Macro and Financial Implications of Aging*

Guillermo Ordoñez† Facundo Piguillem‡

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Abstract

The U.S. economy has recently experienced two salient, seemingly unrelated, phenomena: a large increase in post-retirement life expectancy and a major expansion in securitization. We argue they are intimately related. While aging induces an increase in the demand of saving instruments, it also puts pressure on financial innovations that expand their supply. We quantitatively single out the role of securitization in accommodating demographic transitions. In spite of its potential fragility, we show securitization was critical on increasing credit and output by channeling savings for retirement needs towards productive uses.

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†University of Pennsylvania and NBER (e-mail: ordonez@econ.upenn.edu).
‡EIEF and CEPR (e-mail: facundo.piguillem@gmail.com).

1 Introduction

In the last four decades the U.S. economy experienced a steep increase in intermediated credit, which almost doubled from one to two GDPs. Due to the magnitude of the 2008 financial crisis, policymakers and scholars rationalized this "credit boom" in different ways, ranging from an atypical influx of foreign funds (an international savings glut) to pure financial speculation. By focusing, perhaps excessively, on its role to trigger crises, these explanations tend to deny the boom's potential benefits and deem it just as a detrimental phenomenon. But what was behind this credit expansion? Was there any gain from the credit boom? If so, how large were these gains?

We analyze the contribution of a domestic factor that has been underemphasized in explaining this prolonged credit boom: the demographic transition characterized by a longer life span – *population aging*. In just four decades, the U.S. population life expectancy, conditional on retirement, increased dramatically from 77 years to around 83 years. Although life expectancy has been increasing for a century, this time frame was unique in that it was driven by people becoming older as opposed to previous decades in which it was driven by a decline in child mortality.[1]

Living longer after retirement induces an increase in the demand of savings during working years, consistent with the *increase in savings out of total wealth* documented in Lustig, van Nieuwerburgh, and Verdelhan (2013) and Ordonez and Piguillem (2021), in spite of the well-known *decline in savings out of disposable income*. We argue that this increase in the demand for savings introduces pressure for new and more efficient tools to supply savings, such as *securitization*. This view is in line with the recent work of Scharfstein (2018) who, using cross-country evidence, highlights that pension policies and other *restrictions to save for retirement* affect the structure of financial systems, in particular the balance between banks and capital markets. In a similar vein we argue, using time series evidence for the U.S., that the *needs to save for retirement* affect the type of financial instruments used by financial intermediaries.

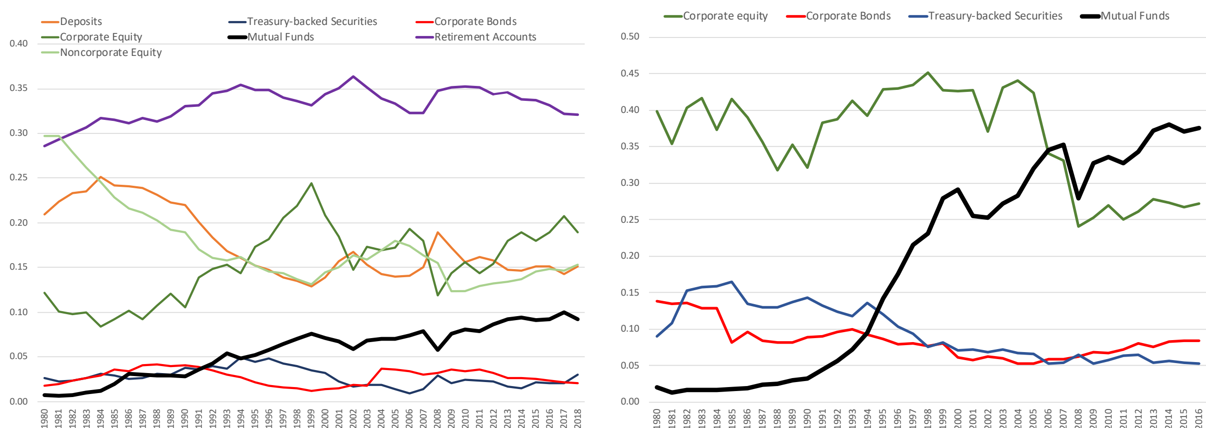
Given that retirees hold a large fraction of total aggregate wealth, savings for retirement needs have been always considered a fundamental factor for macroeconomic outcomes. Wolff (2004) documents that more than a third of total wealth in the United States is held by households whose heads are over 65, and Gustman and Steinmeier (1999) show that for households near retirement, wealth is around one-third of lifetime income. Even before retirement, Kotlikoff and Summers (1981) argue that most people's savings are

[1] The average retirement age in the U.S. is 63.5 years. For the historical evolution of life expectancy, see https://www.cdc.gov/nchs/data/hus/2011/022.pdf.

intended to be used after retirement. It is not surprising then the existence of a rich literature on the *macroeconomic implications of savings for retirement*, dating as back as the celebrated overlapping generations model of Samuelson (1958).

What is puzzling, however, is the scarce connection to the *financial implications of savings for retirement*. Indeed, a large fraction of U.S. financial wealth is managed by financial intermediaries, in ways that have dramatically changed in recent years as population aged. The first panel of Figure 1 shows that at least 50% of total wealth is managed by financial intermediaries (retirement accounts by pension funds, deposits by banks and shares by mutual funds). The composition has moved away from traditional deposits and towards mutual funds shares, not only directly (as seen in the first panel) but also indirectly through changes within intermediaries portfolios (such as the increase of mutual fund shares held by private pension funds, the black line of the second panel of Figure 1). This large expansion in the operation of mutual funds was mostly driven by their heavy involvement and investment in securities.[2]

Figure 1: Increasing Importance of Mutual Funds



Note: The first panel shows households' wealth composition (Flow of Funds, Table B101). The second panel shows the portfolio of private pension funds (Flow of Funds, Table L118).

In this paper we connect *theoretically* the increase in life expectancy that raises savings for retirement needs with the increase in securitization that characterized the changes in the anatomy of financial intermediation. We then evaluate this connection *quantitatively*. In particular, we show that *i)* securitization was instrumental in accommodating the larger saving needs, and it did so by substantially decreasing the financial sector's liquidity cost; *ii)* this *domestic savings glut* can account for most of the observed credit

[2]This aggregate evidence is consistent with the more detailed portfolio composition based on the Vanguard Research Initiative reported by Ameriks et al. (2014).

boom; and *iii)* even if we assume (as commonly argued) that the great recession was entirely generated by the extensive use of securitization, the benefits prior to the crisis were an order of magnitude larger than the cost of the crisis.

To study the macroeconomic and financial implications of aging, we proceed in four stages. *The first stage is theoretical* (Section 2). We propose an overlapping generations model with heterogeneity in bequest motives that allows for the coexistence of lenders and borrowers. Individuals with low-bequest motives save for retirement by depositing their funds in *financial intermediaries (banks or mutual funds)*. Individuals with high-bequest motives save for retirement by buying stocks in *capital markets*. While Scharfstein (2018) focuses on this last margin (banks vs. capital markets), we instead explore the first margin (the different forms of financial intermediation).

