Credit Market Matching Efficiency	0.1725
s_J	Unconditional Firm Exit Rate	0.0233
d	Firm Exit Rate for Matched Firms	0.1643
σ	Rate of Capital Replacement Shock	0.1087
F	Size of Capital Replacement Shock	1.1328
α_C	Bank's Bargaining Power	0.8268
κ	Banks' Participation Cost	0.8120
c	Entrepreneurs' Participation Cost	0.0940
$\overline{\delta}$	Higher Bound of Investor Valuations	0.7949
γ	Investor Valuations' Change Rate	2.1080
λ	Meeting Rate in the OTC Market	0.0352
$\tilde{\xi}$	Loan-servicing Cost Constant	0.4221
ϵ	Loan-servicing Cost Elasticity	0.4224

Table 2: Internally Calibrated Parameters

et al. (2020). Finally, we normalize the following variables: i) y, the output of a firm-worker match, to 1; ii) $\mathcal{L}$, the measure of investors in the OTC market, to 1; and iii) $\underline{\delta}$, the lowest possible investor valuation in the OTC market, to 0. The externally calibrated parameters are collected in Table 1.

This parameterization, together with the following constant elasticity functional form for loan-servicing costs, $\xi(L) = \tilde{\xi}L^{\epsilon}$, leaves us with fifteen parameters to be calibrated internally through the lens of the model. The model features block recursivity, guiding our calibration strategy: the OTC market is connected with the real side of the model only through the price of securitized loans, P. Hence, the model structure suggests the following strategy: first, calibrate the real side of the model and use the implications of the calibrated parameters for P to pin down the relevant financial parameters; then, complement with other statistics to pin down the remaining parameters of the OTC market.

We start with three empirical moments that are salient features of the US labor market: a long-run unemployment rate of 6%, a monthly separation rate of 3% (Shimer, 2005; Bethune and Rocheteau, 2023), as well as a long-run job-filling rate of 50%.[26] Using the Beveridge curve, these three numbers pin down the level of labor market tightness in the model, θ, which, in turn, pins down μ_L. To determine the cost of vacancy creation, χ, we employ the measurements of Michaillat and Saez (2021) which imply vacancy costs in the order of 3% of aggregate output. To pin down μ_C we follow a similar approach: we combine information on the average search duration in the credit market (four months, based on Petrosky-Nadeau and Wasmer 2013), which determines the credit market tightness ϕ, together with information on waiting time for loan approval, which determines the credit meeting rate $p(\phi)$.[27]

Next, to pin down the remaining credit parameters we utilize the Small Business Credit Survey (SBCS) conducted by several regional branches of the Federal Reserve System. The SBCS contains information regarding the reasons firms need credit, credit availability, as well as the uses of credit funds. We pool together all waves of the survey (2014-2021) to maximize the number of observations and compute two moments. First, the fraction of firms that received all financing they sought is 42%, consistent with the waiting time for loan approval (see Footnote 27). Together with $p(\phi)$, this moment pins down d (the additional exit rate for filled jobs seeking credit) in the model. Second, 14% of firms that applied for credit did so to finance repairs or replace their capital. We use this as a target for $1 - \pi$, that is the fraction of incumbent firms in the credit market. Using the model's accounting equations at steady state for π and total separations, combined with the moments from the credit surveys and labor market, identifies the exit rate, s_J, and the capital replacement shock for incumbent firms, σ.

We continue by pinning down three more parameters from the real side of the model: the size of the capital replacement shocks, F, the bargaining power of banks in the credit market, α_C, and the flow cost of searching in the credit market κ. To calibrate F, we target the unconditional average of total corporate loans over GDP for the US economy after 2000, at which point the secondary loan market became significant, using data from the Federal Reserve's Board of Governors. To calibrate α_C, we target the fraction of corporate loans that are securitized and traded in the secondary market. As explained above in the Market

[26]For a Cobb-Douglas matching function, the job-filling rate is the product of the unemployed per vacancy ratio (available in JOLTS) times the job-finding rate (computed from CPS data following Goensch et al. 2024). We compute the monthly job-filling rate and use the average from 2001 to 2019 as its long-run value. To be consistent, the long-run monthly unemployment rate is calculated based on the same time interval.

[27]Information on waiting times for loan approval comes from the National Federation of Independent Business (NFIB) Small Business Survey. Specifically, we pooled together the 2014-2019 waves of the survey and computed the average percentage of businesses whose borrowing needs were entirely satisfied with credit *in the last three months*. The average fraction is 30%, varying from 28% to 35% over time.

Background Section, the vast majority of loans traded in the secondary market are leveraged loans (FSB, 2019; Marsh and Virmani, 2022). The volume of leveraged loans is roughly half of the total corporate lending in the US (Bochner et al., 2020; Marsh and Virmani, 2022), and we use 50% as a target for the total fraction of loans that banks supply to the secondary market in the model. Finally, to calibrate κ, we use the evidence provided by Gupta et al. (2008) who estimate that banks charge 137 bps lower rates for loans traded in the secondary market. Through the lens of the model, this statistic speaks directly to the value of repayment for the banks, R_V, and, as a result, it informs the value of κ.

It is important to notice that at this stage of the calibration process the endogenous variables (θ, ϕ, π) have been pinned down. As a result, and due to the block recursive nature of the model, the asset price P is also determined at this stage. To put it differently, since the asset price is pinned down by the real part of the model, it operates as a targeted moment for the calibration of the financial part of the model. Given the strong relationship between investor valuations and the asset price, this moment identifies the highest valuation, $\overline{\delta}$. Moreover, the equilibrium values of θ and ϕ, together with the calibrated values for κ and P, pin down the scale coefficient of firms' loan-servicing costs, $\tilde{\xi}$.[28]

The calibration of γ, λ, and c is straightforward. We use a bid/ask spread of 1.01%, estimated by Saunders et al. (2022), to pin down the rate of valuation switches in the OTC market, γ. For the remaining parameters, we use information found in recent reports by the Loan Syndications and Trading Association (LSTA). First, an annual turnover of 70% identifies the frequency of meetings in OTC market, λ.[29] Second, an annual yield to maturity of 7% pins down the search costs for entrepreneurs c.

To calibrate the last remaining parameter ϵ, we follow the advice of Nakamura and Steinsson (2018) and consider "identified moments." The identified moments we employ are the causal estimates of the effect of bank lending frictions on firms' employment and credit availability, estimated in the influential work of Chodorow-Reich (2014). These statistics are "identified" because they are derived from empirical strategies designed to uncover the causal effects of shocks in the syndicated loan market on credit availability and employment. As Nakamura and Steinsson (2018) point out, the advantage of using identified moments is that they provide direct evidence for the causal mechanisms of the model. This is particularly

[28]In equilibrium, the loan-servicing costs make the banks indifferent between holding the marginal loan on their books vis-a-vis selling it in the secondary market. Hence, the equilibrium price of the loan and the cost of of participating in the credit market are informative about the size of loan-servicing costs.

