American Economic Review 2025, 115(4): 1100–1141
https://doi.org/10.1257/aer.20190650

Fragile New Economy: Intangible Capital, Corporate Savings Glut, and Financial Instability†

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The transition toward an intangible-intensive economy reshapes financial systems by creating a self-perpetuating savings glut in the production sector. As intangibles become increasingly important, firms hoard liquidity to finance investment in intangibles of limited pledgeability. Firms' savings feed cheap leverage to financial intermediaries and allow intermediaries to bid up asset prices, which in turn encourages firms to save more for asset creation. This paper develops a macrofinance model that offers a coherent account of rising corporate savings, debt-fueled growth of intermediaries, declining interest rates, and rising asset valuation. Along these secular trends, endogenous financial risk accumulates. (*JEL* E43, E44, G12, G21, G31, G32)

The development of financial markets and institutions has a profound impact on industrial structure (Rajan and Zingales 1998). Is the reverse true? Can the evolution of industrial structure shape the financial system? In this paper, I examine the transition toward an intangible-intensive economy. In the United States, investment in intangibles has overtaken physical investment as the largest source of economic growth (Corrado and Hulten 2010). By incorporating a defining feature of intangibles—limited pledgeability—in a dynamic model of macroeconomy with financial markets and intermediaries, I show that the rise of intangibles contributes to several secular trends in the US economy, such as the accumulation of corporate savings, the downward trend in interest rates, the growth of the financial intermediation sector, and the rising valuation in asset markets. Importantly, by connecting these secular

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† Go to https://doi.org/10.1257/aer.20190650 to visit the article page for additional materials and author disclosure statement(s).

trends through the rise of intangibles, my model reveals a mechanism of endogenous risk that makes the new economy financially fragile.

US nonfinancial corporations have accumulated a substantial amount of cash (Bates, Kahle, and Stulz 2009; Chen, Karabarbounis, and Neiman 2017; Gao, Whited, and Zhang 2021) and turned from a net borrower to a net saver (Quadrini 2017). The connection between intangibles and corporate savings is intuitive: To finance investment in intangibles of limited pledgeability, firms cannot rely on external financing and must hold internal funds (Pinkowitz, Stulz, and Williamson 2016; Falato et al. 2022; Begenau and Palazzo 2021).

The first innovation of this paper is to connect firms' intangible-driven demand for liquid assets to the secular decline in interest rates. Some have suggested a link between the demand for liquid assets and low interest rates (Del Negro et al. 2017). The focus has been on foreign savings (Caballero, Farhi, and Gourinchas 2008; Caballero and Krishnamurthy 2009; Gourinchas and Rey 2016). Domestic corporate savings, which are comparable in magnitude, received little attention in the literature on low interest rates.[1]

The second innovation and a distinguishing feature of my model is a general equilibrium analysis of liquid assets. What firms hold as cash are mainly deposits and other debt instruments issued by financial intermediaries. In the decades leading up to the Great Recession, debt issuance fueled growth of the intermediation sector (Adrian and Shin 2010; Greenwood and Scharfstein 2013; Pozsar 2014). Taking advantage of the low interest rate, intermediaries are able to lever up cheaply and drive up the prices of collateral assets that can back debt issuance.

In the model, these trends arise in response to an exogenous increase in intangible investment needs. To finance intangibles, firms hold savings in the form of intermediaries' debts. Intermediaries' debts are in turn backed by claims on firms' tangible capital. As firms' savings push down the interest rate, intermediaries can borrow cheaply and bid up the value of tangible capital. Tangible capital can be pledged for external financing, so a higher value of tangible capital allows firms to lever up savings for larger and more profitable investments. As a result, firms are more eager to save, and the interest rate declines more, encouraging intermediaries to borrow more and to further bid up the value of tangible capital. A self-perpetuating savings glut pushes down the interest rate and pushes up the asset (tangible capital) price, allowing intermediaries to grow in the process.

This feedback mechanism also generates endogenous risk. Unlike intermediaries that play the roles as suppliers of liquid assets and hold tangible capital to back their debts, households have higher funding costs and are only willing to pay a lower price for tangible capital. As tangible capital value increases and firms accumulate savings in booms, the interest rate on liquid assets goes down, giving intermediaries an increasingly large advantage in funding cost. The longer booms last, the wider the funding-cost wedge is between intermediaries and households. When negative shocks hit and intermediaries deleverage, the reallocation of tangible capital from intermediaries to households causes a collapse of the market value of tangible capital,

[1] The ratio of nonfinancial firms' liquidity holdings to foreigners' holdings has been stable since the 1990s, around 75 percent. Liquid assets include currency and deposits, open-market papers, and repurchase agreements held directly or indirectly via mutual funds (Board of Governors of the Federal Reserve System 2019).

which discourages firms from saving for investment and exacerbates intermediaries' deleveraging. This channel, based on investment-driven demand for liquid assets, differs from the standard balance sheet channel. It offers a new explanation on why severe crises follow prolonged booms.[2]

In the model, firms' investment is financially constrained, and internal funds are necessary due to the intangible component that has limited pledgeability. The tangible component makes available external financing and a leverage on internal funds, but its endogenous market value triggers feedback effects. Importantly, when the value of tangible capital increases, firms increase savings. I provide evidence on this feature of corporate savings. In contrast, households' holdings of liquid assets decline when asset prices rise. This paper highlights the importance of firms' liquidity demand for understanding asset prices, interest rates, and financial stability. The macrofinance literature focused on households' demand for liquid assets (Kiyotaki and Moore 2000; Stein 2012; Moreira and Savov 2017; Krishnamurthy and Vissing-Jørgensen 2015; Piazzesi and Schneider 2016; Van den Heuvel 2022; Begenau 2020; Begenau and Landvoigt 2022).

Next, I provide an overview of the model and more details on the mechanism and results. The continuous-time economy has entrepreneurs, bankers, and households. Their roles are discussed sequentially. A unit mass of infinitely lived entrepreneurs manage tangible and intangible capital to produce nondurable generic goods. Capital represents efficiency units, and its output is normalized to one unit of goods per unit of time. Capital depreciates stochastically, loading on an aggregate Brownian shock. A negative shock reduces capital stocks that represent the production capacity in the economy. In spite of these common features, tangible and intangible capital differ in liquidity.

As in Holmström and Tirole (1998), entrepreneurs face liquidity shocks. Idiosyncratic Poisson shocks entail a restart of business; a firm's existing capital is destroyed, but it may create new capital. The entrepreneur chooses the amount of goods to invest (scale) and the intangible share of investment (composition). To finance the investment, the entrepreneur can sell the ownership of tangible capital at the market price and commit to dutifully managing the capital on behalf of buyers, delivering goods it produces. In other words, tangible capital is liquid (tradable and pledgeable). In contrast, intangible capital is not tradable or pledgeable, representing technological, human, and organizational capital that are inalienable or difficult for creditors to repossess.

The illiquidity of intangible capital tightens the funding constraint on investment. Investing in tangible capital relaxes the constraint, but intangible investment can be sufficiently productive such that entrepreneurs optimally choose a positive intangible share. Importantly, the productivity of intangible investment increases over time. This captures technological changes. And, as capital is essentially a stream of future consumption units, the fact that intangible investment creates increasingly more capital (production units) also captures the shift of consumers' preference toward output generated by intangibles. For example, the share of expenditure on services

[2] Studies on endogenous risk accumulation focus on intermediaries as lenders rather than issuers of liquid assets (Jordà, Schularick, and Taylor 2013; Gorton and Ordoñez 2014; Krishnamurthy and Muir 2016; Baron and Xiong 2017; López-Salido, Stein, and Zakrajšek 2017; Gorton and Ordoñez 2020).

has been growing in the United States, and intangibles are the key factor input in the sector (McGrattan 2020).[3]

The funding constraint implies that entrepreneurs want to hold liquidity and finance investment with a combination of internal funds and external funds (raised against tangible capital). One solution of liquidity provision, in the spirit of Holmström and Tirole (1998), is to pool all entrepreneurs' tangible capital—the source of capitalizable output—into a mutual fund whose shares are distributed back to entrepreneurs. The fund diversifies away the idiosyncratic Poisson shocks, so when the shock hits an individual entrepreneur, her fund shares are still valuable and can be used to finance investment, even though her own capital is destroyed.

However, such diversification services require expertise. In reality, firms mainly hold money market instruments issued by financial intermediaries in their portfolios of "cash and cash equivalents." A unit mass of infinitely lived bankers are introduced to intermediate the supply of liquidity.

Bankers buy tangible capital with their own wealth (equity) and by issuing short-term safe debts ("deposits") that entrepreneurs hold as liquidity buffers. Bankers create value not as lenders (their typical roles in macrofinance models) but instead as the issuers of liquid assets. The model highlights bankers' role in addressing asset shortages (Caballero 2006; Caballero, Farhi, and Gourinchas 2017b). Entrepreneurs assign a liquidity premium to deposits, which is equal to the marginal value of liquidity due to the Poisson-arriving investment needs (Holmström and Tirole 2001). This liquidity premium lowers the deposit rate, encouraging bankers to expand their balance sheets. However, acquiring tangible capital and issuing safe deposits involve risk taking, so bankers' capacity to intermediate the liquidity supply depends on their wealth as the risk buffer.

Finally, households are introduced, competing with entrepreneurs to hold deposits. Following the literature, households' demand is from deposit-in-utility, motivated by the roles of deposits as means of payment. Households can also own tangible capital, but relative to bankers, they cannot earn the liquidity premium by issuing deposits, so they face a higher funding cost and thereby require a higher expected return for holding tangible capital.

The exogenous process of intangible investment productivity and other parameters of entrepreneurs' investment technology are calibrated to match the trends and cyclical fluctuations of intangible investment and tangible investment. The arrival rate of the Poisson shock is calibrated to generate a positive response of entrepreneurs' liquidity holdings to intangible investment needs that matches the empirical estimate. The model features both firms' and households' liquidity demand, and one of the main contributions is to evaluate their relative importance in driving interest rates, asset prices, and endogenous financial risk through counterfactual analysis. Therefore, it is important to generate realistic dynamics of both firms' (i.e., entrepreneurs') and households' liquidity holdings in the baseline model. For

[3] Two channels have been proposed to explain the growing demand of services. First, income growth, under nonhomothetic preferences, makes the services sector grow faster than the rest of the economy (Kongsamut, Rebelo, and Xie 2001; Herrendorf, Rogerson, and Ákos Valentinyi 2013). Second, productivity growth is biased. Labor-intensive sectors benefit less from technological progress, so the relative prices of their output increase over time relative to other products, forcing an increasingly large share of consumer expenditure (Baumol 1967; Ngai and Pissarides 2007).

this purpose, an exogenous trend is introduced in households' deposit-in-utility, and it is calibrated so that the magnitude of households' liquidity holdings, especially relative to those of entrepreneurs', matches data. The calibration exercise targets the evolution of quantity variables, such as investment and liquidity holdings. For price variables, such as the interest (deposit) rate and tangible capital value, the calibration exercise only targets the values at the beginning of the sample period and leaves the trends to endogenous forces.

In response to the exogenous increase in intangible investment productivity, the model generates upward trends in the intangible share of investment, entrepreneurs' liquidity holdings (and bankers' debt issuances), and tangible capital value and a downward trend in the deposit rate. To address the rising needs for intangible investment, entrepreneurs hold more deposits and push down the deposit rate, feeding bankers with cheap funding and allowing them to bid up the market value of tangible capital. A higher value of tangible capital allows entrepreneurs to lever up their liquidity holdings to larger and more profitable investment. Therefore, entrepreneurs' incentive to save is strengthened, and the deposit rate declines further. The self-enforcing mechanism successfully replicates these secular trends except that for the interest rate, it delivers a stronger downward trend into the negative territory likely due to the lack of nominal frictions and zero lower bound. Note that the feedback effects can be so strong that equilibrium multiplicity arises, in which case, the equilibrium with intangible share of investment closest to data is selected. The multiplicity is interesting by itself, as it offers a potential explanation for why the rise of intangibles and the associated secular trends are more prominent in the United States than the rest of the world.

The feedback mechanism also amplifies economic fluctuations along the trends. Endogenous financial risk accumulates after positive shocks and materializes into a downward spiral when negative shocks hit. Consider a positive shock to capital stocks. Given bankers' levered positions in tangible capital, their wealth increases significantly. The liquidity premium on deposits makes bankers' marginal costs of financing (and discount rates) lower than households'. Therefore, when bankers—the natural buyers of tangible capital—become richer, their demand drives up the market value of tangible capital, which in turn leads to a higher leverage on entrepreneurs' deposits and higher investment profits. So, entrepreneurs save more, driving down the deposit rate and bankers' discount rate, further widening the discount-rate gap between bankers and households. This makes the value of tangible capital increasingly sensitive to negative shocks that trigger reallocation of tangible capital away from the natural buyers (bankers) to households and back to entrepreneurs. Asset price volatility affects the real economy. The value of tangible capital falls significantly after negative shocks, reducing entrepreneurs' leverage on deposit holdings and their investments. By reducing bankers' wealth, the decline of tangible capital value also causes bankers to shrink balance sheets, so entrepreneurs hold fewer deposits and their investments decline further.

I construct counterfactual scenarios to highlight the quantitative importance of the rise of intangibles. In the first scenario, the trend in intangible investment productivity is muted, so parameters governing entrepreneurs' liquidity demand are fixed in the 1980s, while households' liquidity demand exhibited an upward trend. In the second scenario, the trend in households' liquidity demand is shut down, while the upward trend in intangible investment productivity is preserved. For interest rate and asset price (i.e., tangible capital value), these two scenarios generate weaker trends than the main model, with upward trends in both entrepreneurs' and households' liquidity demand.

However, when it comes to endogenous risk, the scenario with an upward trend in intangible investment productivity but no trend in households' liquidity demand dominates the main model. The reason is that entrepreneurs' incentive to save comoves with asset price (tangible capital value) as a higher tangible capital value allows entrepreneurs to lever up their savings for larger and more profitable investments. I provide evidence on such dynamics. In contrast, households' liquidity demand exhibits countercyclicality in both the model and data. In the main model, households' liquidity demand counterbalances entrepreneurs' liquidity demand, moderating the fluctuations of aggregate demand for bank deposits. Without the upward trend in households' liquidity demand, the procyclicality of entrepreneurs' savings is fully unleashed, so the hypothetical scenario where only the rise of intangibles is present features the strongest shock amplification mechanism. Therefore, despite being less than 14 percent of households' liquidity holdings (both in the model and data), firms' liquidity holdings, driven by the rising needs for intangible investments, have a much stronger impact on financial stability.

As the economy becomes more intangible intensive, the pledgeability of intangible assets improves (Mann 2018), and new markets emerge for the exchange of intangibles (Akcigit, Celik, and Greenwood 2016). I extend the model by allowing a fraction of intangibles to be pledgeable or sellable. Note that as long as intangibles are not fully pledgeable, investment still cannot fully rely on external financing, and liquidity holdings are necessary. What improved pledgeability does is to increase the leverage on liquidity holdings, which leads to a higher marginal benefit of holding liquidity. Therefore, the feedback mechanism is amplified. The trend in intangible-investment productivity triggers an increasing and convex trend in the intangible share of investment, in contrast to the linear trend in the intangible share of investment in the baseline model. As a result, entrepreneurs' savings increase more over time, resulting in a much lower deposit rate, higher tangible capital value, and a higher level of endogenous financial risk.

Literature.—This paper contributes to the broad literature on the macroeconomics of intangible capital.[4] The focus is on the limited pledgeability of intangible capital and firms' savings for intangible investment, motivated by evidence on the concentration of massive cash holdings in intangible-intensive firms.[5] The increase of intangible investment productivity is a driving force behind the accumulation

[4] Previous studies have shown that the rise of intangible capital is important for explaining the secular trends in corporate profits and investment (McGrattan and Prescott 2010b; Crouzet and Eberly 2018; Gutiérrez and Philippon 2017; Peters and Taylor 2017). Dell'Ariccia et al. (2021) and Döttling and Perotti (2017) emphasize the decline of firms' borrowings from banks as a result of less collateral assets. In contrast, this paper focuses on the liability side of banks' balance sheets, that is, firms holding banks' liabilities as liquidity buffer. Previous studies also explore broad implications of intangible capital on productivity (Atkeson and Kehoe 2005; McGrattan 2020), current account (McGrattan and Prescott 2010a), stock valuation (Hansen, Heaton, and Li 2005; Ai, Croce, and Li 2013; Eisfeldt and Papanikolaou 2013), and investment (Daniel, Naveen, and Yu 2018).

[5] See the related findings on corporate cash holdings (Pinkowitz, Stulz, and Williamson 2016; Graham and Leary 2018; Falato et al. 2022; Begenau and Palazzo 2021).

of corporate savings that is distinct from what has been proposed in the literature on corporate savings in macroeconomic dynamics (Bacchetta and Benhima 2015; Chen, Karabarbounis, and Neiman 2017; Quadrini 2017).

A unique feature of the model is that liquid assets are supplied endogenously by financial intermediaries.[6] Corporate savings have become a major cash pool that lends to financial intermediaries (Adrian and Shin 2010; Pozsar 2011; Carlson et al. 2016). However, the existing studies on corporate savings and the shortage of saving instruments have ignored the unique roles of financial intermediaries as issuers of liquid assets (Woodford 1990; Holmström and Tirole 1998, 2001; Giglio and Severo 2012; Farhi and Tirole 2012; Martin and Ventura 2012; Hirano and Yanagawa 2017; Miao and Wang 2018). The broader literature on asset shortage also studies foreign savings as sources of demand for liquid assets, but when it comes to the supply of liquid assets, the active roles of financial intermediaries are absent (Bernanke 2005; Caballero and Krishnamurthy 2006; Caballero, Farhi, and Gourinchas 2008; Caballero and Krishnamurthy 2009; Gourinchas and Rey 2016; Maggiori 2017; Bolton, Santos, and Scheinkman 2021).[7]

Connecting firms' demand for liquid assets and financial intermediaries' supply delivers several unique predictions. The downward trend in interest rates has drawn enormous attention and has been studied jointly with other secular trends (Caballero, Farhi, and Gourinchas 2017a; Eggertsson, Robbins, and Wold 2021; Farhi and Gourio 2018; Marx, Mojon, and Velde 2021; Corhay, Kung, and Schmid forthcoming). This paper proposes corporate savings as a driving force behind the declining interest rate and demonstrates the quantitative importance of this channel. The low interest rate allows financial intermediaries to borrow cheaply and creates a discount-rate wedge between financial intermediaries and the rest of the economy, which has a destabilizing effect on the financial system: When negative shocks trigger reallocation of assets from intermediaries to the rest of the economy, asset prices collapse. Moreover, the longer a boom lasts, the wider the discount-rate wedge is, and thus, the more sharply the asset prices fall when negative shocks hit.[8] The previous literature on financial accelerators focuses on firms' borrowing rather than firms' savings as a source of financial instability (Kiyotaki and Moore 1997; Bernanke, Gertler, and Gilchrist 1999).