In our economy intermediaries perform two costly activities, *i)* they channel credit from depositors (low-bequest motives) to investors (high-bequest motives) and *ii)* as deposits or shares can be withdrawn at any period, banks and mutual funds have to guarantee their availability upon withdrawal. The intermediaries' cost of providing credit, which we denote *operation cost*, is the cost of finding the best available investment opportunities to allocate funds. It includes the process of identifying productive opportunities, monitoring the management of projects and administering payments. The cost of guaranteeing the availability of funds in case of withdrawal, which we denote *liquidity cost*, is the cost of transforming long-term risky loans into short-term safe assets, at stable nominal conditions and in relatively short periods of time, in case a large fraction of investors decide to withdraw their funds.

There are two types of financial intermediaries: *i)* Those that perform standard banking activities obtaining funds from depositors, originating loans and retaining them until maturity. We call these *traditional banks* and *ii)* those that instead obtain funds from investors, originate loans and sell them to a third party issuing securities. As in Gorton and Metrick (2012), we call these *securitized banks*.[3] Other denominations have been used to denote "non-traditional banks," such as "originate and distribute banks" or "shadow banks." These denominations focus on risk management or regulatory status differences, while we highlight instead the extensive use of securitization as a differential technology or business banking model.[4]

Securitization is a technology that involves transforming a pool of assets into a new fi-

[3]Banks move their assets off the books to off-balance sheet vehicles, special instrument vehicles (SIVs) special purpose vehicles (SPV), or special purpose entities (SPE). For all purposes these are part of the bank, but legally regarded separate entities.

[4]As highlighted by Acharya and Richardson (2009) "Securitization alters the original idea of banking: banks are now intermediaries between investors (rather than just depositors) and borrowers." (pp 199).

nancial instrument (*security*) that improves the liquidity in the marketplace of the assets being securitized. This technology of pooling assets, dividing the pool into tranches and making transactions complex and opaque discourages asymmetric information among market participants, facilitating trading and improving the liquidity of underlying assets. By operating at lower liquidity costs, there intermediaries can offer better rates to attract funds, but at a cost in terms of fragility (sudden dry up of liquidity) inherent to the use of opaque operations.[5] Combining demographic transitions and financial innovation in a macroeconomic environment leads to our main theoretical insight: a higher life expectancy triggers an appetite for yields, which is satisfied by exploiting the benefits of securitization, even when recognizing its potential fragility.

But how relevant was securitization in the United States to reduce liquidity costs? To address this question, *the second stage is empirical* (Section 3). Measuring the quantitative extents and implications of securitization is challenging because of its ubiquitous use in financial markets, its lack of transparency, and the corresponding double counting issues. Our approach is to use prices instead of quantities. We use the model to map the use of securitization into a "liquidity premium" that can be inferred from measuring the spread between lending and deposit rates in the whole financial sector. Measured this way, the liquidity cost declined from a stable level of 1% in 1980 to almost 0% before the recent financial crisis. This finding is consistent with two alternative estimates in the literature that use unrelated methodologies.

Is this estimated decline in liquidity costs quantitatively consistent with the changes in volumes and prices of intermediated credit observed in the U.S. since 1980? What were the individual contributions of aging and securitization for credit and output? To answer these questions, *the third stage is quantitative* (Section 4). We calibrate the economy to 1980 and input the observed change in life expectancy and liquidity costs to generate a counterfactual for 2007. Only including these two forces we can account for the observed evolution of households' debt over GDP and total financial assets held in the economy, with an increase of around 75% in both figures by 2007. On the one hand, absent securitization, aging could not account for any increase in credit, but just a steep decline in the risk-free rate. The reason is that securitization allows channeling more funds towards productive uses by improving the liquidity of otherwise illiquid loans.[6] On the other hand, absent aging, the risk-free rate would have increased substantially so steady state output would have grown by only half as with both forces combined.

[5] Gorton and Ordonez (2014) provide a microfoundation of this trade-off.

[6] Even though not explored explicitly in this paper, alternatively securitization allows banks to escape blunt, and potentially restrictive, regulatory constraints that inefficiently force them to over-invest in unproductive asset classes, as in Ordonez (2018a).

Our model abstracts from the possibility that securitization collapses on path – *we do not model crises*. Yet, we discuss our initial question, one that has attracted fierce debate in policy and regulatory circles: did the U.S. win or lose from this financial innovation? This justifies our *last, counterfactual, stage* (Section 5). We construct a hypothetical economy without securitization and compare it with the realized economy in the U.S. We find that, from 1980 to 2007, securitization increased output by an accumulated 60% of 2007 GDP. This number can be put in context when compared to the cost of the crisis, around 14% of 2007 GDP. Thus, even in the extreme case of blaming the crisis and its cost entirely on securitization, still the economy gained (net of the crisis) almost half of 2007 GDP by its presence since the 1980s.

Related Literature: We contribute to a literature that quantitatively studies the determinants of aggregate savings. De Nardi, French and Jones (2009, 2010 and 2015) and Imrohoroglu and Zhao (2018), for instance, show that several factors related to aging, such as health care risks, are relevant drivers of savings, while Imrohoroglu, Imrohoroglu, and Joines (1998) point to the sizable impact that assets' *returns* on savings volume. We contribute by linking aging-driven aggregate savings to the set of financial alternatives available to save, with endogenous heterogeneous returns. More recently, Auclert et al. (2021) study how in a world with aging population, the larger needs for retirement insurance could be generating the global decline in interest rates. Here we highlight the endogenous reaction of financial intermediation in taming this decline.

We also contribute to the recent academic and policy debate on the effects of financial innovations for macroeconomic aggregates. While most of this debate focuses on the costs of securitization and shadow banking in terms of inducing financial fragility, much less is known about its potential positive macroeconomic effects. Moreira and Savov (2015) highlight that shadow banking improves liquidity provision during periods of low economic uncertainty, but focus on the implied fragility and its collapse when uncertainty increases. Begenau and Landvoigt (2017) provide a quantitative model of optimal regulation of traditional banking that recognizes that it may induce the creation of fragile shadow banks. Similarly, Farhi and Tirole (2017) argue that traditional banking is sustained on complementarities between costly public supervision and beneficial public liquidity guarantees, and discuss how regulation (taxes and subsidies, ring fencing, etc.) can accommodate these forces to avoid a migration towards shadow banking.[7]

In this paper we take a longer-term perspective and study the role of demographic changes in boosting new financial instruments to better accommodate larger saving

[7]Harris, Opp, and Opp (2014) and Plantin (2015) also study the interactions between regulation of traditional banking and shadow banking, focusing on the use of securities.

needs. Thus, we focus on their implications for economic growth and not on their implications for economic cycles nor on how to regulate their activity. Still, even though we focus on the growth and not on the demise of securitization, we are able to provide an estimate of its net gains when fully attributing the crisis to its presence.