[29]The average turnover for corporate bonds in the TRACE data set is also very close to 70%, as reported by He and Milbradt (2014).

Target	Data	Model
Unemployment Rate	6%	6%
Job Separation Rate	3%	3%
Job Filling Rate	50%	50%
Vacancy Creation Cost over GDP	3%	3%
Bank Search Duration	4 months	4 months
Entrepreneur Search Duration	8.4 months	8.4 months
Fraction of Firms With Completed Borrowing Needs	42%	42%
Fraction of Firms Seeking Capital Replacement	86%	86%
Total Corporate Loans over annualized GDP	9.5%	9.5%
Securitized Fraction of Corporate Loans	50%	50%
Bank Discount for Securitized Loans	137 bps	137 bps
Bid/Ask Spread in the Secondary Market	1.01%	1.01%
Turnover in the Secondary Market	70%	70%
Yield to Maturity of Securitized Loans	7%	7%
Employment Drop due to a Credit Shock (Chodorow-Reich, 2014)	-2.38%	-2.38%

Table 3: Targets and Model Performance

true in our case, since ϵ is the elasticity of loan-servicing costs with respect to the amount of loans the bank keeps on its balance sheet — a key parameter that governs banks' portfolio decisions.

Importantly, one of the exogenous shocks Chodorow-Reich (2014) considers affected the syndicated loan market, making his estimates particularly well-suited for our model. Chodorow-Reich (2014) uses banks' exposure to the Lehman Brothers bankruptcy through the syndicated market as an instrument for banks' credit supply. Next, he estimates the effects of this shock on the probability of firms receiving loans from the affected banks and on firms' employment growth.[30] We interpret this exercise through the lens of the model as a change in the banks' cost of participation in the credit market, κ. To pin down the size of the shock in the model, we adjust the level of κ such that the model matches the magnitude of Chodorow-Reich's estimate of a 2.32pp drop in the probability of a firm receiving a loan. We then pick ϵ such that the model generates a response equal to the -2.38% change in

[30] Our analysis is in steady state, hence we transform the estimates for employment growth in terms of employment levels.

employment Chodorow-Reich (2014) reports empirically.

The values of internally calibrated parameters are collected in Table 2 and the performance of the calibrated model versus the empirical targets can be found in Table 3. In Appendix C we outline the model expressions for each of the fifteen data moments. The tractability of the model allows us to match most of the model's targets exactly. The model match with the targeted moments is excellent, making the model a reliable laboratory for quantitative explorations.

5 Quantitative Exercises

In this section, we study the quantitative implications of the model. Our first goal is to understand the role of the secondary loan market and loan-servicing costs for the real economy. To do so, we consider three alternative model economies in which these features are either absent or operate differently than in the benchmark model. We compute the values of the endogenous variables in the the alternative model steady states and compare them with the benchmark economy in Section 5.1. Our second goal is to understand how the existence of a secondary market and loan-servicing costs affects the magnitude of business cycle fluctuations. To this end, we investigate the model's response in different comparative statics exercises. We consider changes in the values of exogenous parameters and report the effects on endogenous variables in the four model economies mentioned above. We study three comparative statics exercises: i) changes in match output, y, in Section 5.2.1, ii) changes in banks' cost of participation on the credit market, κ, in Section 5.2.2, and iii) changes in investor valuations, δ, in Section 5.2.3.

5.1 Steady-State Levels

We begin by computing the steady-state values of several endogenous variables for various model specifications holding all parameters fixed at the calibrated levels of Tables 1 and 2. In order to evaluate the importance of the novel elements of the benchmark model, namely loan-servicing costs and a secondary loan market, we consider three additional models: i) a model without search frictions in the secondary market, ii) a model without a secondary market, in which banks cannot readjust their balance sheets, and iii) a model with neither a secondary market nor loan-servicing costs.[31] Comparing the levels of endogenous variables

[31] This is the model of Wasmer and Weil (2004) with the addition of capital expenditure financing for firms and the associated capital depreciation shocks.

between the steady states of the various models quantifies the role of loan-servicing costs and the secondary loan market for the real economy. The results are collected in Table 4.

Endogenous Variables	P	Ξ	ϕ	θ	s	u
Benchmark model	17.97	0.42	2.10	0.94	3%	6%
Model with frictionless secondary market	26.06	0.29	1.68	2.13	2.97%	4.79%
Model without secondary market	0	0.54	2.26	0.65	3.01%	6.64%
Model without secondary market and loan-servicing costs	0	0	0.92	8.44	2.89%	3.22%

Table 4: Steady-state Levels of Endogenous Variables in Different Models

In the benchmark model, the price of securitized loans in the secondary market is $P = 17.97$ and removing search frictions raises it to 26.06. Removing search frictions from the secondary market allows the asset to reach high-value investors instantaneously, increasing the value of the asset, and allows banks to securitize more loans, saving on loan-servicing costs. The almost 50% increase in the asset price implies that the search frictions plaguing the secondary market have important effects for asset prices, which translate into large real effects: the economy with a frictionless secondary market features significantly more credit, larger job creation, and lower unemployment than the benchmark model. Shutting down the secondary market has the exact opposite effect operating through the same channels: it lowers the return to loan securitization to zero and forces banks to keep all loans in their balance sheets. In turn, this increases the banks' average loan-servicing costs per unit of repayment over the lifetime of the loan, $\Xi \equiv [\pi\xi(\tau_V L_V) + (1-\pi)\xi(\tau_E L_E)]/(r + s_C)$, since now banks have to take care of twice as many loans as before (50% of loans are securitized in the equilibrium of the benchmark model). The resulting outcomes are qualitatively aligned with those predicted by the parsimonious partial equilibrium model. The zero return to securitization together with the larger loan-servicing costs lowers the surplus in the credit market and fewer entrepreneurs and banks seek a credit partnership. Banks respond more, however, since they are directly affected by the secondary market, and the ratio of entrepreneurs to banks, ϕ, increases. Having fewer banks per entrepreneur implies less credit available for vacancy creation, which lowers the labor market tightness, θ, and increases the total separation rate, s.[32] As a result, the unemployment rate, u, is higher in the model without a secondary market.

[32]We use the term "total separation rate" to refer to the numerator of the Beveridge curve; see (54): $s \equiv s_J + ds_C\sigma/[(s_J + \sigma + s_C)(d + s_J + p(\phi)) + s_C\sigma]$.

To sum up, the existence of a secondary OTC market for securitized loans has large effects on the credit and labor market, as can be seen by either making the market extremely well-functioning or making it disappear. The secondary market affects real variables through two channels in our model: first, it directly changes the match surplus in the credit market, which in turn affects labor market tightness and total separations. Second, and more subtle, the existence of a secondary market allows banks to rebalance their balance sheets and save on loan-servicing costs, which also adds to the direct effect of the asset price. The last counterfactual experiment quantifies the importance of the loan-servicing costs and shows that they are substantial: removing them from the model without a secondary market has large effects on real variables. Shutting down the loan-servicing costs raises the credit market surplus which, in turn, generates more credit and job creation, resulting in fewer separations and lower unemployment.