Recent studies in the macrofinance literature highlight the value of bank liabilities in incomplete markets (Brunnermeier and Sannikov 2016) and as liquid assets for households (Kiyotaki and Moore 2000; Krishnamurthy and Vissing-Jørgensen 2015; Piazzesi and Schneider 2016; Moreira and Savov 2017; Begenau and Landvoigt 2022; Van den Heuvel 2022; Begenau 2020; Egan, Lewellen, and Sunderam 2022).[9]

[6] The literature of firms' liquidity management problem takes a partial equilibrium approach and assumes a perfectly elastic supply of storage technology, leaving out the question of who issues the securities called "cash and cash equivalents" (e.g., Froot, Scharfstein, and Stein 1993; Riddick and Whited 2009; Bolton, Chen, and Wang 2011; Décamps et al. 2011; He and Kondor 2016).

[7] US nonfinancial corporations' holdings of intermediary debts are comparable in magnitude to foreigners' holdings. The ratio of the former to the latter is stable since the 1990s, around 75 percent. Liquid intermediary debts include currency and deposits, open-market papers, and repurchase agreements held directly or indirectly via money market or mutual funds (Board of Governors of the Federal Reserve System 2019).

[8] This procyclical discount-rate wedge is distinct from the constant cash flow wedge between intermediaries and households in Brunnermeier and Sannikov (2014) due to differences in production skills.

[9] See also the banking literature (Diamond and Dybvig 1983; Gorton and Pennacchi 1990; Goldstein and Pauzner 2005; Dang et al. 2017; Hart and Zingales 2014).

This paper is the first to model both households' and firms' liquidity demand, and the model is calibrated so their relative contributions to intermediaries' funding match data. This allows for a counterfactual analysis to show the relative importance of firms' liquidity demand in affecting interest rates, asset prices, and financial instability.[10] Sections I and III provide evidence on the distinct responses of households' and firms' liquidity demand to asset-price variations that are consistent with the model's predictions.[11]

I. Corporate Liquidity Demand

This section establishes a robust empirical link between intangible investment and firms' holdings of liquid assets. The intangible-liquidity link is stronger when the value of tangible capital (i.e., capitalizable or pledgeable value of future output) increases. The sample is Compustat firm-year observations from 1980 to 2019 (CRSP 2019).[12] Firms' liquidity holdings are given by cash and cash equivalents. Intangible intensity is measured by the ratio of intangible investment to total assets averaged over time within firm. Firms are sorted into quintiles to form the ranking variable "Intan./Assets." Following the literature, intangible investment includes R&D and organizational-capital investment that is 30 percent of SG&A expenses.[13]Two aggregate measures of tangible capital valuations are constructed. Each year, I calculate the market capitalization-weighted average ratio of enterprise value (EV) to earnings before interest, tax, depreciation, and amortization (EBITDA). The data are from WRDS (2019). EV is the present value of a firm's *capitalizable* output, that is, the value of tangible capital in the model.[14]

Figure 1 reports scatter charts of cash/assets against capital valuation (and regression lines) for Intan./Assets quintiles. A point is given by the quintile's market capitalization-weighted average cash/assets in a year and average EV/EBITDA in that year. More intangible firms hold more cash, with a stronger correlation between cash and capital valuation. Supplemental Appendix D reports similar patterns with tangible EV/EBITDA and Tobin's Q as measures of capital valuation. Tangible EV/EBITDA is the average EV/EBITDA in the lowest Intan./Assets quintile.[15]

[10] Relatedly, Eisfeldt (2007) shows that the liquidity premium of Treasury bills cannot be explained by the liquidity demand from consumption smoothing under standard preferences. Eisfeldt and Rampini (2009) document that corporate liquidity needs are correlated with measures of liquidity premium.

[11] Except Eisfeldt and Muir (2016), the empirical literature on firms' cash holdings focuses on trends, not cycles. A new finding in this paper is the comovement between corporate savings and asset prices.

[12] This includes Compustat firm-year observations with nonmissing data for total assets and sales. All firms incorporated in the United States are included except financials (SIC 6000-6999) and utilities (SIC 4900-4999). The sample starts from 1980 because, before the 1980s, Regulation Q imposed various restrictions on deposit rates. For example, it prohibited banks from paying interest on demand deposits. This practice is inconsistent with the model specification that the deposit rate, r_t, is the price variable that clears the deposit market. Supplemental Appendix C provides summary statistics.

[13] This follows a large literature on measuring intangible investment (Corrado, Hulten, and Sichel 2009; Eisfeldt and Papanikolaou 2013; Falato et al. 2022; Peters and Taylor 2017; Belo, Lin, and Vitorino 2014).

[14] Supplemental Appendix D uses more restrictive Tangible EV/EBITDA from the lowest quintile of Intan./Assets.

[15] Two versions of Tobin's Q are calculated: the total average Tobin's Q and tangible Tobin's Q that is the average Q of firms in the lowest Intan./Assets quintile. Averages are market capitalization weighted.

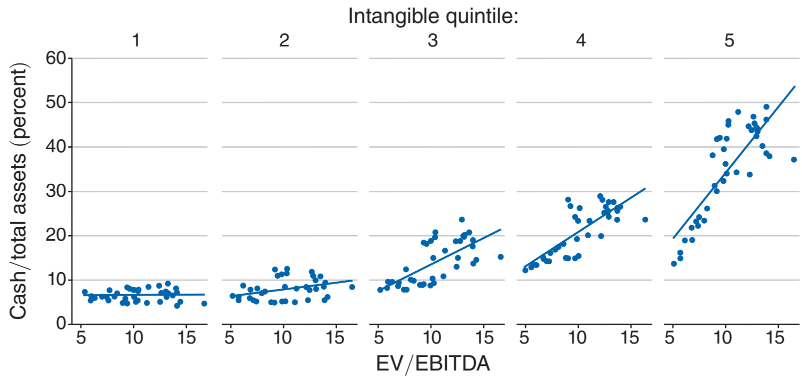

Figure 1. Capital Valuation and Cash Holdings by Intangible Quintile

Table 1—Intangible Investment, Capital Valuation, and Cash Holdings

Cash/Assets	Intangibility = Intan./Assets (quintile)				Intangibility = Intan./Investment			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Intangibility and corporate cash holdings								
Intangibility	6.600	6.493	5.277	5.009	0.207	0.196	0.186	0.170
	(0.440)	(0.455)	(0.320)	(0.335)	(0.015)	(0.016)	(0.010)	(0.010)
Controls	No	No	Yes	Yes	No	No	Yes	Yes
Year fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Observations	152,826	152,826	132,632	132,632	112,171	112,171	98,571	98,571
Adjusted R^2	0.1669	0.1903	0.2588	0.2757	0.0964	0.1185	0.2467	0.2585

Cash/Assets	Valuation = Ave. EV/EBITDA				Valuation = Tangible EV/EBITDA			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel B. Capital valuation and intangible-driven corporate cash holdings								
Intan./Assets	−2.427	−2.742	−1.484	−1.846	−1.039	−1.511	−0.277	−0.813
	(1.199)	(1.134)	(1.012)	(0.943)	(1.438)	(1.449)	(1.207)	(1.216)
Valuation	−0.731		−0.590		−0.789		−0.738	
	(0.097)		(0.066)		(0.131)		(0.082)	
Intan./Assets × Valuation	0.849	0.881	0.638	0.661	0.833	0.884	0.612	0.649
	(0.121)	(0.116)	(0.098)	(0.94)	(0.153)	(0.157)	(0.127)	(0.131)
Controls	No	No	Yes	Yes	No	No	Yes	Yes
Year fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Observations	152,826	152,826	132,632	132,632	152,826	152,826	132,632	132,632
Adjusted R^2	0.2008	0.2128	0.2763	0.2883	0.1863	0.2044	0.2674	0.2832

Note: Firm-year clustered standard errors in parentheses.

Table 1 reports regression results that correspond to the patterns in Figure 1. The explanatory variables of interest, capital valuation and the quintile ranking variable Intan./Assets, are the same as in Figure 1. Different from Figure 1, which plots the time series variation of within-quintile average cash/assets, the regression dependent variable, cash/assets, has both time series and cross section variation. I consider

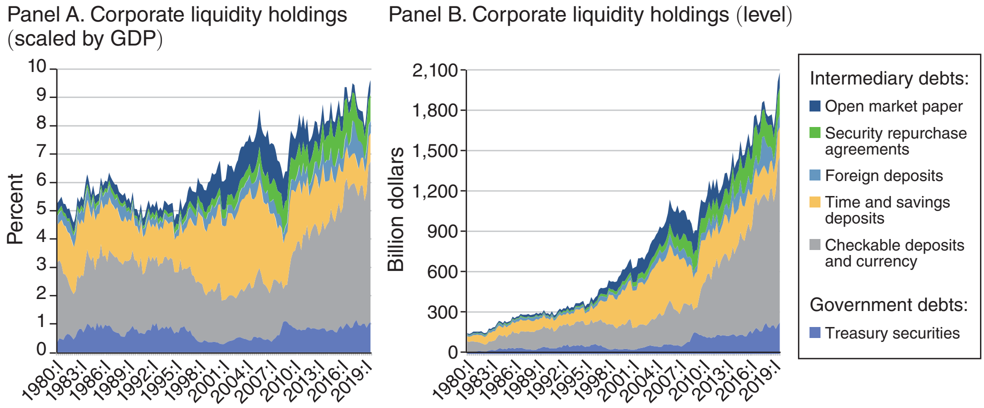

Figure 2. Decomposing Nonfinancial Firms' Holdings of Liquid Securities

different specifications controlling for firm characteristics and/or time fixed effects.[16] Columns 1 to 4 in panel A of Table 1 show that more intangible-intensive firms hold more cash.[17] In column 5 to 8, the ranking variable, Intan./Assets, is replaced by the intangible investment-to-total investment ratio that maps more directly to the model setup in Section II. The estimates will guide model calibration. Columns 1 to 4 in panel B report a positive coefficient of the interaction between asset valuation and intangibility that is robust across specifications. As in Figure 1, more intangible firms' cash holdings are more sensitive to capital valuation. In columns 5 to 8 of panel B, I use a more restrictive measure of tangible capital valuation, tangible EV/EBITDA. Supplemental Appendix C reports similar results with Tobin's Q as a measure of capital valuation.[18]

Figure 2 examines the general equilibrium of liquid assets by shifting focus from demand to supply. Nonfinancial firms' liquid assets are mainly issued by financial intermediaries (Board of Governors of the Federal Reserve System 2019). Mutual fund and money market fund holdings are attributed to underlying assets based on sector-level tables. Firms are among the major cash pools that feed leverage to intermediaries (Carlson et al. 2016; Pozsar 2014). Their liquid assets scaled by GDP almost doubled by 2019. The trend was interrupted by the financial crisis and firms' flight to Treasuries, but the trend resumed afterward. However, the loss of firms' savings for intermediaries in the crisis was recognized by regulators. Retail

[16] The control variables are selected and winsorzied following Opler et al. (1999) and Bates, Kahle, and Stulz (2009). They include (Compustat codes in parenthesis) acquisition activity (aqc/at); capex (capx/at); cash flow ([oibdp − xint − dvc − txt]/at); net working capital ([wcap − che]/at); payout dummy (equal to 1 if dvc is positive); leverage ([dlc − dltt]/at); market to book ratio ([at + prcc_f*csho − ceq]/at); R&D to sales ratio (xrd/sale); size (log of at in 2005 dollars); Tobin's Q ([at + prcc_f*csho − ceq − txdb]/[0.1*(at + prcc_f*csho − ceq − txdb) + 0.9*at]); and industry sigma, which is the 10-year mean of the cross-sectional standard deviations of firms' cash flow/assets in a two-digit SIC industry.

[17] Investment need is a key determinant of cash holdings (Denis and Sibilkov 2010; Duchin 2010). Firms with less collateral hold more cash (Almeida and Campello 2007; Li, Whited, and Wu 2016).

[18] Supplemental Appendix Table D.3 reports similar results under sorting by tangible assets (PPE). Less tangible firms exhibit stronger correlation between cash and capital valuation (measured by EV/EBITDA or Tobin's Q).

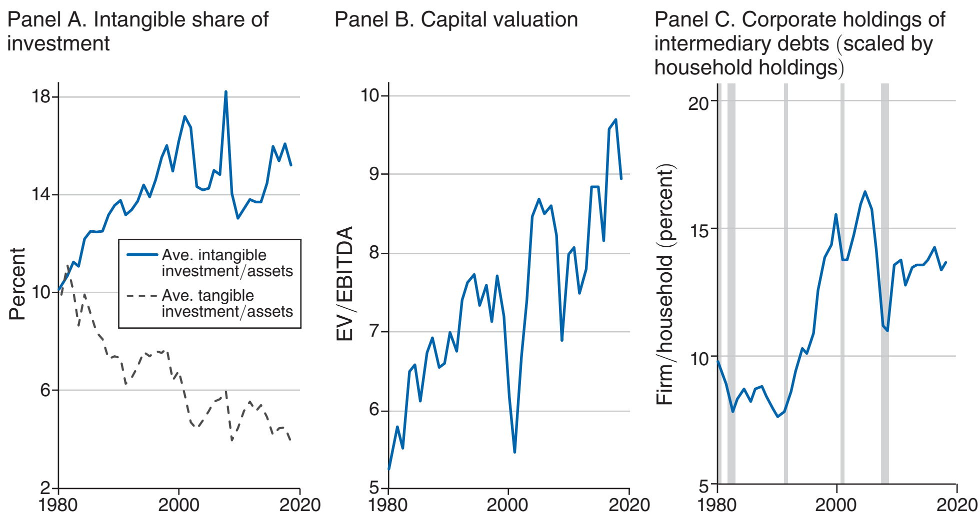

Figure 3. Intangible Investment, Capital Valuation, and Corporate Savings

deposits are assigned 90 percent to 95 percent stable funding factor, while corporate deposits are assigned 50 percent (Basel Committee on Banking Supervision 2014).

The rise of corporate savings in Figure 2 coincided with the secular increase in intangible investment, especially relative to tangible investment in panel A of Figure 3. Moreover, in panel B of Figure 3, capital valuation exhibits an upward trend, which, according to the evidence in Figure 1 and Table 1, reinforced the rise of intangibles in fueling the corporate savings glut. Along the secular trends, cyclical fluctuations emerge in both investment and capital valuation, feeding procyclicality to corporate savings. Panel C of Figure 3 plots the ratio of firms' holdings of intermediary debts to households' holdings (Board of Governors of the Federal Reserve System 2019). Recession years are marked by shaded areas. The ratio trends upward, with cyclical drops in recessions, suggesting that, as a source of funding for intermediaries, corporate liquidity holdings are more procyclical than households'. Next, a model is built to generate both the trends and cyclical fluctuations in intangible share of investment, capital valuation, and corporate liquidity holdings. The model highlights endogenous risk that arises from the reinforcing procyclicality of these variables and becomes increasingly strong along the secular trends. The model also provides a new account of trends in interest rates and the size of the intermediation sector, which have been documented extensively.

II. Model

Consider a continuous-time, infinite-horizon economy. The model fixes an information filtration that satisfies the standard regularity conditions (Protter 1990). The production sector is set up first, with a focus on intangible-driven liquidity demand. Later, bankers and households are introduced.

A. *The Production Sector and Liquidity Demand*

Preferences.—There is a unit mass of entrepreneurs. Let $\mathcal{E} = [0,1]$ denote the set. Let c_t^E denote a representative entrepreneur's *cumulative* consumption up to time t. Throughout this paper, subscripts denote time, and whenever necessary, superscripts are used to denote agents' type, with "E" for entrepreneurs (and later, "B" for bankers and "H" for households). An entrepreneur maximizes the lifetime, risk-neutral expected utility with discount rate ρ:

$$(1) \qquad \mathbb{E}\left[\int_{t=0}^{\infty} e^{-\rho t} dc_t^E\right].$$

Capital and Production.—Each entrepreneur manages a firm that has tangible and intangible capital. Capital represents efficiency units and is counted by its output: One unit of capital produces one unit of nondurable generic goods per unit of time. In aggregate, the economy has K_t^T and K_t^I units of tangible and intangible capital, respectively, at time t that generate a flow of output, $\left(K_t^T + K_t^I\right)dt$ over dt. A fraction $\delta\, dt - \sigma\, dZ_t$ of capital are destroyed over dt. The standard Brownian motion Z_t captures aggregate shocks to production capacity.[19]

The two types of capital differ in liquidity. Tangible capital is liquid. It can be pledged for financing, and entrepreneurs may sell the capital ownership and dutifully manage the capital on behalf of investors delivering goods produced. Tangible capital represents inventory, equipment, plant, and property. In reality, even though certain tangible assets are not actively traded, the securities backed by their cash flows are traded. In contrast, intangible capital is illiquid. It cannot be pledged for financing, and its ownership cannot be traded. It represents human and organizational capital, customer base, and proprietary technologies that are difficult for investors to repossess.

Investment and Liquidity Demand.—The Poisson arrival of investment needs is independent across entrepreneurs with intensity λ. When hit by the shock, an entrepreneur's firm loses all capital but is endowed with a technology to transform goods into new capital instantaneously.[20] She chooses i_t, the amount of goods invested, and θ_t, the intangible share, to create $\kappa_t^I \theta_t i_t$ units of intangible capital and $\kappa^T\left(1 - \theta_t\right) i_t$ units of tangible capital. Tangible investment efficiency is constant κ^T. Intangible investment efficiency increases over time, $\kappa_t^I = \kappa^I\left(t\right)$. Capital corresponds to a stream of future goods, so an increase of κ_t^I means that intangible investment generates more production capacity. It also captures the shift of consumers' preference toward output generated by intangibles, such as professional and business services (McGrattan 2020).[21]

[19] For parsimony, the stochastic depreciation rates are the same for both types of capital. Introducing different depreciation rates for intangible and intangible capital will not change the mechanism.

[20] This specification reflects the lumpiness of investment at micro levels (e.g., Doms and Dunne 1998). Due to the idiosyncratic nature of investments, the aggregate investment is smooth (Thomas 2002).

[21] This paper takes the structural change as exogenous. The literature on the growth of services sector provides several explanations (Kongsamut, Rebelo, and Xie 2001; Herrendorf, Rogerson, and Valentinyi 2013; Ngai and Pissarides 2007).