Our paper is also related to the discussion about the origins of the pressures for channeling more savings. In contrast to a rich literature that argues that the higher demand for safe assets in recent decades can be attributed to larger saving needs of foreign countries (the "global savings glut" hypothesis, as in Caballero (2010), Justiniano, Primiceri, and Tambalotti (2013), Caballero, Farhi, and Gourinchas (2016), Carvalho, Ferrero, and Nechio (2016)), or to larger saving needs of corporations (the "corporate savings glut" hypothesis, as in Gao, Whited, and Zhang (2018)), in this paper we focus on larger saving needs of longer-living U.S. residents (a "domestic savings glut" hypothesis). Interestingly, a large part of the savings glut coming from foreign countries has been accommodated by an increase in U.S. government debt and the provision of U.S. government bonds. Securitization, then, has had a primary role in accommodating the domestic demand for safe assets, with substantial quantitative implications for observed macroeconomic changes.

Finally, the paper also contributes more generally on capturing quantitatively the role of banking in macroeconomics using general equilibrium models, as in Diaz-Gimenez et al. (1992) and Mehra, Piguillem, and Prescott (2011). We extend these environments by studying how saving pressures shape financial intermediation, in particular the use of securitization, and affect macroeconomic variables not only directly but also indirectly through a new financial system. To write a parsimonious model suitable to perform a macro quantitative analysis, we have refrained from modeling the microfoundations of how securitization reduces liquidity costs in the system, as in Ordonez (2018b). Instead we rely on reduced-form specifications that are better suited to discipline the model quantitatively using aggregate financial and macroeconomic data.

2 Model

2.1 Environment

We study an overlapping generations economy populated by agents who work in a competitive production sector, save for retirement (either in capital markets or through financial intermediaries) and are taxed by the government.

2.1.1 Agents

Each period a measure $(1+\eta)^t$ of agents are born, where η is the population growth rate. Agents are born at age $j = 0$ and live with certainty for T periods, during which they work an inelastic amount of hours (normalized to 1) at no utility cost. After age T they can no longer supply labor (they retire) and die with constant probability $0 < \delta < 1$ thereafter. When an agent dies at age j she may leave bequests b_j to her offspring (a younger agent), which provides a utility $\alpha \geq 0$ (in units of consumption) per unit of bequest. Agents are *only* heterogeneous in the intensity of their bequest motive, $\alpha \sim m(\alpha)$.[8]

We denote the consumption of an age-j agent at calendar time t by $c_{t,j}$ and the discount factor by β. Assuming logarithmic preferences, the utility in present value of an agent who is born at a calendar period t is:

$$\sum_{j=0}^{T} \beta^j \log c_{t+j,j} + \sum_{j=T+1}^{\infty} \beta^j (1-\delta)^{j-T-1}[(1-\delta)\log c_{t+j,j} + \delta\alpha \log b_{t+j,j}]. \tag{1}$$

In this specification we make two simplifying assumptions, which are useful for expositional reasons and not overly restrictive. First, we assume just a "joy-of-giving" type of bequest motive, but α may capture other forces as well, such as precautionary savings against possible health shocks.[9] Second, retirement is exogenous at age T. As Costa (1998) and Bloom et al. (2007) show, the retirement age in the U.S., as in many other countries, has been continuously decreasing over the last century. Hence, our assumption is conservative on capturing the effect of aging on savings.[10]

[8] As in Mehra, Piguillem, and Prescott (2011) model of financial intermediation, we rely on heterogeneous bequest motives to capture simultaneously returns differentials and portfolio choices. As is well known from the literatures on the equity premium puzzle, Mehra and Prescott (1985), and the participation puzzle, Mankiw and Zeldes (1991), this is a daunting task using just risk profiles. Using only risk one can either obtain a reasonable spread but with low asset trading, or empirically reasonable volumes of trade but with a small interest rate spread. Assuming a permanent (fixed effect) difference in savings behavior allows us to overcome this problem. Indeed, as shown by Aguiar, Bils, and Boar (2020) empirically, whether an agent is a saver or a borrower is mostly determined by a permanent fixed effect. Further, the relevance of bequest motives for retirement savings has been discussed by Bernheim (1991) and Lockwood (2012), among others.

[9] As De Nardi, French, and Jones (2010) show, one important motive to save after retirement is to insure against medical expenses. De Nardi, French, and Jones (2015) and Lockwood (2015) point out, however, the difficulty to properly disentangle bequests motives from health needs.

[10] As Bloom, Canning, and Moore (2014) argue, as life expectancy increases there are two effects affecting the retirement decision. On the one hand, workers can extend their working life. On the other hand, the increase in labor productivity that usually accompanies a longer life increases the demand for leisure (income-wealth effect), which induces an earlier retirement. The net effect of aging on the retirement age is then ambiguous. Recent work, such as Shourideh and Troshkin (2017), however, point to the

Individuals have three sources of income. First, an agent born in period t receives labor income $y_{t+j,j}$ for the labor provided at age j during her working age. Second, we assume that the bequest $b_{t+j,j}$ that agents leave upon death at age j is equally distributed among all agents alive of age $T_I < T$. Thus, everyone receives an inheritance, $\bar{b}_{t+T_I}$, at age T_I. Finally, a retiree receives pension transfers P^i_{t+j} from Social Security every period after retirement.[11]

Notice that these three sources of income are deterministic and identical to all agents, so we abstract from aggregate risk and other sources of idiosyncratic risk (such as unemployment or health shocks during the working lifetime) and income heterogeneity. This implies that *the only source of risk in the economy is the agent's life span and the only saving motive is retirement*. This assumption allows us to focus on to the role of aging on financial intermediation. First, in spite of underestimating the level of precautionary savings (even though Gale and Scholz (1994) and Kotlikoff and Summers (1981) show that between 75% and 90% of individual savings can be explained by retirement reasons alone), we are interested in their change. Second, although we abstract from the risk premia embedded in interest rates, we are interested on the intermediation spread, not in the level of the interest rate.[12]

In terms of asset accumulation, agents differ on their saving strategies depending on their bequest motives. Denoting agent i's saving returns by r^i_t and assuming a labor income tax τ, the agent i born at t has a consolidated total wealth at birth of:[13]

$$v^i_t = \sum_{j=0}^{T-1} \frac{(1-\tau)y_{t+j,j}}{\prod_{l=0}^{j}(1+r^i_{t+l})} + \frac{\bar{b}}{\prod_{l=0}^{T_I}(1+r^i_{t+l})} + \sum_{j=T}^{\infty} \frac{(1-\delta)^{j-T} P^i_{t+j}}{\prod_{l=0}^{j}(1+r^i_{t+l})}. \tag{2}$$

We restrict agents' saving choices to two alternatives: i) *banks* or ii) *capital markets*. Since the only source of uncertainty is the age of death, we assume that households choose

dominance of the income-wealth effect, except for individuals in top income decile. Alternative explanations of why agents do not retire older range from an increased female labor force participation(Borella, De Nardi, and Yang (2017)), to survey-based evidence about low expectations of finding flexible jobs (Ameriks et al. (2019)). For a cross-section of countries, Bonfatti, Imrohoroglu, and Kitao (2019) discuss the binding statutory nature of retirement in many countries.