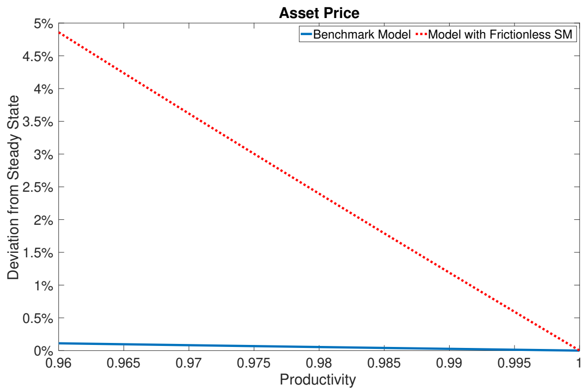
In total, both loan-servicing costs and secondary loan trading have sizeable quantitative implications for the credit and labor market in our model. In the next section, we study how these mechanisms affect the response of the economy to various parameter changes. Since the economies considered thus far have different benchmark steady states, in what follows we express the endogenous variables as percentage deviations from their original steady-state levels.

5.2 Comparative Statics

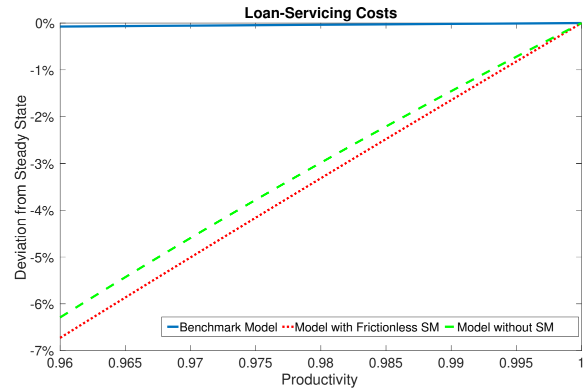
In this section we study how the presence of loan-servicing costs and a secondary loan market affect the magnitude of business cycle fluctuations in the economy. To this end we study the response of both real and financial variables to changes in: i) match output; ii) banks' cost of participation in the credit market; and iii) investor valuations. Each of these can be thought of as a potential source of business cycle fluctuations in the economy. We should stress that our analysis investigates the economy's response at steady state. In this regard we follow Shimer (2005), who shows that in frictional labor market models business cycle fluctuations are well approximated by the steady-state elasticities.

5.2.1 Changes in Match Output

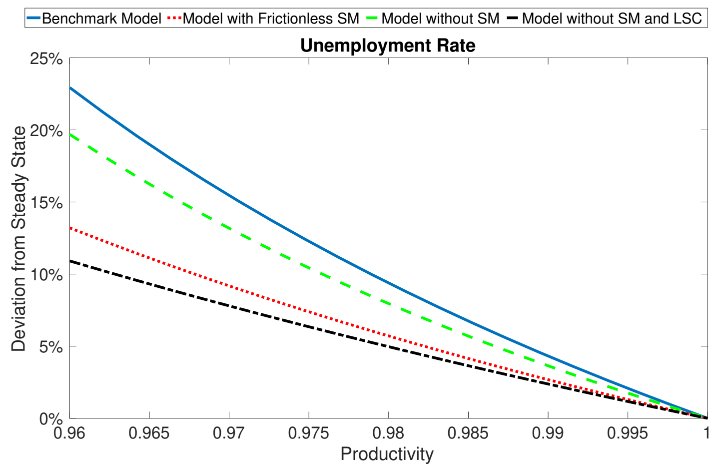
Figure 4 plots the effects of comparative statics with respect to match output in the four alternative models. The endogenous variables of interest are the price of securitized loans (Figure 4a), the total loan-servicing costs (Figure 4b), and the unemployment rate (Figure



(a) Asset Price Response



(b) Loan-servicing Cost Response



(c) Unemployment Rate Response

Figure 4: The Effects of Changes in Match Output y

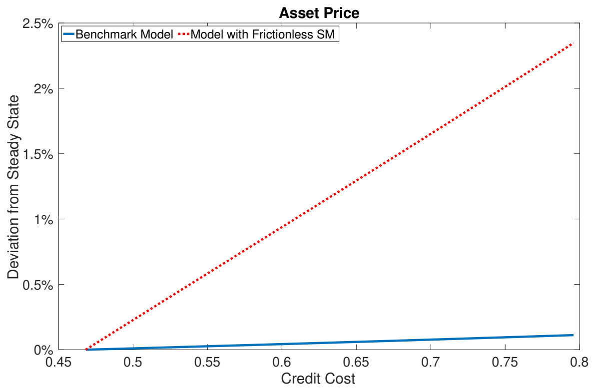
4c). The first thing to notice is that lower values of match output generate an increase in the price of securitized loans P. This is due to the lower asset supply: as the real value of entrepreneurial projects drops, banks provide less credit, and, in turn, the supply of loans in the secondary market is lower. As a result, and given that asset demand remains constant, the equilibrium price of securitized loans increases (Figure 4a). Importantly, the asset price increase is an order of magnitude larger in the model with a frictionless asset market than in the benchmark model: prices respond more in a better functioning market than in a market where search frictions constrain price movements.

The other connection between real and financial variables operates through the total discounted loan-servicing costs Ξ. Since banks provide less credit when productivity drops, they have fewer loans to monitor, and loan-servicing costs decrease. In the model without a secondary market, banks keep all loans in their balance sheets and loan-servicing costs drop sharply (green dashed line in Figure 4b). In the model with a secondary market, the size of the decline in loan-servicing costs depends on the magnitude of the asset price drop. As we showed in Section 2.2, the total loan-servicing cost is a function of P (equation (10)), since the asset price determines the bank's marginal utility of repayment D. Hence, loan-servicing costs drop more in the model with a frictionless secondary market than in the benchmark model, reflecting the different asset price behavior in the two settings.