Let q_t^I denote the value of intangible capital (denominated in goods). The entrepreneur is indifferent in consumption timing, so she values the goods from intangible capital simply by Gordon growth formula, accounting for normal-time depreciation and Poisson-arriving destruction

$$q_t^I = \frac{1}{\rho + \delta + \lambda}. \tag{2}$$

Henceforth, the time subscript is dropped for q^I. As will be emphasized later in the solution, the unit value of tangible capital, denoted by q_t^T, may vary over time and loads on the aggregate shock,

$$dq_t^T = q_t^T \mu_t^T dt + q_t^T \sigma_t^T dZ_t, \tag{3}$$

where the drift and diffusion terms will be solved in equilibrium.

Given q^I and q_t^T, an investing entrepreneur maximizes the investment profits

$$\max_{\{i_t, \theta_t\}} \left[q^I \kappa_t^I \theta_t + q_t^T \kappa^T (1 - \theta_t) - F(\theta_t) \right] i_t - i_t, \tag{4}$$

where a convex $F(\theta_t)$ is introduced to avoid counterfactual corner solutions (i.e., $\theta_t \in \{0, 1\}$). Due to the illiquidity of intangible capital, the scale of investment is constrained by tangible value:

$$i_t \leq q_t^T \kappa^T i_t (1 - \theta_t). \tag{5}$$

Self-financing, $1 \leq q_t^T \kappa^T (1 - \theta_t)$, is ruled out (see details in Supplemental Appendix A).

ASSUMPTION: *Investment projects are not self-financed:* $\kappa^T \left(\frac{1}{\rho + \delta + \lambda} \right) < 1$.

Under the financial constraint, entrepreneurs would hold liquidity, that is, assets other than their own capital, immune to the Poisson shocks.[22] Holmström and Tirole (1998) point out a solution that is to pool pledgeable assets (tangible capital) in mutual funds where idiosyncratic shocks are diversified away. Then entrepreneurs hold the mutual-fund shares and use them for investment. Let m_t^E denote an entrepreneur's liquidity holdings, so the constraint (5) becomes

$$i_t \leq q_t^T \kappa^T i_t (1 - \theta_t) + m_t^E. \tag{6}$$

However, as shown in Figure 2, firms rarely hold direct claims on other firms but instead hold debt securities largely issued by financial intermediaries. Diversification may require intermediaries' expertise.[23] And, under agency frictions that limit equity

[22] It is well documented that intangible investments rely heavily on firms' internal liquidity (for example, R&D investments in Hall 1992; Himmelberg and Petersen 1994; Hall and Lerner 2010).

[23] Intermediation is also motivated by required expertise in monitoring (Diamond 1984), restructuring (Bolton and Freixas 2000), or enforcing collateralized claims (Rampini and Viswanathan 2019).

issuances (e.g., He and Krishnamurthy 2013), firms hold intermediaries' debt rather than equity. Intermediated liquidity supply is also motivated by studies on banks as inside money creators (e.g., Kiyotaki and Moore 2000).

B. *Intermediated Liquidity Supply*

Bankers are introduced to intermediate the supply of liquidity. Entrepreneurs are assumed to hold liquidity in the form of short-term bank debts (referred to as "deposits") that are in turn backed by bankers' holdings of tangible capital. With a slight abuse of notation, m_t^E now represents entrepreneurs' deposit holdings that mature in dt with interests $r_t dt$. I characterize a Markov equilibrium where banks never default, so bank debt is safe and $r_t dt$ is also the realized return.[24]

When the Poisson shocks hit, entrepreneurs use deposits to buy goods as investment inputs. In contrast to the existing macroeconomic models with financial intermediation that emphasize bankers' expertise on lending, this model emphasizes the liability side of bank balance sheets; banks add value to the economy because their debts are held by entrepreneurs as liquidity buffers.

Preferences.—There is a unit mass of bankers. Let $\mathcal{B} = [0,1]$ denote the set of bankers. A representative banker maximizes the lifetime, risk-neutral expected utility with discount rate ρ:

$$\mathbb{E}\left[\int_{t=0}^{\infty} e^{-\rho t} dc_t^B\right], \tag{7}$$

where c_t^B denotes a banker's *cumulative* consumption up to time t.

Balance Sheet.—A banker incurs interest expenses $r_t dt$ on debt liabilities and earns risky return dr_t^T on her holdings of tangible capital, where r_t^T denotes the *cumulative* return that loads on shocks. To characterize dr_t^T, let k_t^{TB} denote a banker's holdings of tangible capital, with "T" and "B" indicating "tangible" and "banker," respectively. Capital stock depreciates stochastically, so

$$dk_t^{TB} = -k_t^{TB}(\delta dt - \sigma dZ_t) - k_t^{TB} \lambda dt. \tag{8}$$

The last term is from the λdt firms that lose capital due to the Poisson shocks. Through diversification, the banker faces a constant rate of capital destruction.

By Itô's lemma, equations (3) and (8) imply the tangible capital return:

$$dr_t^T = \frac{k_t^{TB} dt}{q_t^T k_t^{TB}} + \frac{d\left(q_t^T k_t^{TB}\right)}{q_t^T k_t^{TB}} = \left(\frac{1}{q_t^T} + \mu_t^T - \delta - \lambda + \sigma_t^T \sigma\right) dt + \left(\sigma_t^T + \sigma\right) dZ_t. \tag{9}$$

$1dt/q_t^T$ is dividend yield–production flow, $1dt$, divided by the unit value, q_t^T. $\left(\mu_t^T - \delta - \lambda\right) dt$ account for the expected unit value change, quantity depreciation, and measure of firms hit by the Poisson shocks. $\sigma_t^T \sigma$ is Itô's quadratic

[24] Macrofinance models that are built upon diffusion processes typically do not feature bank default (e.g., Brunnermeier and Sannikov 2014). Default may be introduced through aggregate Poisson shocks.

covariation. Shock loading consists of σ_t^T, the endogenous return volatility of q_t^T (price risk), and σ, the exogenous volatility of depreciation shock (quantity risk).

Let n_t^B denote a representative banker's wealth with the following law of motion,

$$dn_t^B = x_t^B n_t^B dr_t^T - \left(x_t^B - 1\right) n_t^B r_t dt - dc_t^B, \tag{10}$$

where $x_t^B \equiv q_t^T k_t^{TB} / n_t^B$ is the asset-to-wealth ratio and debt value is $\left(x_t^B - 1\right) n_t^B$.

As shown by (10), intermediation involves risk taking. Bankers issue safe deposits while holding risky tangible capital. Equity capital buffers risk. An undercapitalized banking sector cannot adequately fulfill its role as liquidity supplier. To capture this idea, I assume that banks cannot issue outside equity, that is, $dc_t^B \geq 0$ as in Brunnermeier and Sannikov (2014).[25] This can be motivated by agency frictions. As a result, bankers' wealth drives the *intermediation capacity*. In this model, entrepreneurs' liquidity demand from Holmström and Tirole (1998) meets banks' limited balance sheet capacity from Holmström and Tirole (1997).

C. *The Main Mechanism: Trends and Cycles*

The main results are in two categories: (i) the economy's response to the increase of κ_t^I over time (i.e., the trends) and (ii) the economy's response to the aggregate shock, dZ_t (i.e., the cycles). First, I explain the trends as I characterize the entrepreneurs' intangible-driven liquidity demand.

When hit by the Poisson shock, an entrepreneur maximizes investment profits given by (4) facing the liquidity constraint (6). Let π_t denote the marginal value of liquidity, that is, the Lagrange multiplier of constraint (6). The Lagrange function summarizes the entrepreneur's problem:

$$\begin{aligned} \mathcal{L} = \max_{\{i_t, \theta_t\}} \Big\{ & \left[q^I \kappa_t^I \theta_t + q_t^T \kappa^T (1 - \theta_t) - F(\theta_t)\right] i_t - i_t \\ & + \pi_t \left[m_t^E + q_t^T \kappa^T i_t (1 - \theta_t) - i_t\right] \Big\}. \end{aligned} \tag{11}$$

It is assumed that κ^T or κ_t^I is sufficiently high, so the constraint (6) binds. The entrepreneur can pledge the value of tangible capital and lever up one unit of liquidity to $1/\left[1 - q_t^T \kappa^T (1 - \theta_t)\right]$:

$$i_t = \left(\frac{1}{1 - q_t^T \kappa^T (1 - \theta_t)}\right) m_t^E. \tag{12}$$

The funds are raised against tangible capital at a fair price, so the entrepreneur captures all surplus per unit of investment, that is, $\left[q_t^I \kappa_t^I \theta_t + q_t^T \kappa^T (1 - \theta_t) - F(\theta_t)\right] - 1$.[26]

[25] By inspecting equation (9), we can see that negative consumption is equivalent to issuing equity to replenish net worth. See also Phelan (2016) and Klimenko et al. (2016) for similar specifications. Note that negative consumption is allowed for entrepreneurs except when liquidity shocks hit. In other words, entrepreneurs are only financially constrained at such Poisson times. Allowing negative consumption is equivalent to assuming large endowments of goods; if goods are nondurable, entrepreneurs always consume to clear the goods market, indifferent between consuming and saving. This fixes their marginal value of wealth at one and required return at ρ.

[26] The repayment for funds raised against tangible capital is in the ownership of the tangible capital. The entrepreneur is assumed to dutifully pass the production flows generated by the capital to its owners.

Therefore, the marginal value of liquidity, π_t, is the marginal profit of investment multiplied by the leverage on liquidity:

$$(13)\quad \pi_t = \underbrace{\left\{\left[q^I \kappa_t^I \theta_t + q_t^T \kappa^T (1-\theta_t) - F(\theta_t)\right] - 1\right\}}_{\text{marginal profit of investment}} \underbrace{\left(\frac{1}{1 - q_t^T \kappa^T (1-\theta_t)}\right)}_{\text{leverage on liquidity}}.$$

The entrepreneur's choice of θ_t is characterized by the first-order condition that equates the marginal values of intangible and tangible investments:

$$(14)\qquad q^I \kappa_t^I - F'(\theta_t) = (1+\pi_t)\, q_t^T \kappa^T.$$

Note that on the right side of (14), the marginal value of tangible capital, $q_t^T \kappa^T$, is amplified by π_t because investing more in tangible capital not only creates more production units but also relaxes the funding constraint (6). The next proposition summarizes the entrepreneur's liquidity-holding and investment decisions with a focus on the value of liquidity. Supplemental Appendix A provides the proof.

PROPOSITION 1: *Entrepreneurs' investment has the following properties:*

(*i*) *The optimal intangible share of investment, θ_t, in (14) is increasing in κ_t^I.*

(*ii*) *The marginal value of liquidity, π_t, given by (13), is increasing in κ_t^I and q_t^T,*

and entrepreneurs accept a deposit rate below ρ:

$$(15)\qquad r_t = \rho - \lambda \pi_t.$$

Proposition 1 implies several trends in equilibrium. As κ_t^I increases over time, intangible investment creates increasingly more production capacity than tangible investment, so the entrepreneurs optimally choose to tilt investment toward intangibles, that is, to increase θ_t. As the intangible share increases, the entrepreneurs face a tighter liquidity constraint, so the marginal value of liquidity, π_t, increases, driving down the deposit rate r_t. The entrepreneurs accept $r_t < \rho$. The wedge, $\lambda\pi_t$, depends on the probability of liquidity needs and marginal value of liquidity.

The decline of r_t triggers a feedback mechanism. It lowers bankers' cost of financing and allows them to bid up the price of tangible capital, q_t^T. A higher value of tangible capital enlarges the financing capacity of investment projects, allowing liquidity to be leveraged to larger investments. A higher q_t^T also means investments are more profitable. Therefore, π_t, the marginal value of liquidity holdings, increases further, and r_t drops even lower. The downward trend in r_t and upward trend in q_t^T reinforce each other, generating a corporate savings glut. This savings glut arises endogenously in a closed economy, distinct from an exogenous savings glut in open economies that has been shown to affect interest rates and asset prices (Caballero, Farhi, and Gourinchas 2008).

Tangible capital has two sources of value. It produces goods and provides liquidity by backing deposits. The bankers transmit the entrepreneurs' liquidity premium to the value of tangible capital. To fully solve q_t^T, we need a complete characterization of bankers' discount rate, $r_t + \textit{risk premium}$. For the risk-premium component, we obtain bankers' price of risk from the dynamics of marginal value of wealth. The homogeneity property of bankers' problem implies a linear value function $q_t^B n_t^B$. The marginal value of wealth, q_t^B, evolves in equilibrium

$$\frac{dq_t^B}{q_t^B} = \mu_t^B dt - \gamma_t^B dZ_t, \tag{16}$$

where μ_t^B and γ_t^B will be solved in equilibrium.

PROPOSITION 2: *The equilibrium expected return on tangible capital is*

$$\mathbb{E}_t\left[dr_t^T\right] = r_t dt + \gamma_t^B\left(\sigma_t^T + \sigma\right) dt. \tag{17}$$

The equilibrium value of tangible capital satisfies the following equation:

$$q_t^T = \frac{1}{\left[r_t + \gamma_t^B\left(\sigma_t^T + \sigma\right)\right] - \left[\mu_t^T + \sigma_t^T\sigma - \delta - \lambda\right]}. \tag{18}$$

Supplemental Appendix A provides the proof. Intuitively, $dZ_t < 0$ reduces bankers' wealth and increases their marginal value of wealth, so the bankers require a risk premium, $\gamma_t^B\left(\sigma_t^T + \sigma\right)dt$, in the expected return on tangible capital.[27] This is a standard asset-pricing result: γ_t^B is the price of risk and $\left(\sigma_t^T + \sigma\right)$ is the quantity of risk, a sum of exogenous risk, σ, and endogenous price risk, σ_t^T (see (3)). In equilibrium, $r_t + \gamma_t^B\left(\sigma_t^T + \sigma\right) \leq \rho$. When both the entrepreneurs, whose discount rate is ρ, and bankers own tangible capital, the expected return is ρ; when only the bankers own tangible capital, the expected return must not be greater than ρ, the entrepreneurs' required return. Being able to issue deposits at interest rate r_t gives the bankers a discount-rate advantage.

Equation (18) resembles the Gordon growth formula. The numerator is cash flow (production). In the denominator, the first component is discount rate, and the second is expected growth.[28] As κ_t^I drives up θ_t, the intangible share of investment, and π_t, the marginal value of liquidity, entrepreneurs accept an increasingly low deposit rate $r_t = \rho - \lambda\pi_t$ (see (15)), which drives down the discount rate in (18) and pushes up q_t^T. The bankers transmit the rising liquidity premium on deposits to q_t^T. The transmission is incomplete due to the risk-premium component of their discount rate. The risk premium can be shut down if the bankers were allowed to freely issue equity and thus have unlimited balance sheet capacity.[29] Comparing

[27] Like Tobin's Q, q_t^B is a forward-looking measure of profits per unit of equity. This offers an alternative view. Due to the negative shocks and their persistent effects under the equity issuance constraint, the whole banking sector becomes undercapitalized and shrinks for a sustained period of time. To clear the markets of tangible capital and deposits, the spread between the expected return on tangible capital and deposit rate will have to widen so that banks would hold tangible capital and issue deposits. As the expected future profits rise, q_t^B increases.

[28] Investment creates new capital instead of growing the existing capital, so it's not in the growth rate.

[29] Under frictionless equity issuance, $q_t^B = 1$ (i.e., no incentive to retain equity), so $\gamma_t^B = 0$.

(18) and the valuation of illiquid intangible capital (2), we can see that the source of variation in q_t^T is the liquidity value rather than production value. And the liquidity value varies with the bankers' intermediation capacity.

While the increase in κ_t^I generates the self-enforcing trends in r_t and q_t^T, the endogenous variation of γ_t^B generates the fluctuations along the trends (i.e., the cycles). After positive shocks ($dZ_t > 0$), bankers become wealthier, and their price of risk γ_t^B declines, so they bid up q_t^T, which in turn leads to a higher value of liquidity holdings for entrepreneurs (π_t) and a lower r_t. As the bankers' funding cost r_t declines, they push up q_t^T further. As the bankers expand the balance sheet and entrepreneurs hold more deposits, investment booms because the entrepreneurs hold more liquidity and can lever up through a higher value of tangible capital.

Endogenous risk accumulates in booms of liquidity creation and investment. As r_t declines, the wedge between the bankers' discount rate, $r_t + \gamma_t^B\left(\sigma_t^T + \sigma\right)$, and entrepreneurs' discount rate, ρ, widens, which makes q_t^T increasingly sensitive to shocks that cause reallocation of tangible capital between the bankers and entrepreneurs. When negative shocks hit, the bankers sell tangible capital back to entrepreneurs who have a higher discount rate. The reallocation causes a decline in asset price, q_t^T. Endogenous asset-price volatility has an impact on the real economy. Economic growth is directly tied to q_t^T through the leverage on liquidity and scale of investment (see (12)). A vicious cycle ensues. A lower q_t^T reduces investment profits and π_t, discouraging the entrepreneurs from saving for investments. This causes the rise of r_t, the bankers' funding cost, so the bankers' discount rate increases further, causing q_t^T to continue falling. Moreover, the decline of q_t^T erodes the bankers' wealth, further increasing their price of risk, γ_t^B. The risk premium channel and interest rate channel reinforce each other, generating a powerful response to negative shocks.

The accumulation of endogenous risk is asymmetric. Positive shocks trigger the reallocation of tangible capital to the bankers with low discount rates but eventually cause bankers to consume their wealth as q_t^B, the marginal value of wealth, falls to one (when the bankers become indifferent between retaining wealth and consumption). However, negative shocks cause a continuing reallocation of tangible capital to those with high discount rates. Such asymmetry sheds light on the findings that longer booms precede more severe crises.[30] The mechanism differs from the existing models on asymmetric cycles (e.g., Ordoñez 2013).

The model is built on two frictions. The first is the illiquidity of intangible capital. This leads to demand for liquid assets and links the rising productivity of intangible investment to the decline of interest rate and other trends. The second friction is that the bankers cannot raise external equity frictionlessly.[31] This generates the response of risk price to shocks (He and Krishnamurthy 2013; Brunnermeier and Sannikov 2014; Di Tella 2017) and endogenous financial cycles. Removing the second friction eliminates the amplification of fluctuations along the trends but does not

[30] Please refer to Baron and Xiong (2017); Jordà, Schularick, and Taylor (2013); Krishnamurthy and Muir (2016); and López-Salido, Stein, and Zakrajšek (2017), among others. The mechanism is consistent with banks' procyclical payout in data (Baron 2020; Adrian, Boyarchenko, and Shin 2016).