[11]The introduction of social security payments is important because it attenuates the needs for private insurance. Without it, we could be overstating the impact of demographic changes.

[12]When we calibrate the model in Section 4.1, however, we discuss how we adjust interest rates for risk premia to be consistent with this abstraction.

[13]Later we will focus on the balanced growth path. In that case equation (2) greatly simplifies to:

$$v^i_0 = \sum_{j=0}^{T-1} \frac{(1-\tau)y_j}{(1+r^i)^j} + \frac{\bar{b}}{(1+r^i)^{T_I}} + \frac{(1+r^i)}{r^i+\delta} \frac{P^i}{(1+r^i)^T}.$$

among these alternatives at birth and cannot switch across savings alternatives during their lifetime. We take this assumption to mean that there is a cost to choose and to switch strategies, which has empirical support.[14] To be precise these two strategies are:

1) **Save in Capital Markets (Strategy C):** Buy equity or bonds in capital markets (corporate equity) or buy and manage an own firm (non-corporate equity) while working and live out savings after retirement, bequeathing any un-spent savings.

2) **Save in Banks (Strategy B):** Sign a contract with a financial intermediary (we call it generically a bank, but it also applies to mutual or pension funds) that specifies the payment that *the agent must make to the intermediary* during the agent's working age (how much to deposit in the bank or to contribute to the pension plan) and the payment that *the intermediary must make to the agent* when the agent retires. That is, the agent consumes c_j as long as the agent is alive and leaves b_j to her heirs contingent on dying at age j.

We will discuss in detail later how banks operate. It is enough to highlight at this point that there are two differences with capital markets. First, banks constitute a "pool of agents' funds." In this paper this is useful to cross-insure individuals who die old with those who die young, but in general a pool also allows to insure alternative sources of risk. Second, banks manage assets at a cost.

The agent can choose to sign this contract with one of two possible banks: a traditional bank (TB) or a securitized bank (SB). Securitized banks have access to securitization (as we will discuss at length later, securitization reduces the liquidity premium and allows these banks to pay higher rates to their depositors) and signing the contract with a securitized bank implies an additional utility cost κ to the agents. This parameter captures several costs related to securitization, such as the effort cost to understand securities or the uncertainty of participating on a more fragile banking scheme. We model these costs in reduced form here, but in the Appendix we show how they arise endogenously when securitization may collapse, as it happened during the recent U.S. financial crisis.

[14]According to the IRS, individuals withdrawing from a retirement plan before 59.5 years old must pay income tax plus an additional 10% on the amount taken out. Consistent with this cost, Mankiw and Zeldes (1991) show evidence that most households don't ever hold stocks and prefer to keep all their assets in risk-less alternatives (participation puzzle). Even households that hold stocks in their portfolios don't drastically change strategies as they age. Fagereng, Gottlieb, and Guiso (2017) argue that a combination of participation costs and a small "disaster" probability are needed to rationalize the low change in investments. Alvarez, Guiso, and Lippi (2012) show that not only are participation costs needed, but also observational costs.

2.1.2 Productive Sector

The productive sector operates every calendar period t with a Cobb-Douglas production function with exogenous growth rate γ,[15]

$$Y_t = K_t^{\theta}(\Gamma_t L_t)^{1-\theta}$$
$$\Gamma_{t+1} = (1+\gamma)\Gamma_t,$$

where K is the aggregate stock of capital in the economy, L is the aggregate supply of labor, Γ is the average labor productivity and θ is the share of capital income over total income. As we discussed in more detail in Section 4.1, wealth to GDP ratio is a key target moment in our calibration, so we interpreted K not only as productive capital, but also as any kind of storable good, i.e., it includes housing and land.

Labor and capital markets are competitive, which implies that the rental rate of the inputs equals their respective marginal productivity. This is,

$$\delta_k + r_e = F_K(K_t, \Gamma_t L_t)$$
$$y_t = F_L(K_t, \Gamma_t L_t)$$

where δ_k is the capital depreciation rate. Notice that Γ is labor-augmenting productivity. Thus, because average productivity grows at the rate γ per year, individual wages also grow at rate γ as agents age: $y_{t+1,j+1} = (1+\gamma)y_{t,j}$.

2.1.3 Government

The government consumes a constant proportion g of output (not valued by agents), follows a committed debt policy D_t^G (independent of prices and quantities in the economy) and pays average Social Security transfer of $\overline{P}_t$. The government collects taxes on labor income to balance the budget,

$$\tau y_t L_t + (D_{t+1}^G - D_t^G) = gY_t + \overline{P}_t + r_{t,L} D_t^G. \tag{3}$$

We will assume hereafter that the Social Security transfer after retirement is a fraction

[15] We are abstracting from changes on the growth rate of productivity, γ. As Chen, Imrohoroglu, and Imrohoroglu (2006) and Fernandez, Imrohoroglu, and Tamayo (2018) show, these changes can have important effects on savings rates. We are studying, however, a time interval in which the U.S. economy can be considered stationary with minor variations in the growth rate of GDP. Nevertheless, in Section 4.3 we incorporate observe changes in productivity, which slightly improves our results.

ss^i of the last wage $y_{t,T}$ at retirement. The transfer may also be conditional on the individuals saving decisions. As the only source of heterogeneity in wealth is agents' saving decisions, $i \in \{B, C\}$. Then, $P^i_{t+j} = ss^i y_{t+T,T}; \quad \forall j > T$.

2.1.4 Financial Intermediation

The financial sector consists of perfectly competitive intermediaries (a.k.a. "banks") that offer saving contracts, specifying the gross rate $1 + r_t$ that an agent (that we name "depositor") receives per unit of saving. With these funds, the bank can invest either in "safe government bonds" that pay with certainty a unit gross rate $1 + r_{L,t}$ per unit of bond or in a continuum of "risky loans" that pay a unit gross rate $1 + \widehat{r}_{e,t} > 1 + r_{L,t}$ per unit of loan. As the bank invests in a continuum of loans, a known fraction s_b of loans default, so there is no ex-ante uncertainty on their return. Each bank takes the return of bonds (that is, $r_{L,t}$) and the risk-adjusted return on loans (that is, $r_{e,t} \equiv (1-s_b)(1+\widehat{r}_{e,t})-1$) as given. We denote as f_t the fraction invested in loans.

Let D_t be the total financial intermediary's liabilities in period t. We assume that, even though motivated by retirement, bank's contracts are short-term, which means that agents can withdraw D_t from that bank at any period. This assumption captures that, i) savings have liquidity benefits as agents can use them for transaction purposes (deposits as money, as in Dang et al. (2017)) or to face liquidity shocks (deposits as insurance, as in Diamond and Dybvig (1983)) and ii) short-term liabilities induce bankers' discipline, as in Diamond and Rajan (2001). We denote the total financial intermediary's assets in period t by A_t, and assume they mature every period. As banks' liabilities and assets last for a single period, we effectively have a bank's static problem every period and then we dispense from using the calendar subscript t henceforth in this section.