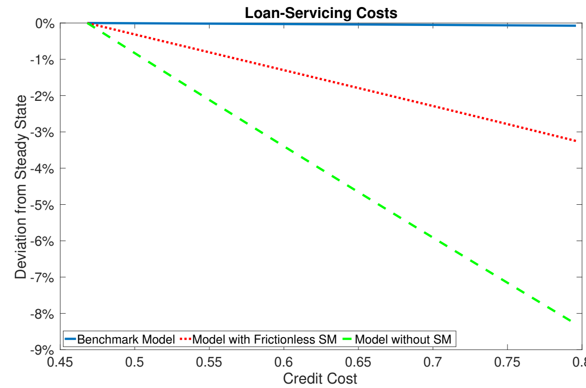
The different magnitudes of the decline in loan-servicing costs are reflected in the response of the unemployment rate to lower levels of match output in Figure 4c. The drop in loan-servicing costs compensates banks for the lower match output and raises the number of banks in equilibrium. Hence, the larger the drop in loan-servicing costs, the smaller the negative impact of the match output on credit and job creation. As a result, the benchmark model features a larger increase in unemployment than both the model with a frictionless secondary market and without a secondary market, since the latter two models feature a sizeable drop in loan-servicing costs. These comparisons imply that a frictional secondary loan market amplifies the effects of drops in productivity on unemployment, in line with the mechanisms we highlighted analytically, but provide some additional nuance. Indeed, our quantitative exercises show that the amplification result is not inherently due to secondary loan trading: a secondary market with low-enough frictions could instead have a dampening effect due to a countervailing increase in the asset price in general equilibrium. Lastly, the most modest unemployment response is found in the model in which both the secondary market and loan-servicing costs are absent. As we explained in the end of Section 2.3, the impact of loan-servicing costs on the volatility of the benchmark model is ambiguous due to the multiple effects they generate. It turns out that the channel working through the credit market tightness ϕ dominates and shutting down loan-servicing costs lowers the unemployment's response to productivity drops.

5.2.2 Changes in Credit Cost

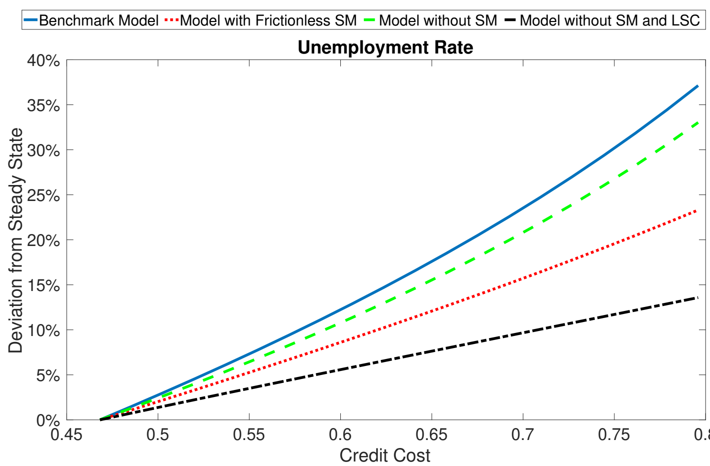
In Figure 5, we present the results for fluctuations that originate in the credit market. We model an exogenous change in the supply of credit as an increase in κ, the banks' cost for credit market participation. Based on our discussion in Section 4, we think of κ as a measure of the banks' balance sheet or screening costs required to initiate a new credit relationship with an entrepreneur or a firm. A higher κ makes lending more costly and, as a result, banks give and securitize less loans, leading to an increase in the secondary market price



(a) Asset Price Response



(b) Loan-servicing Cost Response



(c) Unemployment Rate Response

Figure 5: The Effects of Changes in Credit Cost κ

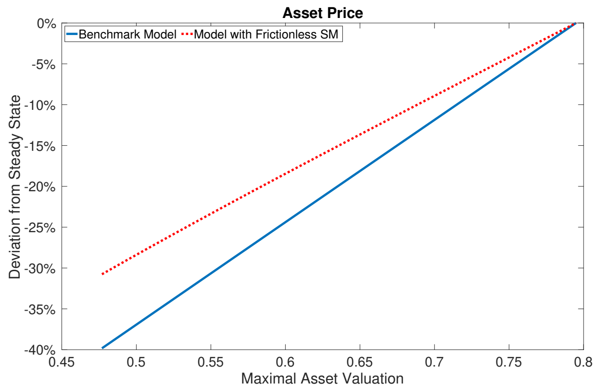
(Figure 5a). The response of the asset price again depends on the existence of frictions in the secondary market, with the frictionless version delivering much larger responses than the benchmark model with search frictions. Given the lower amount of credit, banks have to take care of less loans and loan-servicing costs decrease in the same way as before (Figure 5b). That is, in the model without a secondary market banks keep all loans in their books and the drop in loan-servicing costs is sizeable. In the model with a secondary market, the drop in asset price regulates the loan-servicing costs decline and the frictionless model delivers a much larger drop than the benchmark model.

Turning to the real side of the economy, Figure 5c illustrates the unemployment rate increases due to the rise in credit cost. The behavior of all models is similar to the case of productivity changes with an interesting twist: even though the drop of loan-servicing costs is larger in the model without a secondary market, the model with a frictionless secondary market delivers a smaller increase in unemployment. The reason is twofold. First, the shock under study here is a change in banks' search costs κ which affects banks disproportionately more than entrepreneurs. In contrast, a productivity shock y reduces the match surplus which affects both parties symmetrically, as shown in (50) and (51). Second, banks in the model with a frictionless secondary market can benefit from the increase in asset prices, while banks in the model without a secondary market cannot. The increase in asset prices partially compensates the banks for the higher cost of credit participation. This compensation, however, depends on the extent of search frictions in the secondary market. As a result, the compensatory effect of asset price increases are limited in the benchmark model which features the largest rise in unemployment among all models.

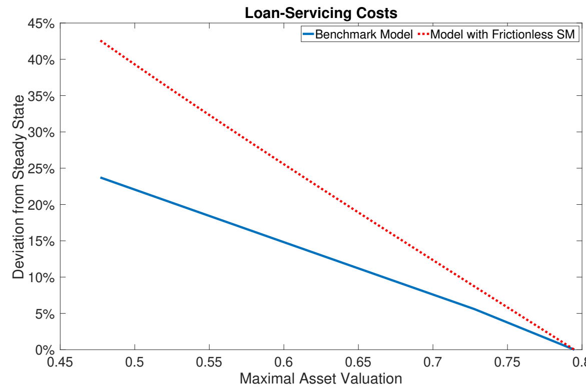
To connect our results with the literature, consider Petrosky-Nadeau (2013) who also studies changes in banks' participation costs. Petrosky-Nadeau (2013) uses steady-state changes in κ to simulate a "credit crunch" in a variant of the Wasmer and Weil (2004) model and he shows that this model produces large responses of real variables to credit fluctuations. Of the four models we consider here, the closest one to Petrosky-Nadeau (2013) is the model without a secondary market and loan-servicing costs. As Figure 5c shows, this model features the smallest increase in unemployment among the four models. Hence, the economic lesson of our analysis is that the existence of loan-servicing costs and of a secondary loan market further increases the sensitivity of real variables to a credit crunch.