[31] Allowing limited equity issuance (e.g., He and Krishnamurthy 2013) changes quantitative performances and causes calibration to deliver different parameter values but will not change the mechanism.

eliminate the trends. If bankers could raise equity freely to replenish net worth, their marginal value of wealth would be pinned to one and price of risk pinned to zero.[32]

This paper continues the tradition of incorporating financial frictions into macroeconomic models. The financial accelerators amplify both trends (driven by κ_t^I) and cycles (triggered by dZ_t). At the core are firms' savings, which is in contrast to the literature that focuses on firms' borrowing (Kiyotaki and Moore 1997; Bernanke, Gertler, and Gilchrist 1999; Gertler and Kiyotaki 2010). Key to the financial cycle is the procyclical wedge in discount rate between bankers, who supply liquidity and are "natural buyers" of tangible capital, and the rest of the economy. The longer a boom lasts, the sharper asset price falls when negative shocks reduce bankers' wealth. This procyclical discount-rate wedge is distinct from the constant cash flow wedge between intermediaries and households as asset owners in Brunnermeier and Sannikov (2014). Endogenous risk accumulation via discount-rate wedge also differs from recent studies that emphasize belief heterogeneity (Caballero and Simsek 2020, 2021).

Discussion: Intangible Risk.—A potential limitation of the model is that intangible capital valuation in (2) does not reflect risk premium. In Eisfeldt and Papanikolaou (2013), the risk of organizational capital is from the cyclical variation in key personnel's outside option. Such risk premium may reduce capital valuation and thus discourage firms from intangible investment, counteracting the rise of κ_t^I. However, other forms of intangibles may serve as a hedge, and their negative risk premia have a counterbalancing effect. An important type of intangible capital is technology.[33] Technological innovation displaces firms and workers that operate with old technologies and have difficulty to adapt (Kogan et al. 2020). Displacement risk makes technological innovation a hedge against systematic technological changes (Gârleanu, Kogan, and Panageas 2012; Bena and Garlappi 2020; Kogan, Papanikolaou, and Stoffman 2020).

D. *Aggregation and the Markov Equilibrium*

Households.—In reality, households also hold intermediaries' debts. Households' demand is not essential for the main mechanism, but it is important to incorporate it for calibration and quantitative analysis. The literature takes a money-in-utility approach, motivated by the role of intermediaries' debts (e.g., deposits) as means of payment (Sidrauski 1967; Stein 2012; Van den Heuvel 2022). Holdings of monetary assets generate utility flows separable from consumption (Poterba and Rotemberg 1986; Nagel 2016; Begenau and Landvoigt 2022) and are complementary to income levels (Begenau 2020; Krishnamurthy and Vissing-Jørgensen 2015). Consider a unit mass of households, $\mathcal{H} = [0,1]$. A representative household has labor that produces w_t^H units of goods. Let W_t^H $(= \int_{i\in\mathcal{H}} w_t^H(i)\, di)$ denote the aggregate labor out-

[32] Without equity issuance friction, the equilibrium of intermediated liquidity supply is the same as the mutual-fund equilibrium that features constant asset price and zero endogenous risk.

[33] The technology sector is the most relevant, as corporate cash holdings mainly reside in "growth sectors" (Begenau and Palazzo 2021; Graham and Leary 2018; Pinkowitz, Stulz, and Williamson 2016).

put, so the total output of the economy is $\left(K_t^I + K_t^T + W_t^H\right) dt$. The utility function is specified as

$$\mathbb{E}\left[\int_{t=0}^{\infty} e^{-\rho t}\left(dc_t^H + \frac{\left(w_t^H \beta_t\right)^{\xi}\left(m_t^H\right)^{1-\xi}}{1-\xi} dt\right)\right], \tag{19}$$

where c_t^H is the cumulative consumption process and m_t^H denotes deposit holdings.[34] The scaling variable is a function of time, $\beta_t = \beta(t)$.

The utility function in (19) implies the following optimality condition for m_t^H:

$$\left(\frac{m_t^H}{\beta_t w_t^H}\right)^{-\xi} = \rho - r_t, \tag{20}$$

which equates the marginal utility of holding deposits and marginal cost, that is, the spread $\rho - r_t$. Rearranging (20) and aggregating over households, we obtain

$$M_t^H = W_t^H \beta_t \left(\rho - r_t\right)^{-\frac{1}{\xi}}. \tag{21}$$

To avoid introducing a new state variable, it is assumed that labor output is proportional to that of tangible capital, that is, $W_t^H = \alpha K_t^T$. In other words, between labor and tangible capital, the labor share of output is a constant, $\alpha/(\alpha + 1)$. This is consistent with the finding in Koh, Santaeulàlia-Llopis, and Zheng (2020) that labor share is stable without accounting for output associated with intangibles.[35] Under this assumption, households' deposits demand is given by

$$M_t^H = \alpha K_t^T \beta_t \left(\rho - r_t\right)^{-\frac{1}{\xi}}; \tag{22}$$

α only has a scaling effect, so only the calibration of $\beta_t = \beta(t)$ is necessary.

The Real-Financial Linkage.—Figure 4 summarizes the model. The economy has three markets to clear (goods, the ownership of tangible capital, and deposits). The output is generated by intangible capital, tangible capital, and labor. The λdt entrepreneurs who are hit by the Poisson shocks acquire goods to create new capital, and the remaining goods are consumed by the rest of the economy.[36] The entrepreneurs, bankers, and households can trade the ownership of tangible capital at competitive price q_t^T given the stock K_t^T. In the deposit market, the bankers' supply is equal to the demand from the entrepreneurs and households. As in Caballero, Farhi, and Gourinchas (2008), only a fraction of output is capitalizable—tangible capital output—and the key inefficiency is a shortage of liquid assets. Depending on the bankers' risk-taking capacity (wealth), the bankers create liquidity by backing deposits

[34] Supplemental Appendix B discusses the implications of incorporating risk-averse preferences and finite EIS.

[35] Intangibles include research and development; software; and entertainment, literary, and artistic originals (US Bureau of Economic Analysis 2019). Analyzing the decline of labor share (e.g., Karabarbounis and Neiman 2014), Koh, Santaeulàlia-Llopis, and Zheng (2020) show that it is attributed to the incorporation of output related to intangibles.

[36] Under risk-neutral utility, the demand for consumption goods is perfectly elastic.

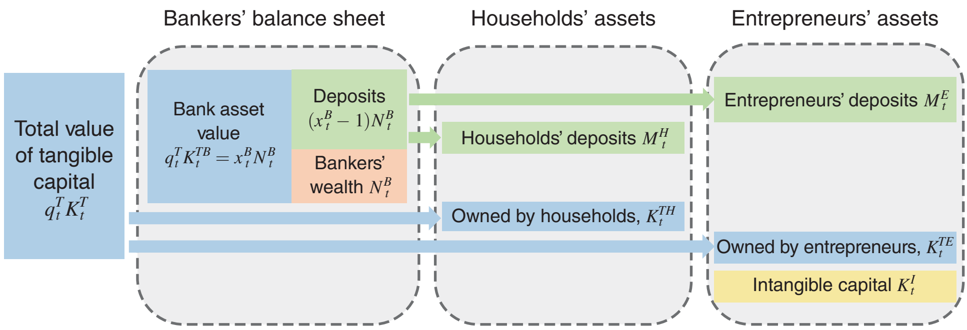

Figure 4. Model Structure

with tangible capital. Entrepreneurs' deposits relax the liquidity constraint (6) on investment. Therefore, economic growth depends on the *intermediated liquidity supply*.

As shown in (12), one unit of liquidity is leveraged up to $1/\left[1 - q_t^T \kappa^T (1 - \theta_t)\right]$ units of goods invested. Given the entrepreneurs' aggregate deposits, M_t^E, the aggregate investment comes from the $\lambda\, dt$ entrepreneurs (hit by the Poisson shocks):

$$\left(\frac{1}{1 - q_t^T \kappa^T (1 - \theta_t)}\right) M_t^E \lambda\, dt. \tag{23}$$

The deposit-market clearing condition links the entrepreneurs' liquidity to bankers' wealth:

$$M_t^E = \left(x_t^B - 1\right) N_t^B - M_t^H, \tag{24}$$

where the right side is the total deposits minus the households' holdings.

The law of motion of intangible capital is

$$\begin{aligned} dK_t^I = {} & \underbrace{\left(\frac{1}{1 - q_t^T \kappa^T (1 - \theta_t)}\right)}_{\text{leverage}} \underbrace{\left[\left(x_t^B - 1\right) N_t^B - M_t^H\right]}_{\text{entrepreneurs' liquidity}} \theta_t \kappa_t^I \lambda\, dt \\ & - \underbrace{\left(\delta\, dt - \sigma\, dZ_t + \lambda\, dt\right) K_t^I}_{\text{depreciation, Poisson destruction}}, \end{aligned} \tag{25}$$

and the law of motion of tangible capital is

$$\begin{aligned} dK_t^T = {} & \left(\frac{1}{1 - q_t^T \kappa^T (1 - \theta_t)}\right) \left[\left(x_t^B - 1\right) N_t^B - M_t^H\right] \left(1 - \theta_t\right) \kappa^T \lambda\, dt \\ & - \left(\delta\, dt - \sigma\, dZ_t + \lambda\, dt\right) K_t^T. \end{aligned} \tag{26}$$

Total investment in (23) is split into the tangible and intangible parts by entrepreneurs' choice of intangible share, θ_t. Then investments are multiplied by the productivities, κ_t^I and κ^T.[37]

Equations (25) and (26) highlight the link between intermediation capacity and growth. When bankers are well capitalized, more deposits are issued. Liquidity can be leveraged up to create capital. Equations (25) and (26) also show how the financial conditions drive economic fluctuations. Entrepreneurs' leverage on liquidity increases in the value of tangible capital, q_t^T. Therefore, the endogenous asset-price volatility, that is, σ_t^T in (3), feeds into investment dynamics and has a direct impact on the real economy. Moreover, the variation of q_t^T has a levered impact on the bankers' wealth and their capacity of liquidity creation.

State Variables.—The Markov equilibrium has four state variables, time, which drives κ_t^I and β_t, and the three stock variables, $N_t^B \equiv \int_{i\in\mathcal{B}} n_{i,t}^B di$ (the bankers' aggregate wealth), K_t^I, and K_t^T.[38]These four state variables have a convenient hierarchical property. First, apparently, time progresses linearly and has an autonomous law of motion. Second, $\left(N_t^B, K_t^I, K_t^T\right)$ can be equivalently represented by $\left(\eta_t, K_t^I, K_t^T\right)$, where η_t, the intermediation intensity, is defined by

$$\text{(27)} \qquad \textit{Intermediation Intensity}: \eta_t \equiv N_t^B / K_t^T.$$

It is a ratio of the bankers' wealth to the amount of assets to be intermediated. The next proposition states that its evolution only depends on itself and time, and that the market prices, such as q_t^T and r_t, and the K_t^T-scaled quantities are functions of η_t and time only. To solve the equilibrium, I first focus on the subsystem where η_t and time are the two state variables and solve the market prices and the K_t^T-scaled aggregate quantities, which requires solving a system of differential equations. The solutions of these variables are then fed into the laws of motion of K_t^I and K_t^T (see (25) and (26)) for a complete characterization of equilibrium dynamics. Supplemental Appendix A provides the proof.

PROPOSITION 3 (Financial System): *The equilibrium law of motion of intermediation intensity is*

$$\text{(28)} \qquad \frac{d\eta_t}{\eta_t} = \mu^\eta(\eta_t, t)\, dt + \sigma^\eta(\eta_t, t)\, dZ_t,$$

for $\eta_t \in \left(0, \bar{\eta}(t)\right]$. $\mu^\eta(\eta_t, t)$ *and* $\sigma^\eta(\eta_t, t)$ *are defined in Supplemental Appendix A, and* $\bar{\eta}(t)$ *is a reflecting boundary where the bankers consume. Prices and* K_t^T*-scaled quantities are functions of* η_t *and t: (i) the value of tangible capital,* $q_t^T = q^T(\eta_t, t)$*; (ii) the deposit rate,* $r_t = r(\eta_t, t)$*; (iii) the* K_t^T*-scaled households' deposits,* $\tilde{M}_t^H = \tilde{M}^H(\eta_t, t)$*; (iv) the* K_t^T*-scaled entrepreneurs' deposits,* $\tilde{M}_t^E = \tilde{M}^E(\eta_t, t)$*; (v) the optimal intangible*

[37] The shocked entrepreneurs' lost capital is evenly endowed to other entrepreneurs, so the λdt measure of lost capital is not in equations (25) and (26). One interpretation is that the λdt entrepreneurs' customer base is seized by the others through creative destruction (Aghion, Akcigit, and Howitt 2014).

[38] Capital composition is a key state variable in Eberly and Wang (2008), who study agents' trade-off between diversification benefits and reallocation costs when two sectors are available for investment.

share of investment, $\theta_t = \theta(\eta_t, t)$*; (vi) bankers' asset-to-wealth ratio,* $x_t^B = x^B(\eta_t, t)$*; (vii) the bankers' marginal value of wealth,* $q_t^B = q^B(\eta_t, t)$.[39]

III. Quantitative Analysis

This section starts with calibration and presents the results on trends and cyclical variations due to endogenous financial risk. It ends with counterfactual analysis that demonstrates the quantitative importance of the rise of intangibles.

A. *Parameter Calibration*

Calibration takes five steps. The guiding principles are explained first. The first step is to calibrate the investment technology to match the trends in intangible and tangible investments and volatilities along those trends. The productivity of intangible investment, $\kappa^I(t)$, is parameterized as $\kappa_t^I = \kappa_0^I + \kappa_1^I t$, and the cost of adjusting investment portfolio is specified as $F(\theta_t) = \phi\theta_t^2/2$. Thus, the investment technology is summarized by four parameters, κ_0^I, κ_1^I, κ^T, and ϕ. As will be shown shortly, these specifications generate realistic investment dynamics.

The choice of intangible share, θ_t, drives firms' liquidity needs. After matching investment dynamics, the second step is to calibrate λ, the arrival rate of investment and liquidity needs, so the response of firms' liquidity holdings to changes in θ_t matches the estimate in Section I.

Third, parameters in households' liquidity utility are calibrated to match the dynamics of household liquidity holdings. This is important for counterfactual analysis where investment technology is adjusted to create scenarios with and without the rise of intangibles while households' liquidity utility is fixed. Fourth, the shock size, σ, is calibrated to generate a volatility of bank asset return in the baseline model that matches the estimate in the literature.

So far, the calibration has been guided by the estimate in Table 1 and data displayed in Figure 3 in Section I. The fifth and last step is to calibrate ρ, discount rate, and δ, capital depreciation rate. The calibration targets have been quantity variables, such as investment and liquidity holdings. Now the focus shifts to the two price variables, interest rate and tangible capital value. However, with only two parameters left, the calibration exercise cannot target different aspects of equilibrium dynamics (the level, trends, volatilities along the trends, etc.) but instead matches the interest rate and capital valuation at the beginning of sample period 1980 to 2019. This leaves the price variables' paths over time completely to the equilibrium forces. Therefore, when examining model performances, whether the dynamics of price variables match data is a stricter criterion than the match of quantity variables, which benefits from more degrees of freedom in parameters.

Next, I provide more details on calibration. One unit of time in the model is set to one year. For calibration and later comparing the endogenous variables with empirical

[39] $q_t^B \in [1, +\infty)$. At $\eta_t = \bar{\eta}(t)$, $q_t^B = 1$ and bankers consume. Consumption reduces N_t^B, but once q_t^B is above one, consumption stops (retaining wealth is worth $q_t^B > 1$). Thus, $\bar{\eta}(t)$ is a reflecting boundary. Bankers' HJB equation and equation (18) imply a system of differential equations for $q^B(\eta_t, t)$ and $q^T(\eta_t, t)$. Once they are solved, the other variables are solved analytically. See Supplemental Appendix A.

counterparts, I extract trends in data through 20-year rolling averages from 1980 to 2019 (the sample period in Section I).[40] In the model, the variation in η_t generates fluctuation along the trends. To extract trends from the solution, I average out η_t at every t.[41] For example, $\mathbb{E}^{\eta}\left[r(\eta, t = 0)\right]$ is mapped to the first rolling average of interest rates in the data, which centers around 1990. The same logic applies to all prices and K_t^T-scaled quantities, which will be used in calibration and, according to Proposition 3, are also functions of η_t and t. The model is solved for $t \in [0, 20]$ because the last moving average in the data centers around 2010 (which maps to $t = 20$) and ends in 2019 (the sample end).

The productivity of intangible investment has two parameters, κ_0^I that determines the base rate and κ_1^I that determines the time trend. κ_0^I is calibrated so the average θ_t matches the sample average of *Intan.*/*Investment* in Section I. κ_1^I is calibrated so the average annual change in the trend of intangible investment/tangible capital, that is, $\mathbb{E}^{\eta}\left[\theta_t I_t / K_t\right] = \mathbb{E}^{\eta}\left[\theta_t \tilde{I}_t\right]$, matches data.[42] The productivity of tangible investment, κ^T, is calibrated so the average annual change in the trend of tangible investment/tangible capital, that is, $\mathbb{E}^{\eta_t}\left[(1 - \theta_t) I_t / K_t\right] = \mathbb{E}^{\eta_t}\left[(1 - \theta_t)\tilde{I}_t\right]$, matches data. The parameter ϕ in $F(\theta_t)$ governs the cost of adjusting investment composition, and its calibration targets the relative volatilities of intangible and tangible investments. At time t, the conditional distribution of η_t (implied by (28)) is used to calculate the volatility ratio of intangible to tangible investment (both scaled by K_t^T), $\frac{\mathrm{Vol}^{\eta_t}\left[\theta \tilde{I}\right]}{\mathrm{Vol}^{\eta_t}\left[(1 - \theta)\tilde{I}\right]}$, and the ratio is averaged over time to match the volatility ratio of detrended intangible to tangible investment.[43]

Firms' liquidity needs are driven by the random arrival of projects that require intangible investment. The arrival rate λ is calibrated so that the model-implied response of firms' liquidity holdings to the increase of intangible investment matches the estimate in Section I (column 8 of Table 1), the change in cash/assets for one unit of change of *Intan.*/*Investment* (θ_t in the model). The model counterpart is $\left(\mathbb{E}^{\eta}\left[\frac{\tilde{M}^E(\eta, 20)}{q^T(\eta, 20)}\right] - \mathbb{E}^{\eta}\left[\frac{\tilde{M}^E(\eta, 0)}{q^T(\eta, 0)}\right]\right) / \left(\mathbb{E}^{\eta}\left[\theta(\eta, 20)\right] - \mathbb{E}^{\eta}\left[\theta(\eta, 0)\right]\right)$, where the η_t-averages are used as the match focuses on disciplining the trend rather than cyclical fluctuations and $\tilde{M}_t^E / q_t^T = M_t^E / \left(q_t^T K_t^T\right)$ is the ratio of firms' liquidity scaled by tangible capital value that corresponds to the accounting asset value mostly excluding intangibles (e.g., Peters and Taylor 2017).