The problem for banks of holding short-term liabilities is that they maybe subject to *bank runs*: all depositors choose to withdraw their funds and move them to another bank. If a bank does not have enough funds to cover these withdrawals, it must default completely on all depositors, which creates a coordination problem for depositors (as in Diamond and Dybvig (1983)). How easily can a bank liquidate its assets on short notice and raise funds to be insulated from this possible coordination failure? The intermediary could raise funds from selling bonds, at a price $1 + r_L$, and from selling its self-originated loans, potentially at a fire-sale price that we denote by $1 + q$.

The fire-sale price $1 + q$ depends, however, on how valuable those loans are for potential buyers (other banks not facing a run at the same time). There are many reasons why buyers cannot reap all the benefits of non-originated loans, which range from asymmetric information about their quality to relationship lending that makes loans more easily monitored by the originator. For a given rate r promised to depositors, the bank is *resilient* (not subject to a bank run) when

$$[z(1+q)+(1-f)(1+r_L)]A \geq (1+r)D, \tag{4}$$

where $z \leq f$ is the amount of loans that are liquidated to face the run. This inequality restricts banks portfolios and guarantees that there are no runs (and thus no default) in equilibrium. As we are interested in long run effects of financial innovation we impose this inequality throughout.

In terms of the banking technology and market structure, we assume that banks face a constant returns to scale technology, with a constant marginal cost of operation $\widehat{\phi}$ per unit of asset managed, and that there is perfect competition, such that a bank's zero profit condition is:

$$[f(1+r_e)+(1-f)(1+r_L)-\widehat{\phi}]A = (1+r)D. \tag{5}$$

Finally, we introduce the next two natural parametric assumptions.

Assumption 1 *No arbitrage (agents can buy bonds at no cost). This guarantees $r = r_L$.*

Assumption 2 *Operational costs are not high ($r_e > \widehat{\phi}$). This guarantees $A = D$.*

The Role of Securitization: Now we introduce the market for fire sales that determines q, and highlight the role of securitization.

We assume that a bank facing a run (*in distress*) randomly matches with another bank to sell its loans. Since the buyer may not have the expertise to operate the loans, it will try to sell those loans to another bank that is better suited to operate them, obtaining the corresponding return r_e. The probability the buyer can resell a loan is:

$$Pr(reselling) = (1+\Psi)\ln\zeta\frac{1+z}{z}\frac{1+r}{1+r_e}.$$

If the buyer does not find another intermediary willing to buy the loans obtained from the bank in distress, the buyer does not obtain any return.

The reselling probability captures the simplicity of exchanging assets in financial markets. We assume this probability increases in an exogenous parameter $\Psi \geq 0$ that captures the technology available for finding counterparties and for reducing frictions for trading and re-trading assets in the market. As securitization improves trading in secondary markets, relaxing asymmetric information considerations, we model a better securitization technology with a higher Ψ. In order to obtain q in a simple analytical form, we also assume the probability of reselling a single loan decreases as there are more sales z, decreases in the ratio $\frac{1+r_e}{1+r}$ (a measure of loan specialization vis-a-vis government bonds and other standard assets) and increases in a parameter ζ that we just introduced to guarantee the probability is bounded between 0 and 1 for the relevant parameters. The specific form of this probability is helpful in characterizing the solution, but it is not restrictive as long as the qualitative properties remain.

The demand of a distressed bank's loans is determined by the following maximization problem of a potential buyer:

$$\max_z \left[(1+\Psi)\ln \zeta(1+z)\frac{1+r}{1+r_e}\right](1+r_e) - (1+q)z$$

subject to $z \leq f$. The demand for distressed loans is then:

$$1 + q_D = \frac{(1+\Psi)(1+r)}{1+z}.$$

The supply of loans is given by the binding liquidity constraint of a distressed intermediary (4), which, given assumptions 1 and 2, can be rewritten as $z(1+q)+(1-f)(1+r) = (1+r)$. Then the supply of distressed loans is:

$$1 + q_S = \frac{f(1+r)}{z}.$$

Market clearing implies that $q_D = q_S$. Thus $z^* = \frac{f}{1+\Psi-f}$, subject to the constraint that $z^* \leq f$, which implies,

$$f \leq \Psi. \tag{6}$$

The operation of fire-sale markets puts a bound on the fraction of loans that a bank can hold in order to guarantee enough funds for liquidation in case of distress.

Given these assumptions, a bank simply chooses the fraction f^* of investments in loans and the interest rate r^* to pay to savers, taking as given the securitization technology Ψ and the return r_e. The next proposition summarizes these optimal choices.

Proposition 1 *Banking Optimal Choices.*

The fraction of loans in the portfolio f^* is given by

$$f^* = \min\{1, \Psi\}.$$

The payment to savers r^* is given by

$$r^* = r_e - \frac{\widehat{\phi}}{f^*},$$

where f^* and r^* are both increasing in securitization (decreasing in Ψ).

Proof When $r_e > \widehat{\phi}$ the objective is to maximize f subject to the liquidity constraint (4), which in a fire sale market is simply given by constraint (6). Given f^*, the promise to savers, r^*, is determined by the zero profit condition (5). It is trivial that both f^* and r^* are increasing in securitization (decreasing in Ψ). Q.E.D.

Intuitively, when it is easy to trade assets (a liquid interbank market), there are fewer losses in case of liquidation and distress. The higher is the fire-sale price, the higher is the fraction of loans that a bank can hold and still successfully face withdrawls (a higher Ψ allows for a higher f^*). As banks can hold more productive assets in their portfolio and still avoid a run on path, zero profit conditions imply a better return for depositors (a higher f^* implies a higher r^*). Combining equilibrium values of f^* and r^* we can define a risk-adjusted interest spread as

$$\phi \equiv r_e - r^* = \max\left\{\widehat{\phi}, \frac{\widehat{\phi}}{\Psi}\right\}. \tag{7}$$

The risk-adjusted interest spread has two main components: i) the physical cost of production, represented by the *value-added component*, $\widehat{\phi}$ and ii) the *liquidity-premium component*. This last component depends on the securitization technology. It increases as Ψ decreases (securitization becomes worse) and it is zero when $\Psi \geq 1$.

Notice that in this model the liquidity constraint always holds but never binds, which implies that there is never a run in equilibrium and fire sales restrict outcome off-equilibrium. The absence of runs on the equilibrium path is an artifice from the absence of exogenous shocks that force the constraint to bind. This could be easily accommodated, but our intention is to characterize steady states and not fluctuations.

Traditional and Securitized Banks: We assume there are two technologies available in the economy that differ in how loans are packaged, pooled, and tranched to be exchanged in the interbank market. Traditional banks operate with Ψ_{TB} and securitized banks with $\Psi_{SB} > \Psi_{TB}$. This setting justifies securitized banks investing a larger fraction of their portfolio in productive loans, facing less liquidation costs and offering larger return to depositors.