5.2.3 Changes in Investor Valuations

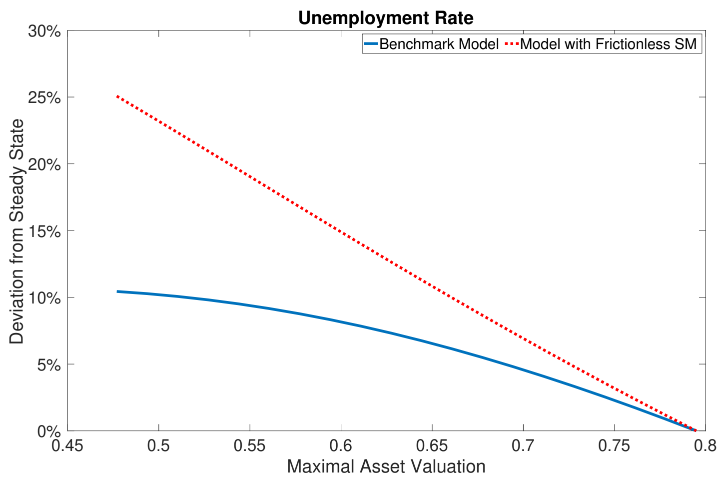
In this section, we study the implications of the model for fluctuations that originate in the OTC financial market. Since the focus is on the secondary market, we disregard the models without that feature. Figure 6 illustrates the results for changes in $\bar{\delta}$, the maximal asset valuation. By changing $\bar{\delta}$ while holding $G(\delta)$ to uniform and $\underline{\delta}$ to zero, we manipulate the value of securitized loans for all investors. We choose the lowest value of $\bar{\delta}$ in the experiment to engineer a 40% drop in the asset price, which was the magnitude observed in the secondary market during the financial crisis of 2009 (Irani and Meisenzahl, 2017). The main result of Figure 6 is that this drop in investors' valuations creates a sizeable increase in the unemployment rate (Figure 6c). A simple back-of-the-envelope calculation can provide some context: during the Great Recession, the US unemployment rate increased from roughly 6% to 10%, a 67% increase. Our model implies that the drop in the price of securitized loans *alone* can explain almost a sixth of the unemployment rate increase.



(a) Asset Price Response



(b) Loan-servicing Cost Response



(c) Unemployment Rate Response

Figure 6: The Effects of Changes in the Maximal Asset Valuation $\overline{\delta}$

Moreover, Figure 6 also sheds light on the mechanics behind this result. As securitized loans become less valuable to investors, their price declines (Figure 6a). The magnitude of the asset drop depends on the existence of frictions: prices drop less without search frictions than in the benchmark model. In turn, these differences are reflected in loan-servicing costs, which increase as loans become less valuable and banks keep more of them in their balance sheet (Figure 6b). The combined effects of lower asset prices and higher loan-servicing costs result in lower credit, less job creation, and higher unemployment. Interestingly, in this case the model with a frictionless asset market generates larger responses than the benchmark model (Figure 6c). This implies that a better-functioning secondary market would serve to stabilize output fluctuations that stem from either productivity or credit shocks, but would have the opposite effect during crises caused by financial shocks.

6 Conclusion

We develop a microfounded general equilibrium search-theoretic model with a labor, credit, and financial markets in order to study the the mechanisms through which the secondary loan market affects the real economy. The modeling of each frictional market follows an established path from the literature: the labor market is à la Diamond (1982) and Mortensen and Pissarides (1994); the credit market is à la Wasmer and Weil (2004); and the secondary financial market is à la Duffie et al. (2005). Our model departs from the literature in a crucial way: banks suffer loan-servicing costs for each unit of loan they keep on their books. This assumption enables us to capture the central reason motivating banks to securitize loans in practice, and to study the macroeconomic implications of their optimal portfolio decisions.

We show analytically that loan-servicing costs act as an automatic stabilizer. Intuitively, following a decrease in productivity, worker-firm matches are less profitable, which lowers vacancy creation and raises unemployment. At the same time, lower vacancy creation reduces congestion in the labor market, making it cheaper to find a worker. As a result, banks issue less credit, which decreases their operating costs. This effect serves to partially outweigh the negative impact of lower productivity, thereby mitigating the magnitude of the unemployment response. Introducing a secondary loan market reduces the steady-state level of unemployment, as banks can now securitize some of their loans and save on loan-servicing costs. At the same time, if the asset price in the secondary market is fixed, we show that the presence of the market amplifies the volatility of unemployment. The reason is that banks' loan-servicing costs are now tied to the price of the asset which is stable.

To study the quantitative importance of our mechanisms, we calibrate an augmented version of our framework to the U.S. economy. The calibrated model matches a rich set of identified and unidentified moments, making it a good laboratory for our numerical experiments. First, when we shut down the secondary loan market, we find that steady-state unemployment increases by 0.6pp, but its response to a 1% decrease in productivity reduces by 0.7pp. Intuitively, due to frictions in the secondary loan market, prices do not respond much following a decrease in productivity. This lends credence to our analytical exercise which keeps prices fixed. Second, we find that frictions in the market are indeed important. When we eliminate frictions from the secondary loan market, the level of steady-state unemployment and its volatility decrease by 1.2pp and 1.6pp respectively. Intuitively, when there are no frictions, the asset price responds much more to changes in the asset supply. This makes loan-servicing costs more volatile, boosting their ability to act as an automatic stabilizer. Lastly, we show that reducing the frictions in the market creates negative unintended consequences. Following a financial shock that reduces asset prices by 40% (the reduction observed during the 2007 financial crisis), unemployment rises by an additional 15pp in the model with a frictionless secondary market compared to the benchmark. This generates a notable policy trade-off.

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A Proof that $\theta \leq \theta^{WW}$

Proof. First, recall that when $D = 1$ the model economy converges to that in WW, so $\theta = \theta^{WW}$. Next, consider $D < 1$. Thus, $\phi > \phi^{WW}$, which implies that $c/p(\phi) > c/p(\phi^{WW})$. Hence,

$$\begin{aligned}
\frac{q(\theta)}{r+q(\theta)}\left[\frac{y-w}{r+s}-\frac{1}{D}\frac{\chi}{q(\theta)}\right] &> \frac{q(\theta^{WW})}{r+q(\theta)^{WW}}\left[\frac{y-w}{r+s}-\frac{\chi}{q(\theta)^{WW}}\right],\\
\frac{q(\theta)}{r+q(\theta)}\left[\frac{y-w}{r+s}-\frac{\chi}{q(\theta)}\right] &> \frac{q(\theta^{WW})}{r+q(\theta)^{WW}}\left[\frac{y-w}{r+s}-\frac{\chi}{q(\theta)^{WW}}\right],\\
\frac{q(\theta)}{r+q(\theta)}\frac{y-w}{r+s}-\frac{\chi}{r+q(\theta)} &> \frac{q(\theta^{WW})}{r+q(\theta)^{WW}}\frac{y-w}{r+s}-\frac{\chi}{r+q(\theta)^{WW}},\\
\theta &< \theta^{WW},
\end{aligned}$$

where the first inequality follows from $D < 1$ and the last follows from $q(z)/[r + q(z)]$ and $-1/[r + q(z)]$ both being strictly decreasing functions of z. ■

B Full model equilibrium

In this section, we detail the equilibrium of the extended model that we introduced in Section 3. We begin by describing the equilibrium of the real economy.