Next, I calibrate the households' liquidity utility. The only goal of incorporating the households' liquidity utility is to generate realistic liquidity demand, especially

[40] Before the 1980s, Regulation Q imposed various restrictions on deposit rates. For example, it prohibited banks from paying interest on demand deposits. This practice is inconsistent with the model specification that the deposit rate, r_t, is the price variable that clears the deposit market.

[41] Instead of averaging over the simulated paths, the η-averages can be calculated using the t-conditional stationary distribution of η_t, implied by (28), and the solved functions of endogenous variables, for example, $q_t^T = q^T(\eta_t, t)$. Supplemental Appendix A solves the t-conditional stationary distribution of η_t.

[42] Each year, I calculate cross section total asset-weighted average of ratio of intangible investment to tangible capital (PPE) and calculate the 20-year rolling averages.

[43] Each year, I take the ratio of intangible investment (scaled by PPE) and tangible investment (scaled by PPE) (see also footnote 42). The resulting time series exhibits a linear trend.

relative to firms', for the purpose counterfactual analysis where the rise of intangibles and associated liquidity demand of firms will be shut down to examine how interest rate, asset valuation, and other variables respond. The value of ξ, households' liquidity demand elasticity, is chosen so that the model generates a stable path over time of the ratio of safe assets (households' and firms' holdings of deposits) to capitalizable assets (tangible capital value), that is, $\mathbb{E}^{\eta}\left[\frac{M^E(\eta,t) + M^H(\eta,t)}{q^T(\eta,t)K_t^T}\right] = \mathbb{E}^{\eta}\left[\frac{\tilde{M}^E(\eta,t) + \tilde{M}^H(\eta,t)}{q^T(\eta,t)}\right]$ in line with the stability in safe asset share (Gorton, Lewellen, and Metrick 2012).[44] $\xi = 1.1$, close to households' deposit-demand elasticity in other banking models, e.g., 1.4 from Begenau (2020).

The scaling function, $\beta(t)$, in households' liquidity utility is calibrated to match the trends of households' liquidity holdings relative to firms'. $\beta(t)$ is specified as

$$\beta_t = \beta_0 + \beta_1 t + \beta_2 t \mathbf{1}\{t > 3\}. \tag{29}$$

In data, the logarithm of households' holdings of intermediary debts has a structural break in its time trend at 1992 ($t = 3$ in the model), detected by supremum Wald test and LR test with p-values below 0.0001 (Andrews 1993; Perron 2006). I take the logarithm because households' deposits grow exponentially along with capital stock (see (22)), and empirically, households' holdings of intermediary debts also exhibit exponential growth.[45] It is important to include the structural break, as, without it, the match of households' liquidity holdings deteriorates significantly. The value of β_0 is chosen so that $\mathbb{E}^{\eta}\left[\frac{\tilde{M}^E(\eta,0)}{\tilde{M}^H(\eta,0)}\right]$, that is, the initial η-average ratio of entrepreneurs' to households' holdings of deposits matches the rolling average of data centering at 1990.[46] The value of β_1 is chosen so the average annual change of $\left\{\mathbb{E}^{\eta}\left[\frac{\tilde{M}^E(\eta,t)}{\tilde{M}^H(\eta,t)}\right]\right\}_{t=3}$ matches its empirical counterpart, and β_2 is set so the average annual change of $\left\{\mathbb{E}^{\eta}\left[\frac{\tilde{M}^E(\eta,t)}{\tilde{M}^H(\eta,t)}\right]\right\}_{t>3}$ matches data.

The shock size, σ, is chosen so the model generates a volatility of bankers' return that matches data (Gornall and Strebulaev 2018). Later, when conducting counterfactual analysis by shutting down the rise of intangibles, I will fix the exogenous risk, σ, and show how endogenous risk responds. The discount factor, ρ, is chosen so $\mathbb{E}^{\eta}\left[r(\eta,0)\right]$ matches the average rate of intermediary debts in 1990.[47] The capital

[44] The empirical counterpart is the ratio of nonfinancial firms' and households' holdings of intermediary debts (listed in Figure 2) to nonfinancial firms' fixed assets from US Bureau of Economic Analysis (2019) (current-cost net stock). I subtract the value of intellectual properties to obtain tangible asset value.

[45] I also use supremum Wald and LR tests on the ratio of households' holdings of intermediary debts to total assets and detect a break in the level at 1992. Supplemental Appendix Figure D.4 reports the data.

[46] Data are from panel C of Figure 3. Figure 2 list the securities that map to deposits in the model.

[47] The interest rates are the real rates with CPI deflator from US Bureau of Labor Statistics (1947–2020). The securities include (i) jumbo and non-jumbo checking deposits, savings deposits, and certificate of deposits; (ii) three-month certificate of deposits; (iii) one- , two-, and three-month AA-rated financial commercial papers;

TABLE 2—PARAMETER CALIBRATION

Parameters	Symbol	Value	Moment	Model	Data
(1) Intangible investment productivity: Intercept	κ_0^I	1.075	Average $\mathbb{E}^\eta[\theta(\eta,t)]$	63.9%	61.6%
(2) Intangible investment productivity: Time coefficient	κ_1^I	0.018	Average annual change of $\mathbb{E}^\eta[\theta(\eta,t)\tilde{I}(\eta,t)]$	1.6%	1.4%
(3) Tangible investment productivity	κ^T	0.011	Average annual change of $\mathbb{E}[(1-\theta(\eta,t))\tilde{I}(\eta,t)]$	0.0%	−0.1%
(4) Investment cost $F(\theta) = \phi\theta_t^2/2$	ϕ	9.540	Average $\frac{\mathrm{Vol.}^\eta[\theta(\eta,t)\tilde{I}(\eta,t)]}{\mathrm{Vol.}^\eta[(1-\theta(\eta,t))\tilde{I}(\eta,t)]}$	1.84	2.06
(5) Investment project arrival rate	λ	0.050	$\frac{\mathbb{E}^\eta\left[\frac{\tilde{M}^E(\eta,20)}{q^T(\eta,20)}\right] - \mathbb{E}^\eta\left[\frac{\tilde{M}^E(\eta,0)}{q^T(\eta,0)}\right]}{\mathbb{E}^\eta[\theta(\eta,20)] - \mathbb{E}^\eta[\theta(\eta,0)]}$	0.162	0.170
(6) Household deposit demand elasticity to deposit rate	ξ	1.100	Average annual change of $\mathbb{E}^\eta\left[\frac{\tilde{M}^E(\eta,t)+\tilde{M}^H(\eta,t)}{q^T(\eta,t)}\right]$	0.0%	0.3%
(7) Household deposit utility scale: Intercept	β_0	0.196	$\mathbb{E}^\eta\left[\frac{\tilde{M}^E(\eta,t)}{\tilde{M}^H(\eta,t)}\right], t = 0$	9.8%	9.6%
(8) Household deposit utility scale: Time coefficient ($\leq$ 1992)	β_1	0.019	Average annual change of $\mathbb{E}^\eta\left[\frac{\tilde{M}^E(\eta,t)}{\tilde{M}^H(\eta,t)}\right], t \leq 2$	0.32%	0.29%
(9) Household deposit utility scale: Time coeff. increase ($>$ 1992)	β_2	0.003	Average annual change of $\mathbb{E}^\eta\left[\frac{\tilde{M}^E(\eta,t)}{\tilde{M}^H(\eta,t)}\right], t > 2$	0.19%	0.20%
(10) Capital depreciation rate: Vol.	σ	0.020	Vol. of bank asset return	2.9%	2.6%
(11) Agents' discount rate	ρ	0.062	$\mathbb{E}^\eta[r(\eta,t)], t = 0$	3.2%	3.5%
(12) Capital depreciation rate: Mean	δ	0.088	$\mathbb{E}^\eta[q^T(\eta,t)], t = 0$	6.6	6.8

depreciation rate, δ, is chosen so $\mathbb{E}^\eta[q^T(\eta,0)]$ matches the average EV/EBITDA ratio in 1990.[48] Capital generates one unit of goods per year, so $q_t^T = q_t^T/1$ is the ratio of capital value to its annual output. Because tangible capital produces all capitalizable output, its value maps to firms' enterprise value, which is the present value of cash flows reflected in debt and equity markets. The calibration of ρ and δ fixes the starting points of interest rate and capital valuation but leaves their paths over time to be determined by equilibrium forces. Table 2 summarizes the calibration.

B. *The Rise of Intangibles and Long-Run Trends*

The results are in two categories, the economy's response to a rising κ_t^I over time (trends) and response to shocks, dZ_t (cycles). This subsection focuses on the trends. Table 3 reports how the economy evolves over time. According to the calibration of κ_0^I and κ_1^I, the productivity of intangible investment, $\kappa^I(t)$, increases by around

(iv) three- and six-month bankers' acceptance; (v) one- , two-, and three-month month AA-rated asset-backed commercial papers; (vi) Fed fund. The interest rates of these securities are from Board of Governors of the Federal Reserve System(1980–2019). We also include GCF repo rates with Treasury securities, mortgage-backed securities, and agency- and GSE-backed securities as collateral from DTCC (2005–2019)..

[48] The average is taken over median EV/EBITDA of 11 Fama-French nonfinanical sectors (Compustat).

Table 3—Long-Term Trends and Endogenous Financial Risk

Time	Intangible inv. share $\mathbb{E}^{\eta}\left[\theta(\eta,t)\right]$	Firm deposits capital value $\mathbb{E}^{\eta}\left[\frac{\tilde{M}^E(\eta,t)}{q^T(\eta,t)}\right]$	Firm deposits HH deposits $\mathbb{E}^{\eta}\left[\frac{\tilde{M}^E(\eta,t)}{\tilde{M}^H(\eta,t)}\right]$	Interest rate $\mathbb{E}^{\eta}\left[r(\eta,t)\right]$	Capital valuation $\mathbb{E}^{\eta}\left[q^T(\eta,t)\right]$	Financial risk multiplier $\max_{\eta}\left\{\frac{\sigma^T(\eta,t)+\sigma}{\sigma}\right\}$
$t = 0$	55.2%	7.6%	9.8%	3.24%	6.6	2.7
Data '90	54.4%	6.3%	9.6%	3.45%	6.8	
$t = 4$	58.7%	8.5%	11.1%	2.11%	6.9	3.2
Data '94	58.2%	7.1%	10.8%	2.59%	6.9	
$t = 8$	62.2%	8.2%	10.7%	0.95%	7.3	3.6
Data '98	61.9%	7.9%	12.2%	1.77%	7.3	
$t = 12$	65.7%	9.2%	12.2%	−0.20%	7.6	4.0
Data '02	66.0%	8.4%	13.1%	0.97%	7.5	
$t = 16$	69.1%	10.2%	13.7%	−1.50%	7.8	4.4
Data '06	69.1%	9.1%	13.8%	0.46%	7.7	
$t = 20$	72.6%	10.4%	14.1%	−2.88%	7.9	4.7
Data '10	72.7%	9.7%	14.0%	−0.36%	8.0	

1.6 percent per year. Firms tilt investment toward intangibles gradually over time, increasing θ_t from 55.2 percent to 72.7 percent over 20 years. Column 1 shows the model generates a trend in intangible share of investment that matches data closely in every year. Note that the calibration of κ_1^I targets the average rate of change but does not guarantee the match with data every year. The year-by-year match suggests that the model has a proper specification of intangible investment productivity and a proper mapping from investment productivity to the intangible share through the setup of firms' investment problem.

As θ_t increases, firms face a tighter financial constraint and hold more liquidity. The calibration of λ, the arrival rate of investment needs, targets the response of firms' liquidity-to-tangible asset ratio to variation in θ_t. In column 2 of Table 3, the trend in $\mathbb{E}^{\eta}\left[\frac{\tilde{M}^E(\eta,t)}{q^T(\eta,t)}\right] = \mathbb{E}^{\eta}\left[\frac{M_t^E}{q_t^T K_t^T}\right]$ captures the well-documented rise in firms' cash-to-asset ratio before the 2010s. The ratio increased from 6.3 percent by more than 50 percent to 9.7 percent in the data. In the model, it started at a higher level, 7.6 percent, and increased to 10.4 percent.[49] Later in the counterfactual analysis, I will examine how the economy responds when the rise of intangibles is shut down and the trend in firms' liquidity demand is muted. In this scenario, households' liquidity utility becomes the sole driver behind trends in liquidity demand. Therefore, it is important to match the relative dynamics of firms' versus households' liquidity holdings in the baseline model. It is done through the calibration of households' liquidity utility, as explained in Section IIIA. The results are reported in column 3 of Table 3.

The rising intangible share of investment, θ_t, drives up the marginal value of liquidity, π_t, by tightening firms' financial constraint. The upward trend in π_t in turn leads to a downward trend in r_t, the yield on liquid assets in column 4 of Table 3. The

[49] The discrepancy in level is due to the omission of other determinants of firms' liquidity holdings that, unlike intangibles, do not exhibit trends over time. This paper focuses on intangible-induced trends.

bankers take advantage of a lower funding cost and push up tangible capital value, q_t^T. Column 5 reports an upward trend in capital valuation that closely matches the data.[50] Importantly, these trends reinforce each other. A rising q_t^T further increases π_t and thereby lowers r_t (see Proposition 1). Multiplicity may arise due to the feedback effects: A solution has low r_t, high q_t^T, high π_t, and high θ_t, while the other has high r_t, low q_t^T, low π_t, and low θ_t. The solution with θ_t closest to the data is chosen.[51] Multiplicity helps explain why the rise of intangibles and related trends are largely a US phenomenon.

As κ_t^I increases and the economy becomes more intangible intensive, it also becomes increasingly fragile. By Itô's lemma, the total value of capitalizable output, $q_t^T K_t^T$, evolves as

$$\frac{d\left(q_t^T K_t^T\right)}{q_t^T K_t^T} = \left(\mu_t^T - \delta - \lambda + \sigma_t^T \sigma\right) dt + \left(\sigma_t^T + \sigma\right) dZ_t. \tag{30}$$

A measure of endogenous risk is the ratio of total shock exposure of $q_t^T K_t^T$ (including σ_t^T, the endogenous volatility of q_t^T) to exogenous shock exposure, σ:

$$\textit{Financial Risk Multiplier}: \quad \frac{\sigma_t^T + \sigma}{\sigma}. \tag{31}$$

This ratio is a function of t and η_t (see Proposition 3). The last column of Table 3 reports the maximum (over η_t) at $t = 0, 4, \ldots, 20$. It also reports the corresponding years in data to show the model-implied accumulation of endogenous risk in real time. Over 20 years, the endogenous risk multiplier almost doubled as the economy became increasingly intangible intensive.

Overall, the solution matches data reasonably well, except for a lower and more negative r_t in the 2000s. This may be explained by the omission of zero lower bound (ZLB) on nominal rates that binds in reality and, under nominal price rigidity, translates into a lower bound on real rates (Eggertsson and Woodford 2003; Fischer 2016; Korinek and Simsek 2016; Caballero and Simsek 2020). In fact, the model suggests that the rise of intangibles leads to a strong liquidity demand and thereby widens the wedge between the natural rate without nominal rigidity and the actual rate, exacerbating the liquidity trap at ZLB (Christiano, Eichenbaum, and Rebelo 2011; Eggertsson and Krugman 2012; Caballero and Farhi 2017; Guerrieri and Lorenzoni 2017). While the rise of intangibles is largely a US phenomenon, the resultant liquidity trap may spread globally (Caballero, Farhi, and Gourinchas 2021). Supplemental Appendix C discusses the model mechanism under ZLB and its interactions with the forces in New Keynesian models.

[50] Tangible capital represents capitalizable production capacity. The ratio of q_t^T to one unit of goods produced per unit of time (one year) maps to EV-to-EBITDA ratio since, by definition, enterprise value is the present value of capitalizable output of a firm, reflected in the debt and equity markets.

[51] Note that θ_t is still endogenous and optimally chosen by firms. If the firms' investment and liquidity management problems have not been properly specified, none of the solutions is likely to match data.