2.1.5 Aggregates and Definition of (Stationary) Equilibrium

Since η, γ, τ and g are all constant in our setting, in what follows we will focus on a balance growth path equilibrium. Along it, all aggregate variables, except L, grow at the rate $\hat{\gamma} = (1+\gamma)(1+\eta) - 1$ and all per capita variables grow at the rate γ. For instance, $K_{t+1} = (1+\hat{\gamma})K_t$, while investment is $X_t = (\delta_k + \hat{\gamma})K_t$; therefore, from now on, we omit the time subscript. Even though we will present the main results comparing stationary equilibria, in Section 4.3 we compute the transitions between these stationary equilibria.

In a balanced growth path we only need to analyze the problem of an individual born at $t = 0$, as the problem of any other individual born at any other calendar period t is simply $c_{t,j} = (1+\gamma)^t c_{0,j}$. Thus, we solve for the life pattern of consumption of individuals born at $t = 0$ (that is, $c_{0,j}$) and apply it to all agents born at $t > 0$. Then, in the balance growth path, we simply denote the life pattern of consumption as c_j.

First, we specify aggregates along the balanced growth path. As the only source of heterogeneity in the model arises from α, let $\mathcal{A}^i$ be the stationary set of agents α choosing strategy i, $\mu_i(\alpha) = m(\alpha)$ if $\alpha \in \mathcal{A}^i$ and define $\mu_i = \int_{\alpha \in \mathcal{A}^i} m(\alpha) d\alpha$. In every period t, a density $(1+\eta)^t m(\alpha)$ of agents are born and their survival probabilities are exogenous; then the density of agents of age j and type α choosing strategy i is:

$$\mu_j^i(\alpha) = \begin{cases} \frac{\mu_i(\alpha)}{(1+\eta)^{j-t}} & \text{if } j \leq T \\ \frac{(1-\delta)^{j-T-1}\mu_i(\alpha)}{(1+\eta)^{j-t}} & \text{if } j > T. \end{cases}$$

We use these measures to obtain aggregates for each agent type i, as functions of two endogenous state variables: the marginal productivity of capital, r_e, and the bequest obtained by individuals, $\bar{b}$.

$$\begin{aligned}
\mathbb{C}(r_e, \bar{b}) &= \sum_{i=S,B} \sum_{j=1}^{\infty} \int c_j^i(r, \bar{b}; \alpha) \mu_j^i(\alpha) d\alpha \\
\mathbb{W}^i(r_e, \bar{b}) &= \sum_{j=1}^{\infty} \int w_j^i(r, \bar{b}; \alpha) \mu_j^i(\alpha) d\alpha \\
\mathbb{B}(r_e, \bar{b}) &= \sum_{i=C,B} \sum_{j=T+1}^{\infty} \delta \int b_j(r, \bar{b}; \alpha) \mu_{j-1}^i(\alpha) d\alpha \\
L_t &= \sum_{j=0}^{T-1} (1+\eta)^{t-j}
\end{aligned}$$

where $\mathbb{C}$ is aggregate consumption; w^i the individual net worths of agents following strategy i, and $\mathbb{W}^i$ the corresponding aggregates; $\mathbb{B}$ is aggregate bequest; and L_t is total labor supply in calendar period t.

Definition 1 *Stationary Equilibrium.*

Given fiscal policies $\{g, ss_i, D^G\}$, a stationary equilibrium is characterized by saving choices $\{\{TB, SB\}, C\}$, individual allocations $\{\underline{c}(\alpha), \underline{w}(\alpha), \underline{b}(\alpha)\}_{\forall \alpha \geq 0}$, prices $\{y, r_e, r_L, r\}$, and aggregate allocations $\{Y, X, K, \mathbb{B}, \mathbb{C}\}$, such that

1. *Given prices $\{y, r_e, r_L, r\}$ and fiscal policies $\{g, ss_i, D^G\}$, individual allocations $\{\underline{c}(\alpha), \underline{w}(\alpha), \underline{b}(\alpha)\}$ solve the consumer-saver problem for all $\alpha > 0$: households choose their retirement plan and consumption path to maximize utility.*

2. *Banks choose rates to pay and their portfolio allocation to maximize profits.*

3. *Factor prices are equal to marginal productivities.*

4. *The government chooses τ to balance the budget.*

5. *Markets clear:*

   - *Feasibility:* $Y = gY + \mathbb{C}(r_e, \bar{b}) + X + \phi[\frac{\mathbb{W}^B(r_e,\bar{b})}{1+r} - D^G]$.
   - *Assets market:* $\frac{\mathbb{W}^B(r_e,\bar{b})}{1+r} + \frac{\mathbb{W}^C(r_e,\bar{b})}{1+r^e} = D^G + K$.
   - *Bequest=inheritance:* $\bar{b} = (1+\gamma)^{T_I} \mathbb{B}(r_e, \bar{b})$.

2.2 Equilibrium Characterization

We solve the equilibrium backwards. First, we characterize the optimal consumption path of an α-agent *conditional* on saving in capital markets or through intermediaries. Then we solve for its optimal saving strategy.

Saving through Intermediaries: First, consider the strategy of saving through intermediaries. The following analysis holds regardless of whether the agent chooses to use traditional or securitized banking, which will be determined later by comparing the higher rate r and the higher cost κ of securitized banking. Since the age of death is the only source of uncertainty, and banks can provide insurance against living too long by pooling resources from a continuum of depositors, the optimal contract agents would sign with banks is an *annuity contract*, which guarantees a constant path of consumption after retirement. In this sense we denote saving for retirement in banks as obtaining *safe assets*.

Any agent saving in banks maximize the utility in equation (1) subject to equation (2), knowing that consumption after retirement is constant. In the appendix we show that the solution is characterized by:

$$c_j^B = \bar{c}^B \beta^j (1+r)^j v_0^B, \qquad \text{and} \qquad b_j^B = c_j^B. \tag{8}$$

for some constant $\bar{c}^B > 0$. Notice that b can be considered as another consumption good, so that intra-temporal optimality imposes $b = \alpha c$. If $\beta(1+r) = 1$ a depositor would consume a constant amount throughout its lifetime and would leave exactly the same bequest, *independently of how long the household lives*.

This consumption plan implies the following pattern of the net worth evolution,

$$\begin{aligned}
w_0^B &= 0 && (9)\\
w_j^B &= (w_{j-1}^B - c_{j-1}^B + (1-\tau)y_j)(1+r), && 1 \le j \le T,\ j \neq T_I\\
w_j^B &= (w_{j-1}^B - c_{j-1}^B + (1-\tau)y_j)(1+r) + \bar{b}, && j = T_I\\
w_j^B &= \sum_{t=0}^{\infty} \frac{(1-\delta)^{t-1}}{(1+r)^t} \left[(1-\delta)c_{j+t} + \delta\alpha b_{j+t} - ss_B y_T\right], && j > T
\end{aligned}$$

Intuitively, agents are born with zero wealth, and as they work, they deposit in banks (at return r) any non-consumed income. At age T_I each household receives an inheritance, which is mostly saved; thus the net worth jumps at this age. After retirement, banks pay according to the contract specified.