The real economy. It is straightforward to show that the optimal τ_V^* is still implicitly given by (9) (with s replaced by s_C). Analogously, we can derive an expression for τ_E^* and show that the it satisfies $\tau_E^* = \tau_V^* L_V/L_E$. Intuitively, the bank wishes to hold the same amount of assets on its book regardless of the nature of the borrower, so $\tau_E^* L_E = \tau_V^* L_V$. Depending on parameter values, it could be the case that $L_E < \tau_V^* L_V$, i.e. the negotiated repayment for an incumbent firm is less than the optimal amount of assets the bank will hold on its books. In that case the optimal τ_E^* is 1 and $\tau_E^* L_E < \tau_V^* L_V$. However, we do not detail this case in the exposition as it is not relevant given the calibrated model parameters.[33]

[33] In particular, given our calibration, F is large enough so that banks always want to securitize at least a portion of the loan.

Solving for the repayments, R_V and R_E yields the expressions:

$$\frac{R_V}{r+s_C} = \alpha_C \Psi + \frac{1-\alpha_C}{D_V}\left[\frac{\chi}{q(\theta)} + F\right], \tag{48}$$

$$\frac{R_E}{r+s_C} = \alpha_C\left(\Psi - E_J^F\right) + \frac{(1-\alpha_C)}{D_E}F, \tag{49}$$

where $D_i \equiv \tau_i^*[1-\xi(\tau_i^* L_i)] + (1-\tau_i^*)P(r+s_C)$ is the average marginal flow utility the bank receives per unit of repayment R_i $(i = V, E)$ and $\Psi \equiv (y - w - s_C E_J^0)/(r + s_C + s_J)$ is the firm's expected revenue net of wages and future capital expenditures. Compared to (16), the expression for R_V is very similar — there are only two differences: the firm's revenue now takes into account that the loan may mature before the firm-worker pair separates; the vacancy loan includes the capital expenditures F. The expression for R_E is analogous but with two main differences from that for R_V. First, the outside option for an incumbent firm is to continue searching for financing, so the maximal payoff the bank can extract is $\Psi - E_J^F$. Second, the firm already has a worker so the loan principal is only F.

Next, plugging the solutions for R_V and R_E into the forward looking expressions for E_V and B_V and using the free entry conditions yields

$$\text{EE'}: \quad \frac{c}{p(\phi)} = (1-\alpha_C)\frac{q(\theta)}{r+q(\theta)}\left[\Psi - \frac{1}{D_V}\left(\frac{\chi}{q(\theta)} + F\right)\right], \tag{50}$$

$$\text{BB'}: \quad \frac{\kappa}{\phi p(\phi)} = (1-\pi) D_V \alpha_C \frac{q(\theta)}{r+q(\theta)}\left[\Psi - \frac{1}{D_V}\left(\frac{\chi}{q(\theta)} + F\right)\right] + \pi D_E \alpha_C \left[\left(\Psi - E_J^F\right) - \frac{F}{D_E}\right], \tag{51}$$

where $E_J^F = [y - w + p(\phi)(\Psi - R_V/(r+s_C))]/[r + s_J + d + p(\phi)]$, as implied by the Bellman equations (24) and (26). Comparing the above two equations to the EE and BB locii in the benchmark economy, we see that the EE' locus has the same functional form, but the BB' locus as an extra term corresponding to the possibility a banker will meet an incumbent firm on the credit market. This affects the bank's expected profit through three distinct channels. First, the benefit to the bank from extending a loan to an incumbent firm is relatively lower because that firm has a better outside option — E_J^F vs 0 for a new entrant. This tends to lower the bank's expected profit from participating in the credit market. Second, the loan size is smaller when the bank extends credit to an incumbent firm. This effect works in the opposite direction and tends to increase expected profits. Third, besides the difference in the outside option of the firm and the loan size, there is a timing difference associated with extending credit to incumbent firms as opposed to new entrants. When a bank extends credit to an incumbent firm, the capital is purchased instantaneously and the firm begins repayment immediately. This is in contrast to extending credit to a new entrant who begins repaying only after she finds a worker. This effect tends to make lending to incumbent firms relatively more profitable.

Next, because of the possibility of capital depreciation, the firm's expected revenue net of wages, Ψ, is now lower than in the benchmark economy. Intuitively, this is the case because (i) the possibility of capital depreciation reduces the expected duration of the match and (ii) the need to secure future financing allows the bank to extra some of the match surplus. Mathematically, using the Bellman equations for the firm, (24), (27), (25), (26) one can show that

$$\Psi = \frac{a(\phi)}{[1-a(\phi)]p(\phi)}(y-w)\left[1+\frac{r+s_J+d+p(\phi)}{\sigma}\left(1+\frac{r+s_J+\sigma}{s_C}\right)\right]$$

$$-\frac{a(\phi)}{1-a(\phi)}\left[\alpha_C\Psi+\frac{1-\alpha_C}{D_V}\left[\frac{\chi}{q(\theta)}+F\right]\right], \tag{52}$$

where $a(\phi) \equiv s_C\sigma p(\phi)/[(r+s_J+s_C)(r+s_J+\sigma)(r+s_J+d+p(\phi)]$.

Lastly, the probability a bank will meet an incumbent firm on the credit market, π, is an endogenous variable that depends on the relative sizes of new entrants to incumbents looking for financing. In particular, $\pi \equiv A^F/(N+A^F)$. Manipulating the laws of motion, (33) - (39) yields

$$\pi = \frac{s_C}{s_C+s_J}\frac{\sigma}{s_J+\sigma}\frac{p(\phi)}{d+s_J+p(\phi)}. \tag{53}$$

This gives rise to a composition effect — as the ratio of credit seekers to banks, ϕ, increases, the credit-finding rate $p(\phi)$ goes down, and so does π. Hence, there are relatively fewer incumbent firms looking for financing. Since ϕ and θ co-move along the BB' locus, when θ is high the bank finds it relatively more profitable to lend to incumbent firms, but there is very few of them on the market which serves to lower the bank's expected payoff. This composition effect tends to rotate the BB' locus up.

Apart from its effect on the equilibrium tightnesses, the incumbent firm financing channel affects unemployment directly because separations are endogenous in this setting. In particular, once a firm's capital depreciates the chance that it finds financing before its capital becomes unproductive is $p(\phi)/[d+p(\phi)]$. This probability is endogenous and depends on the level of congestion in the credit market: if firms find it hard to secure financing, then it is less likely they will find the funds in time, which results in a higher aggregate separation rate. To see this clearly, focus on the steady-state unemployment level. Applying straightforward algebra to (34) - (40) leads to the following expression

$$\mathcal{U} = \frac{s_J + \frac{d s_C \sigma}{(s_J+\sigma+s_C)(d+s_J+p(\phi))+s_C\sigma}}{\theta q(\theta) + s_J + \frac{d s_C \sigma}{(s_J+\sigma+s_C)(d+s_J+p(\phi))+s_C\sigma}}. \tag{54}$$

The endogenous component of separations is then $\frac{d s_C \sigma}{(s_J+\sigma+s_C)(d+s_J+p(\phi))+s_C\sigma}$, which is strictly decreasing in the loan-finding rate, as expected.