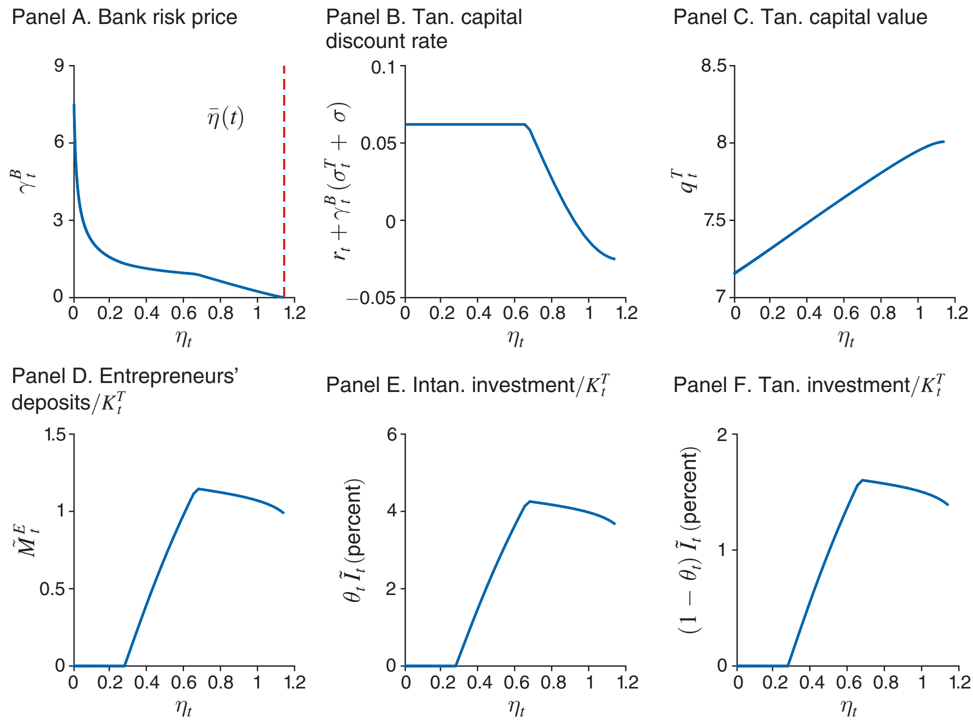

Figure 5. Financial Cycle

C. *Endogenous Financial Risk and Economic Fluctuation*

This subsection focuses on economic fluctuations along the trend, driven by the intermediation intensity, η_t. Figure 5 plots six endogenous variables against η_t. The plots are for $t = 20$ (which maps to 2010 in the data) and end at $\bar{\eta}(t)$, the endogenous upper boundary of η_t beyond which the bankers optimally consume (see Proposition 3). To understand the economy's response to shocks, first consider positive shocks that move η_t to the right. Panel A of Figure 5 plots the bankers' price of risk (or required Sharpe ratio) for holding tangible capital:

$$\gamma_t^B = \frac{\mathbb{E}_t\left[dr_t^T\right] - r_t}{\sigma_t^T + \sigma}, \tag{32}$$

which declines as η_t increases and eventually reaches zero at $\bar{\eta}(t)$. This implies a procyclical intermediation capacity. In panel B, the discount rate for tangible capital, that is, the expected return $\mathbb{E}\left[dr_t^T\right]$, is at ρ when η_t is low to clear the market by attracting demand from entrepreneurs and households whose discount rate is ρ. However, as η_t increases, bankers eventually hold all tangible capital, and the discount rate falls below ρ. Recall that the cash flow of tangible capital is constant, so what drives the variation of q_t^T is the discount rate. Therefore, as the discount rate declines following positive shocks that increase η_t, the value of tangible capital, q_t^T, increases as shown in panel C. Note that the increase of q_t^T in η_t is smooth even though the decrease of discount rate in η_t is not. Under rational expectation, q_t^T

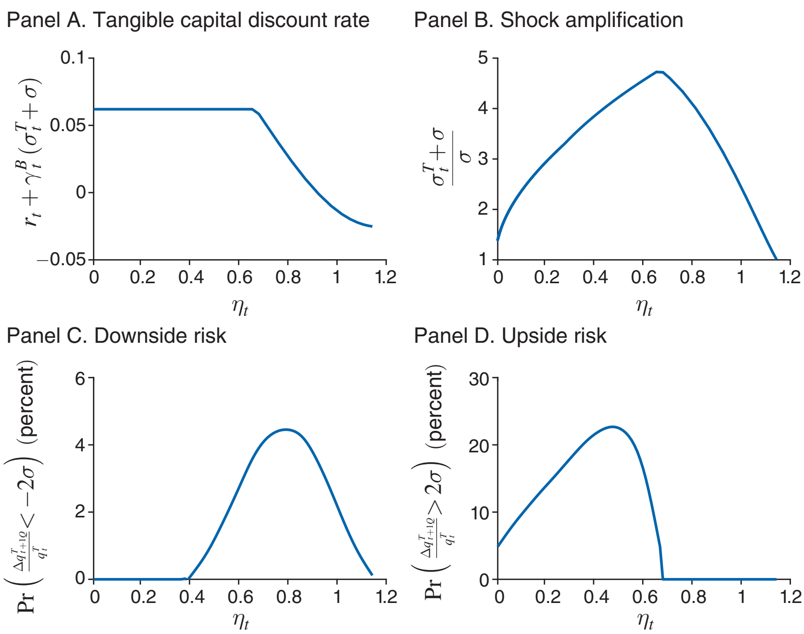

Figure 6. Endogenous Financial Risk

is forward-looking, so any increase of η_t raises the conditional probability of low discount-rate regions and therefore increases q_t^T.

As q_t^T increases, a feedback mechanism emerges. Investment becomes more profitable, and the leverage on liquidity is higher, so holding liquidity is more profitable. Therefore, entrepreneurs accept a lower r_t (Proposition 1), holding more deposits as shown in panel D of Figure 5.[52] A lower r_t further reduces the bankers' discount rate, leading to an even higher q_t^T. In the process, the entrepreneurs hold more liquidity and invest more as shown in panels E and F. Note that when scaled by K_t^T, the run-up of entrepreneurs' deposits and investments stops when the growth of the bankers' wealth outpaces that of the tangible capital value (bank asset value). When this occurs, bank equity crowds out debt on the balance sheet, causing a reduction in deposits/tangible capital.

The upward spiral triggered by positive shocks, $dZ_t > 0$, seems benign, featuring a boom of liquidity creation and investment. However, endogenous risk accumulates. Consider a value of η_t near zero in panel A of Figure 6 (reproducing panel B of Figure 5). The discount rate stays at ρ with a large probability. However, as we move to the right, η_t approaches the cutoff point where the discount rate falls below ρ. As a result, even small shocks can cause a large discount-rate change and variation of q_t^T. Therefore, q_t^T becomes more sensitive to shocks (i.e., higher σ_t^T) as η_t moves to the right. This explains why in panel B of Figure 6, the risk multiplier, $(\sigma_t^T + \sigma)/\sigma$, is increasing in η_t. The amplification becomes stronger as booms prolong, so negative

[52]When $\eta_t < 0.28$ (1.7 percent probability), $M_t^E = 0$ and $r_t < \rho - \lambda\pi_t$ (i.e., (15) no longer holds). r_t is solved by equating households' demand and bankers' supply. See Supplemental Appendix A.2

shocks trigger a vicious downward spiral.[53] The mechanism eventually subdues as η_t approaches its upper bound where bankers are sufficiently rich and the sensitivity of discount rate to η_t diminishes.

The accumulation of endogenous risk in booms is asymmetric. Positive shocks trigger the reallocation of tangible capital to bankers with low discount rates but eventually cause them to consume wealth at $\overline{\eta}(t)$; in contrast, negative shocks cause a continuing reallocation of tangible capital away from bankers. Panels C and D of Figure 6 plot, respectively, the probabilities of a 2σ decrease and a 2σ increase of q_t^T in one quarter.[54] Note that at sufficiently low (high) values of η_t, a further decrease (increase) by 2σ is impossible, as it goes beyond the equilibrium range of q_t^T. Following positive shocks, the probability of a drop in q_t^T increases as η_t increases. It eventually declines as shock amplification weakens (panel B). The probability of an increase in q_t^T also rises but declines earlier, suggesting that risk accumulation is downward biased. Following negative shocks, the economy moves leftward. The downside risk in q_t^T rises in panel C, while the upside risk is relatively insensitive in panel D. This offers a new explanation of why downside risks rise faster than upside risks as financial conditions deteriorate (Adrian, Boyarchenko, and Giannone 2019).

D. *Counterfactual Analysis*

I construct two hypothetical scenarios to examine the quantitative importance of the rise of intangibles. In *Intan. Trend*, the increase of intangible investment productivity is kept, while the trend in households' liquidity demand is muted (i.e., $\beta_1 = 0$ and $\beta_2 = 0$). In *HH Trend*, the increase of intangible investment productivity is muted (i.e., $\kappa_1^I = 0$), while the trend in households' liquidity demand remains. *HH Trend* sets a benchmark of the literature on households' liquidity demand and its implications on interest rate, asset price, and financial instability (Kiyotaki and Moore 2000; Krishnamurthy and Vissing-Jørgensen 2015; Piazzesi and Schneider 2016; Moreira and Savov 2017; Begenau and Landvoigt 2022; Van den Heuvel 2022; Begenau 2020; Egan, Lewellen, and Sunderam 2022).

Panels A and B of Figure 7 show, respectively, the trends of interest rate, $\mathbb{E}^{\eta}\left[r(\eta,t)\right]$, and asset price (tangible capital value), $\mathbb{E}^{\eta}\left[q^T(\eta,t)\right]$, for the three scenarios. A common pattern emerges: Removing the trend in intangibles (*HH Trend*) moderates the downward trend in interest rate and upward trend asset price more than removing the trend in households' liquidity demand (*Intan. Trend*) does. This suggests the trend in firms' demand for liquid assets driven by the rise of intangibles is a more potent force than households' liquidity demand.

The greater quantitative importance of firms' liquidity demand seems puzzling given the fact that firms' liquidity holdings are only $1/7$ that of households by $t = 20$ and $1/10$ at $t = 0$ both in the baseline model and data. This observation ignores the fact that once the trend in households' liquidity needs is removed, the firms' liquidity holdings will increase in equilibrium and rise faster over time in the absence of households' competition. The counterfactual, *Intan. Trend*, does not

[53] This mechanism offers a new explanation of the findings that long periods of banking expansion often precede severe crises (e.g., Jordà, Schularick, and Taylor 2013; Baron and Xiong 2017).

[54] Given the model solution, these probabilities can be calculated using the Feynman-Kac PDEs.

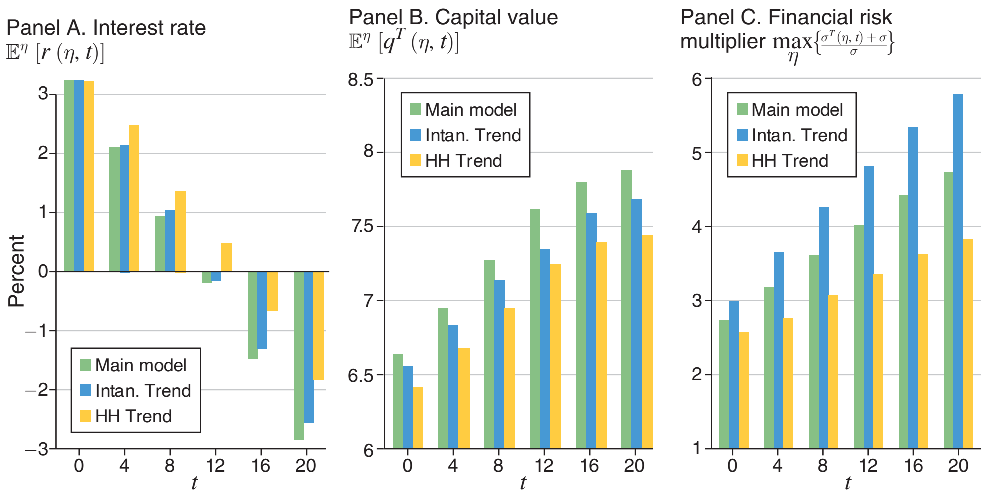

Figure 7. Counterfactual Analysis

and should not fix the equilibrium level of firms' liquidity holdings to that of the main model. What should be fixed are the parameters underlying firms' liquidity management problems; likewise, in *HH Trend*, households' liquidity holdings increase in the absence of firms' competition as the rise of intangibles is shut down, while parameters in households' liquidity utility are fixed.

In panel C of Figure 7, *Intan. Trend* generates the most endogenous risk, the main model the second highest, and *HH Trend* the lowest, and the wedges widen over time as the different trends in the three models unfold. This finding is particularly interesting because one would have expected the main model to generate the most endogenous risk by having both firms' and households' liquidity needs trending up over time and feeding leverage to bankers. The key to understanding this result is the distinct cyclical property of firms' and households' liquidity demand. Consider positive shocks. The subsequent increase in q_t^T encourages the firms to save more as investment becomes more profitable and the leverage on liquidity holdings, backed by tangible capital, increases. The increase of liquidity value, π_t, drives down r_t. As r_t declines, the households' liquidity holdings decrease, counteracting the increase in firms' liquidity demand (see (22)). Following negative shocks, the opposite happens: q_t^T and π_t decline, resulting in a higher r_t that induces households to hold more liquidity, counteracting the decrease in firms' demand. In sum, firms' liquidity demand exhibits procyclicality, while the households' demand features countercyclicality.[55] In the main model, the two forces act against each other, while in *Intan. Trend*, there is only an upward trend in firms' demand for liquid assets, so its procyclicality is fully unleashed.

Section I provides evidence that firms' liquidity demand increases in asset valuation, that is, the procyclicality key to the quantitative importance of intangible-driven liquidity needs. Next, I show that households' demand for liquid assets decreases

[55] The countercycality is in line with flight to safety in crises (Caballero and Krishnamurthy 2008).

Table 4—Asset Valuations and Household Holdings of Intermediaries' Debts

RHS: Financial market valuation metrics =	Tangible EV/EBITDA	Average EV/EBITDA	Tangible Tobin's Q	Average Tobin's Q		Tangible EV/EBITDA
LHS: HH holdings of intermediary debts scaled by GDP	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Regression analysis of aggregate data						
Financial market valuation	−0.017	−0.010	−0.190	−0.095		−0.016
	(0.002)	(0.002)	(0.019)	(0.012)		(0.002)
Housing-market valuation (Price/Rent)					−0.142	−0.060
					(0.024)	(0.024)
Observations	160	160	160	160	160	160
Adjusted R^2	0.3015	0.1953	0.2880	0.2456	0.0771	0.3138
LHS: HH cash holdings scaled by income	(1)	(2)	(3)	(4)	(5)	(6)
Panel B. Regression analysis of micro data						
$\Delta\ln(\text{Housing Price Index})$	−0.059	−0.119	−0.114	−0.046	−0.086	−0.081
	(0.045)	(0.040)	(0.040)	(0.037)	(0.031)	(0.039)
Controls	No	No	No	Yes	Yes	Yes
Household fixed effects	No	Yes	Yes	No	Yes	Yes
State fixed effects	No	No	Yes	No	No	Yes
Year fixed effects	No	No	Yes	No	No	Yes
Observations	70,442	70,032	70,032	65,280	65,215	65,215
Adjusted R^2	0.0001	0.2389	0.2495	0.1370	0.3438	0.3510

Notes: For panel A, heteroskedasticity-consistent standard errors in parentheses. For panel B, state-time clustered standard errors in parentheses.

in measures of asset valuation, counteracting the procyclicality in firms' liquidity demand as in the model. For time series regressions in panel A of Table 4, the dependent variable is quarterly household holdings of intermediary debts scaled by GDP from 1980 to 2019.[56] The explanatory variables are measures of capital valuation (see Section I) and housing price-to-rent ratio (data from FRED 2019). Summary statistics are reported in Supplemental Appendix D. Column 6 shows that financial market and housing valuations together explain 31 percent of variation.[57]

The analysis of aggregate data has a small sample size and does not utilize cross-sectional variations. Next, I use household-level data from the Panel Study of Income Dynamics (PSID 2019).[58] The financial market valuation metrics do not have regional variation and are thus excluded. PSID reports biannual information on households' financials from 1999 to 2017.[59] The dependent variable is the liquidity

[56] Data are from Board of Governors of the Federal Reserve System (2019). Intermediary debts are listed in Figure 2, and indirect holdings via money market funds and mutual funds are attributed to underlying securities.

[57] This is the ratio of two time series in FRED: (i) All-Transactions House Price Index for the United States and (ii) Consumer Price Index for Urban Consumers: Rent of Primary Residence in US City Average.

[58] The collection of data used in this study was partly supported by the National Institutes of Health under grant number R01 HD069609 and R01 AG040213, and the National Science Foundation under award numbers SES 1157698 and 1623684.

[59] Liquidity holdings include checking/savings deposits, money market funds, certificates of deposit, Treasury securities (not including IRA). A breakdown into instruments issued by intermediaries and the government is unavailable, but as shown in Supplemental Appendix Figure D.3, Treasury securities account for less than 15 percent. Relatedly, to analyze households' mortgage refinancing behavior, Chen, Michaux, and Roussanov (2020) use data from financial accounts of the United States for time series analysis and PSID (including households' liquidity

TABLE 5—INTANGIBLE CAPITAL AND CREDIT CONSTRAINT

	Intangibility = Intan./Assets (decile)			Intangiblity = − PPE/Assets (decile)		
Leverage = $\frac{\text{Debts}}{\text{Assets}}$	Total debts (1)	Asset-based loans (2)	Cash flow–based loans (3)	Total debts (4)	Asset-based loans (5)	Cash flow–based loans (6)
Intangibility	−1.219	−0.745	−0.715	−0.914	−0.728	−0.158
	(0.092)	(0.083)	(0.197)	(0.090)	(0.076)	(0.118)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	114,626	39,750	39,819	114,608	39,749	39,818
Adjusted R^2	0.2159	0.0891	0.1298	0.2116	0.0934	0.1263

Note: Firm-year clustered standard errors in parentheses.

holdings normalized by household income. The explanatory variable of interest is the log difference of state-level home price index from the Federal Housing Finance Agency (FHFA 2019).[60] Rent data are unavailable, so the log difference is taken to address apparent nonstationarities in these house prices. Panel B of Table 4 reports a statistically significant negative response of households' liquidity holdings to an increase in house prices, robust to different combinations of control variables and fixed effects.[61] Including control variables and fixed effects increases the adjusted R^2 to above 34 percent (in columns 5 and 6) by reducing noise, allowing the correlation to emerge between households' liquidity holdings and housing price variation. The evidence suggests that in line with the model setup, households' liquidity holdings respond negatively to asset-price increase, opposite to the positive response in firms' liquidity holdings (see Section I).

IV. Extension: Intangible Capital of Limited Pledgeability

The key friction in the model is limited pledgeability of intangibles. Columns 1 and 4 of Table 5 show that more intangible firms borrow less, which indicates tighter credit constraints. The sample is from Section I, with debt classification data from Lian and Ma (2020b).[62] For different measures of intangibility, columns 2 and 5 and

holdings) for panel-data analysis. The regression sample starts in 2001 because the calculation of log difference requires housing price.

[60] US state abbreviation and FIPS codes are from the Federal Communications Commission (FCC 2019).

[61] Following studies on household consumption-savings decisions and portfolio allocation (Bergstresser and Poterba 2004; Campbell and Cocco 2007; Bogan 2015; Chetty, Sándor, and Sziedl 2017; Stroebel and Vavra 2019), I construct the following control variables using PSID data: the log difference of total household income, the log difference of total household wealth, the number of people in a household, the age of household head, the education level of household head, a homeowner dummy, and a couple dummy (equal to one if the household head lives with a partner). I consider household, state, and year fixed effects. Note that the number of observations decline after household fixed effects are added because 65 households only appear once in the panel. Supplemental Appendix C provides summary statistics.

[62] Control variables are included following Lian and Ma (2020), who share their loan categorization data: size (log total assets in 2005 dollars); market-to-book ratio; cash-to-asset ratio; EBITDA-to-asset ratio ([sale −cogs − xsga]/at); net cash receipts-to-asset ratio ([oancf + xint]/at); inventory-to-asset ratio (invt/at). Time fixed effects are added to absorb common variations, such as tax and regulatory changes.

columns 3 and 6 show, respectively, that intangible firms are constrained in borrowing backed by both collateral and cash flow.