Saving in Capital Markets: Now we consider the strategy of saving for retirement in capital markets. In this case households must plan how much to save for retirement and how to spend those savings after retirement. This can be considered as two separate problems. We solve it backwards, characterizing first the problem after retirement.

Since all bequests are accidental $b_j = w_j$ for all $j \geq T$, the problem after retirement solves:

$$V(w) = \max\{\log c + (1-\delta)\beta V(w') + \delta\beta\alpha \log w'\}$$
$$\text{s.t.} \quad c + \frac{w'}{(1+r_e)} \leq w$$

where r_e is the risk-adjusted return on equity, the return or this strategy.

Given the assumed functional forms for consumption and bequests, it is straightforward to verify that the value function is logarithmic in w. That is,

$$V(w) = \bar{\nu}_1(\alpha) + \bar{\nu}_2(\alpha) \log w$$
$$\text{with} \quad \bar{\nu}_2(\alpha) = \frac{1+\alpha\beta\delta}{1-(1-\delta)\beta}.$$

The optimal consumption plan and the implicit optimal bequest plan are:

$$\begin{aligned} c &= w/\bar{\nu}_2(\alpha) \\ w' &= (1+r_e)(w - c + ss_S y_T). \end{aligned} \tag{10}$$

Given this solution after retirement, the optimal plan at entry in the labor force solves:

$$\max \sum_{j=0}^{T-1} \beta^j log c_j + \beta^T V(w_T)$$
$$\text{s.t.} \quad \sum_{j=0}^{T-1} \frac{c_j}{(1+r_e)^j} + \frac{w_T}{(1+r_e)^T} \leq v_0^C$$

with v_0^S given by equation (2). The solution is:

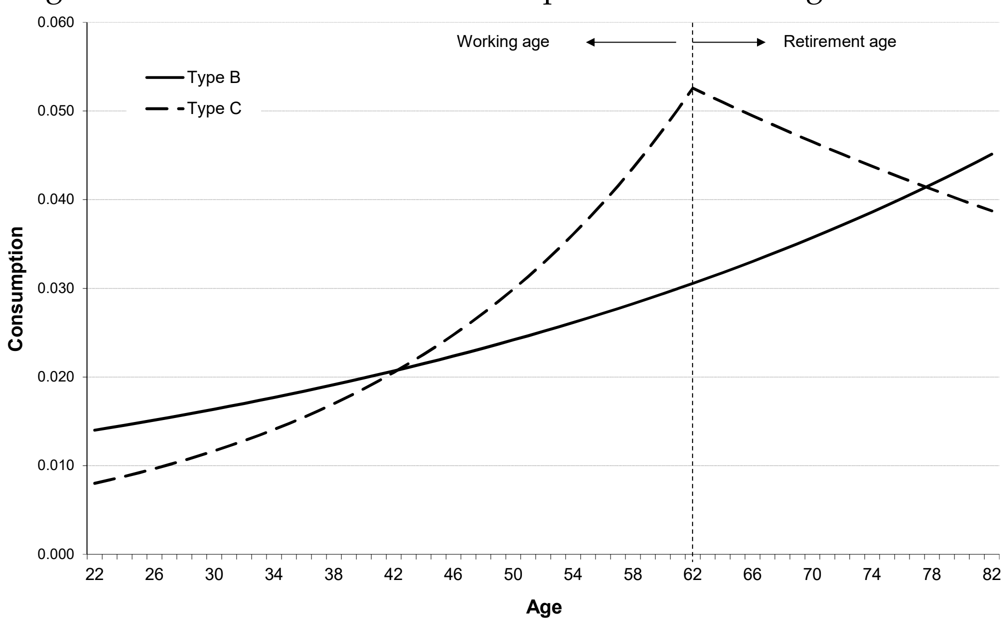
$$\begin{aligned} c_j^C &= \bar{c}^C \beta^j (1+r_e)^j v_0^C, \qquad j < T \\ w_T^C &= [1 - \sum_{j=0}^{T-1} \bar{c}^C \beta^j](1+r_e)^T v_0^C. \end{aligned} \tag{11}$$

During working age, the net worth of agents that follow strategy S evolves as:

$$\begin{aligned} w_0^C &= 0 \\ w_j^C &= (w_{j-1}^C - c_{j-1}^C + (1-\tau)y_j)(1+r_e), \qquad 1 \le j \le T,\ j \ne T_I \\ w_j^C &= (w_{j-1}^C - c_{j-1}^C + (1-\tau)y_j)(1+r_e) + \bar{b}, \qquad j = T_I \end{aligned} \tag{12}$$

Two features of this economy are apparent when we compare equations (11) and (10) with equation (8). First, since $r_e > r$, the consumption of agents who save in capital markets grows faster that the consumption of those who save in banks. After retirement, however, the former experience a faster decline in consumption than the latter. In fact, the consumption of agents that save in capital markets converges to zero as the agent lives long enough. This patterns are summarized in Figure 2. The difference in the return of these two strategies also has the same implications for the evolution of net worth across agents with different saving strategies. In the Online Appendix we provide evidence, based on the Survey of Consumer Finances, that households with and without equity in their portfolios show a trajectory of net worth over their lifetime that is consistent with the characterization in the model for types B (who only save on banks, no equity) and C (who save in capital markets, or equity).

Figure 2: Lifetime Pattern of Consumption Under Strategies B and C



Now, based on these different consumption paths, we characterize the saving strategies of agents with different bequest motives when entering the labor force. First, conditional on depositing in the bank, the agent must choose a traditional or a securitized bank. The trade-off between these two alternatives is that the return from saving in securitized banks is higher, but represents a utility cost κ of searching, understanding the contract, and potentially facing an aggregate crisis, incurred at the time of signing the contract. The next proposition shows that, conditional on depositing in a bank, the agent chooses securitized banking when expects to live long enough, enjoying the additional return longer at the same cost κ. This is true when the agents' bequest motive is not so large. As we show next, these are the agents selecting into banking.

Proposition 2 *Choice between traditional and securitized banking.*

For agents with relatively low bequest motives ($\alpha < \frac{1}{1-\beta}$), there exists a unique $\delta^*(\alpha, \kappa) > 0$ such that, when $\delta \geq \delta^*(\alpha, \kappa)$, households that follow strategy B sign the annuity contract with traditional banks, and when $\delta < \delta^*(\alpha, \kappa)$, they sign the annuity contract with securitized banks. Furthermore, $\delta^*(\alpha, \kappa)$ is increasing in α and decreasing in κ.