Together (48), (49), (50), (51), (52), (53), and (54), along with the optimal τ_V^* and τ_E^* solve for ϕ, θ, Ψ, π, u R_E, R_V as a function of the inter-dealer price for assets P.

The secondary loan market and the asset price. Next, we characterize the equilibrium in the secondary loan market. To begin with, we focus on the price of the asset in the inter-dealer market, P. First, plugging the solution for the bid and ask prices, $B(\delta) = A(\delta) = \alpha_D \Delta V(\delta) + (1-\alpha_D)P$, into the Bellman equations for the investor when she does and does not have the asset, (41) and (42), and combining the two yields an expression for the investor's reservation value

$$(r+s_C)\Delta V(\delta) = \delta + \gamma \int [\Delta V(\delta') - \Delta V(\delta)] \mathrm{d}\delta' + \lambda(1-\alpha_D)\max\{P - \Delta V(\delta), 0\} - \lambda(1-\alpha_D)\max\{\Delta V(\delta) - P, 0\}. \tag{55}$$

This expression has a standard interpretation: the left-hand side of the equation is the annualized reservation value. The first term on the right-hand side is the utility flow of holding the asset, the second term is the flow of expected net utility from a type change, the third term captures the net utility flow of selling the asset, and the last term is the negative of the utility flow from purchasing the asset. Using that $\max\{P - \Delta V(\delta), 0\} - \max\{\Delta V(\delta) - P, 0\} = P - \Delta V(\delta)$, one can express the reservation value of the investor by

$$(r+s_C)\Delta V(\delta) = \delta + \gamma \int [\Delta V(\delta') - \Delta V(\delta)] \mathrm{d}\delta' + \lambda(1-\alpha_D)[P - \Delta V(\delta)]. \tag{56}$$

Taking the expectations of both sides of the above expression and substituting it back yields an explicit solution for the reservation value:

$$\Delta V(\delta) = \frac{r + s_C}{r + s_C + \lambda(1-\alpha_D)} \left[\frac{r + s_C + \lambda(1-\alpha_D)}{r + s_C + \gamma + \lambda(1-\alpha_D)} \frac{\delta}{r + s_C} \right.$$
$$\left. + \frac{\gamma}{r + s_C + \gamma + \lambda(1-\alpha_D)} \int \frac{\delta'}{r + s_C} g(\delta') \mathrm{d}\delta' \right] + \frac{\lambda(1-\alpha_D)}{r + s_C + \lambda(1-\alpha_D)} P. \tag{57}$$

Conditional on contacting a dealer, investors find it optimal to hold the asset if and only if $\delta > \delta^*$. Thus, $P = \Delta V(\delta^*)$. Hence, the price satisfies

$$P = \frac{1}{r + s_C} \left[\frac{r + s_C + \lambda(1-\alpha_D)}{r + s_C + \gamma + \lambda(1-\alpha_D)} \delta^* + \frac{\gamma}{r + s_C + \gamma + \lambda(1-\alpha_D)} \mathbb{E}(\delta) \right]. \tag{58}$$

At first glance, it may seem like the price does not depend on the real side of the economy. Upon further inspection, however, it becomes evident that the real economy affects the inter-dealer price through the supply of the asset, which ultimately determines the reservation investor type δ^*. In particular, all of the asset must be held by some investors, so $\mathcal{A} = \int \psi_1(\delta)\mathrm{d}\delta$. Using the steady-state expression for $\psi_1(\delta)$ from (45) yields

$$\mathcal{A} = \frac{\lambda}{\lambda + s_C}[1 - G(\delta^*)], \tag{59}$$

implicitly characterizing the marginal investor valuation δ^* as a function of the asset supply $\mathcal{A}$. The two objects are inversely related: for the market to clear, an increase in the asset supply must be accompanied by a decrease in the mass of investors willing to purchase the asset, which implies a decrease in the valuation of the marginal investor. Therefore, using (58), we can observe that an increase in asset supply goes hand-in-hand with a decrease in the asset price, as would be expected. Note that the marginal investor type is such that in the absence of frictions ($\lambda \to \infty$) there is just enough investors who are willing to hold the asset as there are units of the asset.

In equilibrium the asset supply is determined by the real side of the economy. Specifically, at any point in time there are $A^V + D^V$ firms with a vacancy loan. Each of these loans has been securitized into R_V units of the asset at the time of origination, and a fraction $1 - \tau_V^*$ of these units were sold by the bank on the inter-dealer market. Similarly, there are $A^E + D^E$ incumbents with a loan, each securitized into R_E units of the asset. Since banks only sell a fraction $1 - \tau_E^*$ of these assets to the secondary market upon origination, it follows that asset supply is

$$\mathcal{A} = (1-\tau_V^*)R_V(A^V + D^V) + (1-\tau_E^*)R_E(A^E + D^E). \quad (60)$$

Together (58), (59), and (60) solve for the price, P, reservation value, δ^*, and asset supply, $\mathcal{A}$, as a function of the real variables τ_E^*, τ_V^*, R_E, and R_V.

C Model Expressions for Data Targets

In this section we derive the model expressions of the data targets for the calibration in Section 4. A detailed description of the targets and their sources is included in the main text, so here we focus on mapping the targets to model expressions. We proceed in the same order as the one followed in Table 3.

First, the target for unemployment is simply $\mathcal{U}$. Next, the job separation rate in our economy is endogenous and given by

$$\text{Job separations} = s_J + \frac{d s_C \sigma}{(s_J + \sigma + s_C)(d + s_J + p(\phi)) + s_C\sigma}, \quad (61)$$

as implied by (54). Next, the job-filling rate is simply $\theta q(\theta)$. The vacancy creation costs in our model are χ and there are $\mathcal{V}$ vacancies at every instance, thus

$$\frac{\text{Vacancy creation costs}}{\text{GDP}} = \frac{\mathcal{V}\chi}{y(1-\mathcal{U})}. \quad (62)$$

Turning to the credit market, the bank's search duration is given by $1/[\phi p(\phi)]$ and the entrepreneur's search duration is $1/p(\phi)$. Next, the fraction of firms that have satisfied their borrowing needs are all these firms who have been looking for credit and were able to find a loan before suffering a capital inoperability shock d. Thus,

$$\text{Fraction of firm with completed borrowing needs} = \frac{p(\phi)}{d + p(\phi)}. \quad (63)$$

Next, the fraction of firms who are seeking capital replacement loans is simply the fraction of firms not looking for a vacancy loan, i.e, π. In the model total loans are given by F times the number of firms with any kind of loan, $A^V + D^V + A^E + D^E$, plus $\chi/q(\theta)$ times the number of firms with vacancy loans, $A^V + D^V$. Thus,

$$\frac{\text{Total corporate loans}}{\text{Annualized GDP}} = \frac{F(A^V + D^V + A^E + D^E) + \frac{\chi}{q(\theta)}(A^V + D^V)}{12(1 - \mathcal{U})y}. \tag{64}$$