As the US economy becomes more intangible intensive, the legal system develops to improve the pledgeability of intangibles. This section presents an extension: When hit by the Poisson shock, an entrepreneur may raise funds from households against χ fraction of intangible capital as collateral.[63] The repayment is in the form of intangible capital ownership.[64] Equivalently, the entrepreneur may sell intangible capital rather than pledge it as collateral. It is assumed that bankers do not lend against intangibles or own intangibles.[65] In practice, intangibles are mainly financed by nonbank intermediaries (e.g., venture capital funds).

The improved pledgeability of intangibles relaxes the funding constraint:

$$i_t \leq m_t^E + q_t^T \kappa^T \big(1 - \theta_t\big)\, i_t + \chi\Big(q^I \kappa_t^I \theta_t i_t\Big). \tag{33}$$

The calibration of χ is based on the percentage of marketable intangibles. Among different categories of intangible capital, intellectual properties have relatively clear market value (around 16 percent of patents according to Akcigit, Celik, and Greenwood 2016). Intellectual properties accounted for 37.7 percent of intangible investment in the United States (Corrado et al. 2016). Therefore, χ is calibrated to be $6.0\% = 37.7\% \times 16\%$. This value is in the same magnitude as the value implied by the findings in Mann (2018): 38 percent of US patenting firms had previously pledged patents as collateral for financing, and these firms account for 20 percent of R&D expense and patenting in Compustat, so $\chi = 38\% \times 20\% = 7.6\%$.

Table 6 shows that the improved pledgeability of intangibles amplifies the mechanism. The intangible share of investment is higher, and its increase over time becomes convex. In contrast, the main model produces a linear trend. The difference widens from 2.1 percent at $t = 0$ to 10.1 percent by $t = 20$. The improved pledgeability of intangibles increases the leverage on liquidity holdings and the marginal value of liquidity. The feedback mechanism is strengthened, resulting in a much higher level and faster growth of entrepreneurs' liquidity holdings, a sharper decline of the interest rate, and a stronger upward trend in the value of tangible capital. The financial risk multiplier is higher than that of the main model, as shown in the last column of Table 6. A lower level of the interest rate widens the discount-rate wedge between bankers and the rest of the economy, making the value of tangible capital more sensitive to shocks that trigger reallocation between the two groups. The concave upward trend in financial risk multiplier in the main model becomes a linear trend once intangibles become more pledgeable. A more volatile tangible capital value translates into more volatile liquidity creation and investment.

[63] Financing for intangibles often comes from venture capital funds (VC). Akcigit et al. (2019) examine the role of VC in creating endogenous growth.

[64] Alternatively, the entrepreneur can promise to repay all the future goods produced by the intangible, which have the same present value as the intangible capital itself. Given risk-neutral preference, households are indifferent between owning intangible capital now or owning the stream of goods.

[65] Intangible capital is still less liquid than tangible capital due to search friction in patent trading (Akcigit, Celik, and Greenwood 2016): (i) the market is specialized (often involving lawyers as middlemen); (ii) the sensitivity of intellectual property makes potential participants reluctant to reveal information.

Table 6—Pledgeable Intangibles and the Reinforcing Trends

Time	Intangible inv. share $\mathbb{E}^{\eta}[\theta(\eta,t)]$	$\frac{\text{Firm deposits}}{\text{Capital value}}$ $\mathbb{E}^{\eta}\left[\frac{\tilde{M}^{E}(\eta,t)}{q^{T}(\eta,t)}\right]$	Interest rate $\mathbb{E}^{\eta}[r(\eta,t)]$	Capital valuation $\mathbb{E}^{\eta}[q^{T}(\eta,t)]$	Financial risk multiplier $\max_{\eta}\left\{\frac{\sigma^{T}(\eta,t)+\sigma}{\sigma}\right\}$
Model $t = 0$	55.2%	7.6%	3.24%	6.6	2.7
Pledgeable Intan.	57.3%	27.3%	2.58%	7.8	3.6
Model $t = 4$	58.7%	8.5%	2.11%	6.9	3.2
Pledgeable Intan.	61.8%	30.4%	1.06%	8.5	4.4
Model $t = 8$	62.2%	8.2%	0.95%	7.3	3.6
Pledgeable Intan.	66.6%	33.2%	−0.64%	9.2	5.2
Model $t = 12$	65.7%	9.2%	−0.20%	7.6	4.0
Pledgeable Intan.	71.6%	36.2%	−2.59%	9.9	6.0
Model $t = 16$	69.1%	10.2%	−1.50%	7.8	4.4
Pledgeable Intan.	76.9%	38.8%	−4.81%	10.4	6.8
Model $t = 20$	72.6%	10.4%	−2.88%	7.9	4.7
Pledgeable Intan.	82.7%	42.1%	−7.32%	10.7	7.6

V. Conclusion

The transition toward an intangible-intensive economy has a profound impact on the financial system. This paper provides a coherent account of several trends in the United States that emerged from the rise of intangibles, such as the accumulation of corporate cash holdings, growth of the financial intermediation sector, declining interest rate, and rising valuation of risky assets. At the core of the model is the endogenous supply and demand for liquid assets. To finance intangible investment, firms hold cash in the form of financial intermediaries' debts. Firms' growing demand for liquid assets, driven by intangible investment needs, pushes down the interest rate and feeds cheap leverage to intermediaries, allowing intermediaries to bid up the market value of collateral assets that back debt issuances. The model characterizes a self-enforcing mechanism that connects these trends, and the feedback mechanism also amplifies economic fluctuations along the trends.

An interesting direction for future research is to incorporate nominal frictions. The savings glut leads to a negative real rate in the model that, under low inflation, implies a binding lower bound on the nominal rates. Therefore, the rise of intangibles exacerbates the liquidity trap (Eggertsson and Woodford 2003; Fischer 2016; Christiano, Eichenbaum, and Rebelo 2011; Eggertsson and Krugman 2012; Caballero and Farhi 2017; Guerrieri and Lorenzoni 2017; Caballero and Simsek 2020). A liquidity trap in one country can spread to the rest of the world (Caballero, Farhi, and Gourinchas 2021), so the US economy becoming more intangible intensive has broader implications on the global financial system.

The interaction between industrial structure and the financial system deserves more attention in future research. While this paper focuses on how the transition to an intangible-intensive economy affects the financial system, a growing financial sector may also affect industrial structure. When financial intermediaries become more productive, it extends more credit (asset side of balance sheets) and issues more money-like securities (liability side of balance sheets). The former facilitates tangible investment, which is often credit financed, while the latter facilitates intangible investment by providing firms with storage of internal funds. A bias in productivity improvement toward the liability side contributes to faster growth of intangible capital. This seems to be the case in the run-up to the global financial crisis, as the development of shadow banking allows more effective creation of near-money assets that firms hold via money market funds and other vehicles.

REFERENCES

Adrian, Tobias, Nina Boyarchenko, and Domenico Giannone. 2019. "Vulnerable Growth." *American Economic Review* 109 (4): 1263–89.

Adrian, Tobias, Nina Boyarchenko, and Hyun Song Shin. 2016. *On the Scale of Financial Intermediaries*. Federal Reserve Bank of New York.

Adrian, Tobias, and Hyun Song Shin. 2010. *The Changing Nature of Financial Intermediation and the Financial Crisis of 2007-09*. Federal Reserve Bank of New York.

Aghion, Philippe, Ufuk Akcigit, and Peter Howitt. 2014. "What Do We Learn from Schumpeterian Growth Theory?" In *Handbook of Economic Growth*, Vol. 2, edited by Philippe Aghion and Steven N. Durlauf, 515–63. Elsevier.

Ai, Hengjie, Mariano Massimiliano Croce, and Kai Li. 2013. "Toward a Quantitative General Equilibrium Asset Pricing Model with Intangible Capital." *Review of Financial Studies* 26 (2): 491–530.

Akcigit, Ufuk, Murat Alp Celik, and Jeremy Greenwood. 2016. "Buy, Keep, or Sell: Economic Growth and the Market for Ideas." *Econometrica* 84 (3): 943–84.

Akcigit, Ufuk, Emin Dinlersoz, Jeremy Greenwood, and Veronika Penciakova. 2019. "Synergizing Ventures." NBER Working Paper 26196.

Almeida, Heitor, and Murillo Campello. 2007. "Financial Constraints, Asset Tangibility, and Corporate Investment." *Review of Financial Studies* 20 (5): 1429–60.

Andrews, Donald W. K. 1993. "Tests for Parameter Instability and Structural Change with Unknown Change Point." *Econometrica* 61 (4): 821–56.

Atkeson, Andrew, and Patrick J. Kehoe. 2005. "Modeling and Measuring Organization Capital." *Journal of Political Economy* 113 (5): 1026–53.

Bacchetta, Philippe, and Kenza Benhima. 2015. "The Demand for Liquid Assets, Corporate Saving, and International Capital Flows." *Journal of the European Economic Association* 13 (6): 1101–35.

Bansal, Ravi, and Amir Yaron. 2004. "Risks for the Long Run: A Potential Resolution of Asset Pricing Puzzles." *Journal of Finance* 59 (4): 1481–1509.

Baron, Matthew. 2020. "Countercyclical Bank Equity Issuance." *Review of Financial Studies* 33 (9): 4186–4230.

Baron, Matthew, and Wei Xiong. 2017. "Credit Expansion and Neglected Crash Risk." *Quarterly Journal of Economics* 132 (2): 713–64.

Basel Committee on Banking Supervision. 2014. *Basel III: The Net Stable Funding Ratio*. Bank for International Settlements.

Bates, Thomas W., Kathleen M. Kahle, and René M. Stulz. 2009. "Why Do US Firms Hold So Much More Cash Than They Used To?" *Journal of Finance* 64 (5): 1985–2021.

Baumol, William J. 1967. "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis." *American Economic Review* 57 (3): 415–26.

Begenau, Juliane. 2020. "Capital Requirements, Risk Choice, and Liquidity Provision in a Business-Cycle Model." *Journal of Financial Economics* 136 (2): 355–78.

Begenau, J., and T. Landvoigt. 2022. "Financial Regulation in a Quantitative Model of the Modern Banking System." *Review of Economic Studies* 89 (4): 1748–84.

Begenau, Juliane, and Berardino Palazzo. 2021. "Firm Selection and Corporate Cash Holdings." *Journal of Financial Economics* 139 (3): 697–718.

Belo, Frederico, Xiaoji Lin, and Maria Ana Vitorino. 2014. "Brand Capital and Firm Value." *Review of Economic Dynamics* 17 (1): 150–69.

Bena, Jan, and Lorenzo Garlappi. 2020. "Corporate Innovation and Returns." *Review of Corporate Finance Studies* 9 (2): 340–83.

Bergstresser, Daniel, and James Poterba. 2004. "Asset Allocation and Asset Location: Household Evidence from the Survey of Consumer Finances." *Journal of Public Economics* 88 (9–10): 1893–1915.

Bernanke, Ben S. 2005. "The Global Saving Glut and the US Current Account Deficit." Remarks given at the Sandridge Lecture, Virginia Association of Economists, Richmond, Virginia, March 10.

Bernanke, Ben S., Mark Gertler, and Simon Gilchrist. 1999. "The Financial Accelerator in a Quantitative Business Cycle Framework." In *Handbook of Macroeconomics*, Vol. 1, edited by John B. Taylor and Michael Woodford, 1341–93. Elsevier.

Blanchard, Olivier, and John Simon. 2001. "The Long and Large Decline in US Output Volatility." *Brookings Papers on Economic Activity* 2001 (1): 135–64.

Board of Governors of the Federal Reserve System. 1980–2019. *Various Interest Rates*. FRED, Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/ (accessed September 25, 2021).

Board of Governors of the Federal Reserve System. 2019. *Financial Reserve Statistical Release Z.1.* Financial Accounts of the United States.

Bogan, Vicki L. 2015. "Household Asset Allocation, Offspring Education, and the Sandwich Generation." *American Economic Review* 105 (5): 611–15.

Bolton, Patrick, Hui Chen, and Neng Wang. 2011. "A Unified Theory of Tobin's q, Corporate Investment, Financing, and Risk Management." *Journal of Finance* 66 (5): 1545–78.

Bolton, Patrick, and Xavier Freixas. 2000. "Equity, Bonds, and Bank Debt: Capital Structure and Financial Market Equilibrium under Asymmetric Information." *Journal of Political Economy* 108 (2): 324–51.

Bolton, Patrick, Tano Santos, and Jose A. Scheinkman. 2021. "Savings Gluts and Financial Fragility." *Review of Financial Studies* 34 (3): 1408–44.

Bolton, Patrick, Neng Wang, and Jinqiang Yang. 2019. "Optimal Contracting, Corporate Finance, and Valuation with Inalienable Human Capital." *Journal of Finance* 74 (3): 1363–1429.

Brunnermeier, Markus K., and Yuliy Sannikov. 2014. "A Macroeconomic Model with a Financial Sector." *American Economic Review* 104 (2): 379–421.

Brunnermeier, Markus K., and Yuliy Sannikov. 2016. "The I Theory of Money." Unpublished.

Caballero, Ricardo J. 2006. "On the Macroeconomics of Asset Shortages." NBER Working Paper 12753.

Caballero, Ricardo J., and Emmanuel Farhi. 2017. "The Safety Trap." *Review of Economic Studies* 85 (1): 223–74.

Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas. 2008. "An Equilibrium Model of 'Global Imbalances' and Low Interest Rates." *American Economic Review* 98 (1): 358–93.

Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas. 2017a. "Rents, Technical Change, and Risk Premia Accounting for Secular Trends in Interest Rates, Returns on Capital, Earning Yields, and Factor Shares." *American Economic Review* 107 (5): 614–20.

Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas. 2017b. "The Safe Assets Shortage Conundrum." *Journal of Economic Perspectives* 31 (3): 29–46.

Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas. 2021. "Global Imbalances and Policy Wars at the Zero Lower Bound." *Review of Economic Studies* 88 (6): 2570–2621.

Caballero, Ricardo J., and Arvind Krishnamurthy. 2006. "Bubbles and Capital Flow Volatility: Causes and Risk Management." *Journal of Monetary Economics* 53 (1): 35–53.

Caballero, Ricardo J., and Arvind Krishnamurthy. 2008. "Collective Risk Management in a Flight to Quality Episode." *Journal of Finance* 63 (5): 2195–2230.

Caballero, Ricardo J., and Arvind Krishnamurthy. 2009. "Global Imbalances and Financial Fragility." *American Economic Review* 99 (2): 584–88.

Caballero, Ricardo J., and Alp Simsek. 2020. "A Risk-Centric Model of Demand Recessions and Speculation." *Quarterly Journal of Economics* 135 (3): 1493–1566.

Caballero, Ricardo J., and Alp Simsek. 2021. "A Model of Endogenous Risk Intolerance and LSAPs: Asset Prices and Aggregate Demand in a 'COVID-19' Shock." *Review of Financial Studies* 34 (11): 5522–80.

Campbell, John Y., and João F. Cocco. 2007. "How Do House Prices Affect Consumption? Evidence from Micro Data." *Journal of Monetary Economics* 54 (3): 591–621.

Carlson, Mark, Burcu Duygan-Bump, Fabio Natalucci, Bill Nelson, Marcelo Ochoa, Jeremy Stein, and Skander Van den Heuvel. 2016. "The Demand for Short-Term, Safe Assets and Financial Stability: Some Evidence and Implications for Central Bank Policies." *International Journal of Central Banking* 307–33.

Center for Research in Security Prices (CRSP). 2019. *CRSP/Compustat Merged Database*. Wharton Research Data Services.

Chen, Hui, Michael Michaux, and Nikolai Roussanov. 2020. "Houses as ATMs: Mortgage Refinancing and Macroeconomic Uncertainty." *Journal of Finance* 75 (1): 323–75.

Chen, Peter, Loukas Karabarbounis, and Brent Neiman. 2017. "The Global Rise of Corporate Saving." *Journal of Monetary Economics* 89: 1–19.

Chetty, Raj, László Sándor, and Adam Szeidl. 2017. "The Effect of Housing on Portfolio Choice." *Journal of Finance* 72 (3): 1171–1212.

Christiano, Lawrence, Martin Eichenbaum, and Sergio Rebelo. 2011. "When Is the Government Spending Multiplier Large?" *Journal of Political Economy* 119 (1): 78–121.

Cochrane, John H. 2005a. "Financial Markets and the Real Economy." NBER Working Paper 11193.

Cochrane, John H. 2005b. *Asset Pricing*. Princeton University Press.
Corhay, Alexandre, Howard Kung, and Lukas Schmid. Forthcoming. "Q: Risk, Rents, or Growth?" *Journal of Financial Economics*.
Corrado, Carol, Jonathan Haskel, Cecilia Jona-Lasinio, and Massimiliano Iommi. 2016. *Intangible Investment in the EU and US before and since the Great Recession and Its Contribution to Productivity Growth*. European Investment Bank.
Corrado, Carol A., and Charles R. Hulten. 2010. "How Do You Measure a 'Technological Revolution'?" *American Economic Review* 100 (2): 99–104.
Corrado, Carol, Charles Hulten, and Daniel Sichel. 2009. "Intangible Capital and US Economic Growth." *Review of Income and Wealth* 55 (3): 661–85.
Crouzet, Nicolas, and Janice C. Eberly. 2018. "Understanding Weak Capital Investment: The Role of Market Concentration and Intangibles." Unpublished.
Dang, Tri Vi, Gary Gorton, Bengt Holmström, and Guillermo Ordoñez. 2017. "Banks as Secret Keepers." *American Economic Review* 107 (4): 1005–29.
Daniel, Naveen D., Lalitha Naveen, and Jingbo Yu. 2018. "Changing US Economy and Investment-Cash Flow Sensitivity." Unpublished.
Décamps, Jean-Paul, Thomas Mariotti, Jean-Charles Rochet, and Stéphane Villeneuve. 2011. "Free Cash Flow, Issuance Costs, and Stock Prices." *Journal of Finance* 66 (5): 1501–44.
Del Negro, Marco, Domenico Giannone, Marc Giannoni, and Andrea Tambalotti. 2017. *Safety, Liquidity, and the Natural Rate of Interest.* Federal Reserve Bank of New York.
Dell'Ariccia, Giovanni, Dalida Kadyrzhanova, Camelia Minoiu, and Lev Ratnovski. 2021. "Bank Lending in the Knowledge Economy." *Review of Financial Studies* 34 (10): 5036–76.
Denis, David J., and Valeriy Sibilkov. 2010. "Financial Constraints, Investment, and the Value of Cash Holdings." *Review of Financial Studies* 23 (1): 247–69.
Di Tella, Sebastian. 2017. "Uncertainty Shocks and Balance Sheet Recessions." *Journal of Political Economy* 125 (6): 2038–81.
Diamond, Douglas W. 1984. "Financial Intermediation and Delegated Monitoring." *Review of Economic Studies* 51 (3): 393–414.
Diamond, Douglas W., and Philip H. Dybvig. 1983. "Bank Runs, Deposit Insurance, and Liquidity." *Journal of Political Economy* 91 (3): 401–19.
Doms, Mark, and Timothy Dunne. 1998. "Capital Adjustment Patterns in Manufacturing Plants." *Review of Economic Dynamics* 1 (2): 409–29.
Döttling, Robin, and Enrico Perotti. 2017. "Secular Trends and Technological Progress." CEPR Discussion Paper 12519.
DTCC. 2005–2019. *Various Interest Rates*. Depository Trust and Clearing Corporation. https://www.dtcc.com/charts/dtcc-gcf-repo-index (accessed September 25, 2021).
Duchin, Ran. 2010. "Cash Holdings and Corporate Diversification." *Journal of Finance* 65 (3): 955–92.
Duffie, Darrell. 2002. *Dynamic Asset Pricing Theory*. Princeton University Press.
Eberly, Janice, and Neng Wang. 2008. "Reallocating and Pricing Illiquid Capital: Two Productive Trees." Unpublished.
Egan, Mark, Stefan Lewellen, and Adi Sunderam. 2022. "The Cross-Section of Bank Value." *Review of Financial Studies* 35 (5): 2101–43.
Eggertsson, Gauti B., and Paul Krugman. 2012. "Debt, Deleveraging, and the Liquidity Trap: A Fisher-Minsky-Koo Approach." *Quarterly Journal of Economics* 127 (3): 1469–1513.
Eggertsson, Gauti B., Jacob A. Robbins, and Ella Getz Wold. 2021. "Kaldor and Piketty's Facts: The Rise of Monopoly Power in the United States." *Journal of Monetary Economics* 124 (Supplement): S19–38.
Eggertsson, Gauti B., and Michael Woodford. 2003. "The Zero Bound on Interest Rates and Optimal Monetary Policy." *Brookings Papers on Economic Activity* 2003 (1): 139–233.
Eisfeldt, Andrea L. 2007. "Smoothing with Liquid and Illiquid Assets." *Journal of Monetary Economics* 54 (6): 1572–86.
Eisfeldt, Andrea L., and Tyler Muir. 2016. "Aggregate External Financing and Savings Waves." *Journal of Monetary Economics* 84: 116–33.
Eisfeldt, Andrea L., and Dimitris Papanikolaou. 2013. "Organization Capital and the Cross-Section of Expected Returns." *Journal of Finance* 68 (4): 1365–1406.
Eisfeldt, Andrea L., and Adriano A. Rampini. 2009. "Financing Shortfalls and the Value of Aggregate Liquidity." Unpublished.
Falato, Antonio, Dalida Kadyrzhanova, Jae Sim, and Roberto Steri. 2022. "Rising Intangible Capital, Shrinking Debt Capacity, and the US Corporate Savings Glut." *Journal of Finance* 77 (5): 2799–2852.
Farhi, Emmanuel, and François Gourio. 2018. "Accounting for Macro-finance Trends: Market Power, Intangibles, and Risk Premia." NBER Working Paper 25282.

Farhi, Emmanuel, and Jean Tirole. 2012. "Bubbly Liquidity." *Review of Economic Studies* 79 (2): 678–706.

Federal Communications Commission (FCC). 2019. *State Abbreviation and Federal Information Processing System (FIPS) Codes*.

Federal Housing Finance Agency (FHFA). 2019. *FHFA House Price Index*.

Fischer, Stanley. 2016. "Monetary Policy, Financial Stability, and the Zero Lower Bound." *American Economic Review* 106 (5): 39–42.

Froot, Kenneth A., David S. Scharfstein, and Jeremy C. Stein. 1993. "Risk Management: Coordinating Corporate Investment and Financing Policies." *Journal of Finance* 48 (5): 1629–58.

Gao, Xiaodan, Toni M. Whited, and Na Zhang. 2021. "Corporate Money Demand." *Review of Financial Studies* 34 (4): 1834–66.

Gârleanu, Nicolae, Leonid Kogan, and Stavros Panageas. 2012. "Displacement Risk and Asset Returns." *Journal of Financial Economics* 105 (3): 491–510.

Gertler, Mark, and Nobuhiro Kiyotaki. 2010. "Financial Intermediation and Credit Policy in Business Cycle Analysis." In *Handbook of Monetary Economics*, Vol. 3, edited by Benjamin M. Friedman and Michael Woodford, 547–99. Elsevier.

Giglio, Stefano, and Tiago Severo. 2012. "Intangible Capital, Relative Asset Shortages and Bubbles." *Journal of Monetary Economics* 59 (3): 303–17.

Goldstein, Itay, and Ady Pauzner. 2005. "Demand-Deposit Contracts and the Probability of Bank Runs." *Journal of Finance* 60 (3): 1293–1327.

Gornall, Will, and Ilya A. Strebulaev. 2018. "Financing as a Supply Chain: The Capital Structure of Banks and Borrowers." *Journal of Financial Economics* 129 (3): 510–30.

Gorton, Gary, Stefan Lewellen, and Andrew Metrick. 2012. "The Safe-Asset Share." *American Economic Review* 102 (3): 101–06.

Gorton, Gary, and Guillermo Ordoñez. 2014. "Collateral Crises." *American Economic Review* 104 (2): 343–78.

Gorton, Gary, and Guillermo Ordoñez. 2020. "Good Booms, Bad Booms." *Journal of the European Economic Association* 18 (2): 618–65.

Gorton, Gary, and George Pennacchi. 1990. "Financial Intermediaries and Liquidity Creation." *Journal of Finance* 45 (1): 49–71.

Gourinchas, Pierre-Olivier, and Hélène Rey. 2016. "Real Interest Rates, Imbalances and the Curse of Regional Safe Asset Providers at the Zero Lower Bound." NBER Working Paper 22618.

Graham, John R., and Mark T. Leary. 2018. "The Evolution of Corporate Cash." *Review of Financial Studies* 31 (11): 4288–4344.

Greenwood, Robin, and David Scharfstein. 2013. "The Growth of Finance." *Journal of Economic Perspectives* 27 (2): 3–28.

Guerrieri, Veronica, and Guido Lorenzoni. 2017. "Credit Crises, Precautionary Savings, and the Liquidity Trap." *Quarterly Journal of Economics* 132 (3): 1427–67.

Gutiérrez, Germán, and Thomas Philippon. 2017. "Declining Competition and Investment in the US." NBER Working Paper 23583.

Hall, Bronwyn H. 1992. "Investment and Research and Development at the Firm Level: Does the Source of Financing Matter?" NBER Working Paper 4096.

Hall, Bronwyn H., and Josh Lerner. 2010. "The Financing of R&D and Innovation." In *Handbook of the Economics of Innovation*, Vol. 1, edited by Bronwyn H. Hall and Nathan Rosenberg, 609–39. Elsevier.

Hansen, Lars Peter, John C. Heaton, and Nan Li. 2008. "Consumption Strikes Back? Measuring Long-Run Risk." *Journal of Political Economy* 116 (2): 260–302.

Hansen, Lars Peter, John C. Heaton, and Nan Li. 2005. "Intangible Risk." In *Measuring Capital in the New Economy*, edited by Carol Corrado, John Haltiwanger, and Daniel Sichel, 111–52. University of Chicago Press.

Hart, Oliver, and John Moore. 1994. "A Theory of Debt Based on the Inalienability of Human Capital." *Quarterly Journal of Economics* 109 (4): 841–79.

Hart, Oliver, and Luigi Zingales. 2014. "Banks Are Where the Liquidity Is." Unpublished.

He, Zhiguo, and Péter Kondor. 2016. "Inefficient Investment Waves." *Econometrica* 84 (2): 735–80.

He, Zhiguo, and Arvind Krishnamurthy. 2013. "Intermediary Asset Pricing." *American Economic Review* 103 (2): 732–70.

Herrendorf, Berthold, Richard Rogerson, and Ákos Valentinyi. 2013. "Two Perspectives on Preferences and Structural Transformation." *American Economic Review* 103 (7): 2752–89.

Himmelberg, Charles P., and Bruce C. Petersen. 1994. "R&D and Internal Finance: A Panel Study of Small Firms in High-Tech Industries." *Review of Economics and Statistics* 76 (1): 38–51.

Hirano, Tomohiro, and Noriyuki Yanagawa. 2017. "Asset Bubbles, Endogenous Growth, and Financial Frictions." *Review of Economic Studies* 84 (1): 406–43.

Holmström, Bengt, and Jean Tirole. 1997. "Financial Intermediation, Loanable Funds, and the Real Sector." *Quarterly Journal of Economics* 112 (3): 663–91.

Holmström, Bengt, and Jean Tirole. 1998. "Private and Public Supply of Liquidity." *Journal of Political Economy* 106 (1): 1–40.

Holmström, Bengt, and Jean Tirole. 2001. "LAPM: A Liquidity-Based Asset Pricing Model." *Journal of Finance* 56 (5): 1837–67.

Jordà, Òscar, Moritz Schularick, and Alan M. Taylor. 2013. "When Credit Bites Back." *Journal of Money, Credit and Banking* 45 (s2): 3–28.

Karabarbounis, Loukas, and Brent Neiman. 2014. "The Global Decline of the Labor Share." *Quarterly Journal of Economics* 129 (1): 61–103.

Kiyotaki, Nobuhiro, and John Moore. 1997. "Credit Cycles." *Journal of Political Economy* 105 (2): 211–48.

Kiyotaki, Nobuhiro, and John Moore. 2000. "Inside Money and Liquidity." Unpublished.

Klimenko, Nataliya, Sebastian Pfeil, Jean-Charles Rochet, and Gianni De Nicolo. 2016. "Aggregate Bank Capital and Credit Dynamics." Swiss Finance Institute Research Paper Series 16-42.

Kogan, Leonid, Dimitris Papanikolaou, Lawrence D. W. Schmidt, and Jae Song. 2020. "Technological Innovation and Labor Income Risk." NBER Working Paper 26964.

Kogan, Leonid, Dimitris Papanikolaou, and Noah Stoffman. 2020. "Left Behind: Creative Destruction, Inequality, and the Stock Market." *Journal of Political Economy* 128 (3): 855–906.

Koh, Dongya, Raül Santaeulàlia-Llopis, and Yu Zheng. 2020. "Labor Share Decline and Intellectual Property Products Capital." *Econometrica* 88 (6): 2609–28.

Kongsamut, Piyabha, Sergio Rebelo, and Danyang Xie. 2001. "Beyond Balanced Growth." *Review of Economic Studies* 68 (4): 869–82.

Korinek, Anton, and Alp Simsek. 2016. "Liquidity Trap and Excessive Leverage." *American Economic Review* 106 (3): 699–738.

Krishnamurthy, Arvind, and Tyler Muir. 2016. "How Credit Cycles across a Financial Crisis." Unpublished.

Krishnamurthy, Arvind, and Annette Vissing-Jorgensen. 2015. "The Impact of Treasury Supply on Financial Sector Lending and Stability." *Journal of Financial Economics* 118 (3): 571–600.

Li, Shaojin, Toni M. Whited, and Yufeng Wu. 2016. "Collateral, Taxes, and Leverage." *Review of Financial Studies* 29 (6): 1453–1500.

Li, Ye. 2025. *Data and Code for: "Fragile New Economy: Intangible Capital, Corporate Savings Glut, and Financial Instability."* Nashville, TN: American Economic Association; distributed by Inter-university Consortium for Political and Social Research, Ann Arbor, MI. https://doi.org/10.3886/E183683V1.

Lian, Chen, and Yueran Ma. 2020. Replication Data for: "Anatomy of Corporate Borrowing Constraints." Harvard Dataverse. https://doi.org/10.7910/DVN/T9KXMF.

Lian, Chen, and Yueran Ma. 2021. "Anatomy of Corporate Borrowing Constraints." *Quarterly Journal of Economics* 136 (1): 229–91.

López-Salido, David, Jeremy C. Stein, and Egon Zakrajšek. 2017. "Credit-Market Sentiment and the Business Cycle." *Quarterly Journal of Economics* 132 (3): 1373–1426.

Lucas, Robert E., Jr. 1978. "Asset Prices in an Exchange Economy." *Econometrica* 46 (6): 1429–45.

Maggiori, Matteo. 2017. "Financial Intermediation, International Risk Sharing, and Reserve Currencies." *American Economic Review* 107 (10): 3038–71.

Mann, William. 2018. "Creditor Rights and Innovation: Evidence from Patent Collateral." *Journal of Financial Economics* 130 (1): 25–47.

Martin, Alberto, and Jaume Ventura. 2012. "Economic Growth with Bubbles." *American Economic Review* 102 (6): 3033–58.

Marx, Magali, Benoît Mojon, and François R. Velde. 2021. "Why Have Interest Rates Fallen Far Below the Return on Capital?" *Journal of Monetary Economics* 124 (Supplement): S57–76.

McGrattan, Ellen R. 2020. "Intangible Capital and Measured Productivity." *Review of Economic Dynamics* 37 (Supplement 1): S147–66.

McGrattan, Ellen R., and Edward C. Prescott. 2010a. "Technology Capital and the US Current Account." *American Economic Review* 100 (4): 1493–1522.

McGrattan, Ellen R., and Edward C. Prescott. 2010b. "Unmeasured Investment and the Puzzling US Boom in the 1990s." *American Economic Journal: Macroeconomics* 2 (4): 88–123.

Miao, Jianjun, and Pengfei Wang. 2018. "Asset Bubbles and Credit Constraints." *American Economic Review* 108 (9): 2590–2628.

Moreira, Alan, and Alexi Savov. 2017. "The Macroeconomics of Shadow Banking." *Journal of Finance* 72 (6): 2381–2432.

Nagel, Stefan. 2016. "The Liquidity Premium of Near-Money Assets." *Quarterly Journal of Economics* 131 (4): 1927–71.
Ngai, L. Rachel, and Christopher A. Pissarides. 2007. "Structural Change in a Multisector Model of Growth." *American Economic Review* 97 (1): 429–43.
Opler, Tim, Lee Pinkowitz, René Stulz, and Rohan Williamson. 1999. "The Determinants and Implications of Corporate Cash Holdings." *Journal of Financial Economics* 52 (1): 3–46.
Ordoñez, Guillermo. 2013. "The Asymmetric Effects of Financial Frictions." *Journal of Political Economy* 121 (5): 844–95.
Perron, P. 2006. "Dealing with Structural Breaks." In *Palgrave Handbook of Econometrics*, Vol. I, edited by Terence C. Mills and Kerry Patterson, 278–352. Palgrave Macmillan.
Peters, Ryan H., and Lucian A. Taylor. 2017. "Intangible Capital and the Investment-*q* Relation." *Journal of Financial Economics* 123 (2): 251–72.
Phelan, Gregory. 2016. "Financial Intermediation, Leverage, and Macroeconomic Instability." *American Economic Journal: Macroeconomics* 8 (4): 199–224.
Piazzesi, Monika, and Martin Schneider. 2016. "Payments, Credit and Asset Prices." Unpublished.
Pinkowitz, Lee, René M. Stulz, and Rohan Williamson. 2016. "Do US Firms Hold More Cash than Foreign Firms Do?" *Review of Financial Studies* 29 (2): 309–48.
Poterba, James M., and Julio J. Rotemberg. 1986. "Money in the Utility Function: An Empirical Implementation." NBER Working Paper 1796.
Pozsar, Zoltan. 2011. "Institutional Cash Pools and the Triffin Dilemma of the US Banking System." International Monetary Fund Working Paper WP/11/190.
Pozsar, Zoltan. 2014. *Shadow Banking: The Money View*. Office of Financial Research.
Protter, Philip E. 1990. *Stochastic Integration and Differential Equations*. Springer-Verlag.
PSID. 2019. *Panel Study of Income Dynamics*. The Survey Research Center, Institute for Social Research, University of Michigan.
Quadrini, Vincenzo. 2017. "Bank Liabilities Channel." *Journal of Monetary Economics* 89: 25–44.
Rajan, Raghuram G., and Luigi Zingales. 1998. "Financial Dependence and Growth." *American Economic Review* 88 (3): 559–86.
Rampini, Adriano A., and S. Viswanathan. 2019. "Financial Intermediary Capital." *Review of Economic Studies* 86 (1): 413–55.
Riddick, Leigh A., and Toni M. Whited. 2009. "The Corporate Propensity to Save." *Journal of Finance* 64 (4): 1729–66.
Sidrauski, Miguel. 1967. "Inflation and Economic Growth." *Journal of Political Economy* 75 (6): 796–810.
Stein, Jeremy C. 2012. "Monetary Policy as Financial Stability Regulation." *Quarterly Journal of Economics* 127 (1): 57–95.
Stroebel, Johannes, and Joseph Vavra. 2019. "House Prices, Local Demand, and Retail Prices." *Journal of Political Economy* 127 (3): 1391–1436.
Thomas, Julia K. 2002. "Is Lumpy Investment Relevant for the Business Cycle?" *Journal of Political Economy* 110 (3): 508–34.
US Bureau of Economic Analysis. 2019. *Table 4.1. Current-Cost Net Stock of Private Nonresidential Fixed Assets by Industry Group and Legal Form of Organization.* US Department of Commerce. https://apps.bea.gov/iTable/?ReqID=10&step=2#eyJhcHBpZCI6MTAsInN0ZXBzIjpbMiwzXSwiZGF0YSI6W1siVGFibGVfTGlzdCIsIjI2Il1dfQ==.
US Bureau of Labor Statistics. 1947–2020. *Consumer Price Index for All Urban Consumers: All Items in US City Average* [*CPIAUCSL*]. FRED, Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/series/CPIAUCSL (accessed May 27, 2021).
US Bureau of Labor Statistics. 1975–2020. *Consumer Price Index for All Urban Consumers: Rent of Primary Residence in US City Average* [*CUSR0000SEHA*]. FRED, Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/series/CUSR0000SEHA (accessed June 6, 2020).
US Federal Housing Finance Agency. 1975–2020. *All-Transactions House Price Index for the United States* [*USSTHPI*]. FRED, Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/series/USSTHPI (accessed June 6, 2020).
Van den Heuvel, Skander J. 2022. "The Welfare Effects of Bank Liquidity and Capital Requirements." Unpublished.
Woodford, Michael. 1990. "Public Debt as Private Liquidity." *American Economic Review* 80 (2): 382–88.
Wharton Research Data Services (**WRDS**)**.** 2019. *Financial Ratios Firm Level by WRDS* (*Beta*). Wharton Research Data Services.