The fraction of loans that are securitized is simply the amount of loans banks do not keep on their books divided by all loans issued, i.e.

$$\text{Securitized fraction of loans} = \frac{(1-\tau_E^*)F(A^E + D^E) + (1-\tau_V^*)(F + \frac{\chi}{q(\theta)})(A^V + D^V)}{F(A^V + D^V + A^E + D^E) + \frac{\chi}{q(\theta)}(A^V + D^V)}. \tag{65}$$

Next, we turn to the moment on the bank discount for securitized loans. Gupta et al. (2008) report that banks charge 137 bps lower rates for loans traded in the secondary market. More precisely they report that the AIS spread on these loans (the interest rate less the LIBOR rate) is 137bps lower. In our model there is no interest rate, however, given the loan principal and the repayment, the implied interest rate is $i_i = R_i/L_i - s_C$, where the index stands for either E or V depending on the type of the loan. In our model all loans are traded on the secondary market. So, to construct the interest rate for non-traded loans, i_i^N, we calculate the repayment R_i^N the bank and entrepreneur would have negotiated if the bank were forced to keep the entire loan on its books. Equations (48) and (49) imply that the negotiated repayments would have been

$$\frac{R_V^N}{r + s_C} = \alpha_C \Psi + \frac{1-\alpha_C}{1-\xi(L_V)}\left[\frac{\chi}{q(\theta)} + F\right], \tag{66}$$

$$\frac{R_E}{r + s_C} = \alpha_C \left(\Psi - E_J^F\right) + \frac{(1-\alpha_C)}{1-\xi(L_E)}F. \tag{67}$$

Hence, the difference in the two interest rates is

$$i_i^N - i^i = (1-\alpha_C)(r + s_C)\left[\frac{1}{1-\xi(L_i)} - \frac{1}{D_i}\right]. \tag{68}$$

Taking a weighted average of the spread for vacancy and capital replacement loans and annualizing implies

$$\begin{aligned}
&\text{Bank discount for securitized loans} = \\
&12\Bigg\{\frac{(F+\frac{\chi}{q(\theta)})(A^V+D^V)}{(F+\frac{\chi}{q(\theta)})(A^V+D^V)+F(A^E+D^E)}(1-\alpha_C)(r+s_C)\left[\frac{1}{1-\xi(L_V)}-\frac{1}{D_V}\right] \\
&+\frac{F(A^E+D^E)}{(F+\frac{\chi}{q(\theta)})(A^V+D^V)+F(A^E+D^E)}(1-\alpha_C)(r+s_C)\left[\frac{1}{1-\xi(L_E)}-\frac{1}{D_E}\right]\Bigg\}. \qquad (69)
\end{aligned}$$

The last next moments all relate to the secondary loan market. Recall that the bid and ask prices for a type δ investor are given by the weighted average of the reservation value $\Delta V(\delta)$ and the inter-dealer price P: $B(\delta) = A(\delta) = \alpha_D \Delta V(\delta) + (1-\alpha_D)P$. Since, in equilibrium all types below the reservation are only looking to sell the asset and all types above are only looking to buy it, it follows that the average observed bid and ask prices are

$$\mathbb{E}[B(\delta)] = \int_{\delta_L}^{\delta^*} \alpha_D \Delta V(\delta) + (1-\alpha_D)P\psi_1(\delta)\delta, \qquad (70)$$

$$\mathbb{E}[A(\delta)] = \int_{\delta^*}^{\delta_H} \alpha_D \Delta V(\delta) + (1-\alpha_D)P\psi_0(\delta)\delta. \qquad (71)$$

Thus, the model-equivalent expression for the bid/ask spread is given by

$$\text{Bid/ask spread} = \frac{\mathbb{E}[A(\delta)] - \mathbb{E}[B(\delta)]}{(\mathbb{E}[A(\delta)] + \mathbb{E}[B(\delta)])/2} \times 100. \qquad (72)$$

Next, the turnover in the secondary market is the ratio of trade volume to market capitalization. The trade volume is simply the average observed price $\tilde{P}$ times the contact rate λ times the mass of agents that would trade the asset if given the opportunity to contact a dealer. Since this mass is comprised of all non-owners of type above δ^* and all owners of type below δ^*, it follows that

$$\text{Trade volume} = \left[\int_{\delta_L}^{\delta^*} \psi_1(\delta)\delta + \int_{\delta^*}^{\delta_H} \psi_0(\delta)\delta\right]\tilde{P}. \qquad (73)$$

As market capitalization is the product of the average price $\tilde{P}$, times the asset supply, it follows that

$$\text{Turnover} = \frac{\left[\int_{\delta_L}^{\delta^*} \psi_1(\delta)\delta + \int_{\delta^*}^{\delta_H} \psi_0(\delta)\delta\right]}{\mathcal{A}}. \tag{74}$$

Lastly, we turn to the yield to maturity. Our asset yield a coupon payment of 1 every instant and the price at which they are purchased by investors is $A(\delta)$. Thus, the yield to maturity $\iota(\delta)$ is such that the expected yield-discounted sum of coupon payments is equated to the price, i.e.

$$A(\delta) = \mathbb{E}\left[\int_0^{T_s} 1 \times e^{-\iota(\delta)t} dt\right], \tag{75}$$

where T_s is the random maturity rate. Since maturity follows a Poisson process with mean s_C, it then follows that $\iota(\delta) = 1/A(\delta) - s_C$. Taking expectations implies the following average yield to maturity

$$\text{Yield to maturity} = \int_{\delta^*}^{\delta_H} \left[\frac{1}{A(\delta)} - s_C\right] \psi_0(\delta)\delta. \tag{76}$$

The last moment we use is the model-generated response in employment following a shock in κ. Thus, we solve the model' steady-state equilibrium to generate an initial level of employment $e = 1 - \mathcal{U}$, then raise κ by 65.75%, so that the probability a firm receives a loan decreases by 2.32pp, and then calculate the new level of employment, e'. Next, we scale the level of employment in the model e and e' such that its level is comparable to that in Chodorow-Reich (2014).[34] We then calculate the resulting change in employment following the formula in Chodorow-Reich (2014) for the level of employment growth g:

$$g = \frac{e' - e}{0.5(e' + e)} \times 100. \tag{77}$$

Consequently, the resulting change in the growth of employment is found by differentiating with respect to κ, i.e.

$$\frac{dg}{d\kappa} = 200\frac{(e' + e) - (e' - e)}{(e' + e)^2}\frac{de'}{dk} = \frac{400e}{(e' + e)^2}\frac{de'}{dk}, \tag{78}$$

[34] In particular, Chodorow-Reich's sample features 2,400 establishments with a mean employment level of 2,985 individuals. This yields a total number of employed people of 6,089,400. Thus, we re-scale e so that it is equal to 6,089,400 and we re-scale e' so that it is equal to 6,089,400$\times e'/e$.

where we take de'/dk to be the model-generated difference $e' - e$.