For this result, it is important that κ is constant and independent of δ. If κ were solely capturing search and attention costs of securitization, this assumption would arise naturally. If in addition κ captures the probability that securitization collapses, it could also depend on fundamental parameters. To address this issue in Appendix B we consider an alternative environment where instead of the fixing κ, agents face a constant annual probability p of loosing wealth equivalent to $(1 - \zeta)$ units of consumption. Then, the microfounded equivalent of κ would be,

$$\kappa(\delta) = -\beta^T \frac{p \log(\zeta)}{1 - \beta(1 - \delta)} > 0.$$

This representation of the cost κ is increasing both in the probability and the losses of a crisis (note that because $\zeta < 1$, then $\log(\zeta) < 0$). The cost is also increasing on life expectancy, but as we show in Appendix B, the benefit of higher rates increases at a faster rate than this cost. Thus, under some additional conditions (also satisfied in our quantitative exercise), we are able to prove an analogous result to Proposition 2.

Once determined what is the bank's type to invest, agents choose between saving in banks or in capital markets. Saving in banks has the benefit of fully insuring against the risk of living long, but it has the cost of low return. Conversely, saving in capital markets has the benefit of high returns, but at the cost of not providing insurance against living too long, as they may leave large amounts of accidental bequests. Of course, the stronger is the household's bequest motive the lower the implicit cost of accidental bequests. This intuition is confirmed in the next proposition.

Proposition 3 *Choice between banks and capital markets.*

There are $\bar{\phi} > \underline{\phi} > 0$ such that for all $\widehat{\phi} \in [\underline{\phi}, \bar{\phi}]$, there exists a unique $\alpha^*(\delta) > 0$ such that all agents with $\alpha < \alpha^*(\delta)$ follow strategy B and all agents with $\alpha \geq \alpha^*(\delta)$ follow strategy S.

Note that in this economy all agents have access to banks. That is, to safe assets that deliver the same consumption after retirement, regardless of when the agent dies. Individuals with high bequest motives, however, optimally choose not to use them.[16]

From Proposition 3, the fraction of the population using banks and capital markets depends on the distribution of bequest motives, α. Similarly, from Proposition 2, the fraction of the population using traditional and securitized banks depends both on the distribution of bequest motives, α, and of securitized banking costs, κ. In what follows we make the following assumption about these distributions.

Assumption 3 *We assume that the distribution of bequest motives is concentrated in two points: $\alpha = 0$ with probability μ and $\alpha = \widehat{\alpha} > 0$ with probability $(1 - \mu)$. We also assume a single and fixed cost of securitized banking κ for all agents.*

Since there are only two saving alternatives, banks and capital markets, the first part of the assumption is qualitatively without loss of generality. Agents with $\alpha = 0$ will save in banks (as $r_e \to r$), hence we need to guarantee that $\widehat{\alpha}$ is high enough to also have agents saving in capital markets. This assumption immediately implies from Proposition 3 that the size of the banking industry is pinned down by μ, which we assume exogenous. Endogenizing the size of the banking sector is in part the motivation of Scharfstein (2018), but beyond our scope, which instead focuses on the change in composition *within* the banking system.

The combination of the two parts of the assumption has, however, implications for the composition of the banking industry. Since all agents saving in banks (those with $\alpha = 0$) face the same κ, the threshold $\delta^*(\alpha, \kappa)$ from Proposition 2 is identical for all of them, and then all choose to switch to securitized banks simultaneously. This simplification is motivated by the difficulty to measure intermediation costs of traditional and securitized banks separately, which forces us to target *average intermediation costs* when performing the calibration. Since for the aggregate it is inconsequential whether the observed reduction in average intermediation costs arises from a wide adoption of securitized banking with slight less intermediation costs or by a moderate adoption of securitized

[16] This mechanism is in line with the recent finding by Lockwood (2012 and 2015), who argues that a high bequest motive could be an explanation for the "annuity puzzle".

banks with much lower intermediation costs, we assume the first case, with all agents adopting securitized banking at the same time. There is always, however, a distribution of κ that can perfectly match the evolution of securitized bank adoption.

3 Measuring the Evolution of Intermediation Costs

In this section, and in preparation to evaluate the model quantitatively, we document the evolution of average intermediation costs since 1980 and discuss the role of securitization in interpreting such evolution.

We want to measure $\phi = r_e - r$, where r_e has to be corrected for defaulting debt and r has to be corrected for non-priced services. As there is no readily available measure of ϕ in the aggregate, as a proxy for intermediation costs we use *spreads between total interests received and total interests paid in the whole financial sector*, from NIPA tables. We need to adjust r_e by productive investment opportunities being risky and not recovered by the bank, so we subtract from interests received the "bad debt expenses."[17] To adjust r by the many services provided by banks that are not priced in (such as safety, accessibility to ATMs, financial advising, insurance, etc), we add to the interests paid by the financial sector the "services furnished without payment," which assigns a monetary value to these services.

Based these adjustments, we can decompose ϕ into measurable components as

$$\phi = r_e - (\overbrace{r_L + r_s}^{r}) = \frac{\overbrace{fr^e + (1-f)r_L}^{r_T} - r_L}{f} - r_s,$$

where r_L is the interest paid for deposits (same as bond returns), r_s is the return for other services not priced by banks, f the fraction of portfolios in productive loans and $r_e = (1 - s_b)(1 + \widehat{r}_e) - 1$, with $\widehat{r}_e$ being the rate charged for loans and s_b the fraction that defaults. These components have counterparts in NIPA tables:

1. r_T=(Total interest received - bad debt expenses)/hh's debt.

This expression measures the average return on assets for all concepts that banks receive. We use Table 7.11, Line 28 of the NIPA tables, which provides the total interest received by private financial intermediaries and subtract Table 7.1.6 Line 12 of the NIPA

[17] If the law of large numbers holds for financial institutions, the average loss per unit should be equal to the average. From this point of view, the adjusted interest received could be considered as the equivalent risk free return on loans.

table that provides "bad debt expenses" declared by corporate business.[18] To express these values as returns, we divide them by all household liabilities (*hh's debt*) from Table D.3 of the Flow of Funds.

2. r_L=*(Total interest paid)/hh's debt.*

This expression measures the average return on deposits that depositors and savers receive. Table 7.11, Line 4 of NIPA provides information about the total interest paid on deposits by the financial sector, which we divide by *hh's debt*.

3. r_s=*(Services furnished without payment)/hh's debt.*

This expression measures the average return on services provided by financial intermediaries that are not explicitly charged to depositors and savers. We obtain this figure from Table 2.4.5, Line 88 of the Flow of Funds, which we also divide by *hh's debt*.

4. f=*Fraction of portfolio of financial intermediaries allocated to productive investments*

This is perhaps the most difficult figure to measure, but also central to our analysis. We denote by s the fraction of intermediaries not chartered as depository institutions and that more heavily use securitization (mutual funds, hedge funds, SIVs, investment banks, money market funds, etc.) and assume they allocate all of their portfolio to productive assets. The remaining fraction corresponds to *traditional banks* that only allocate a fraction $\widehat{f}$ of their assets to productive assets (either they are constrained by the threat of runs or regulations). The fraction of productive investments in the financial sector is,

$$f = s + (1 - s)\widehat{f}.$$

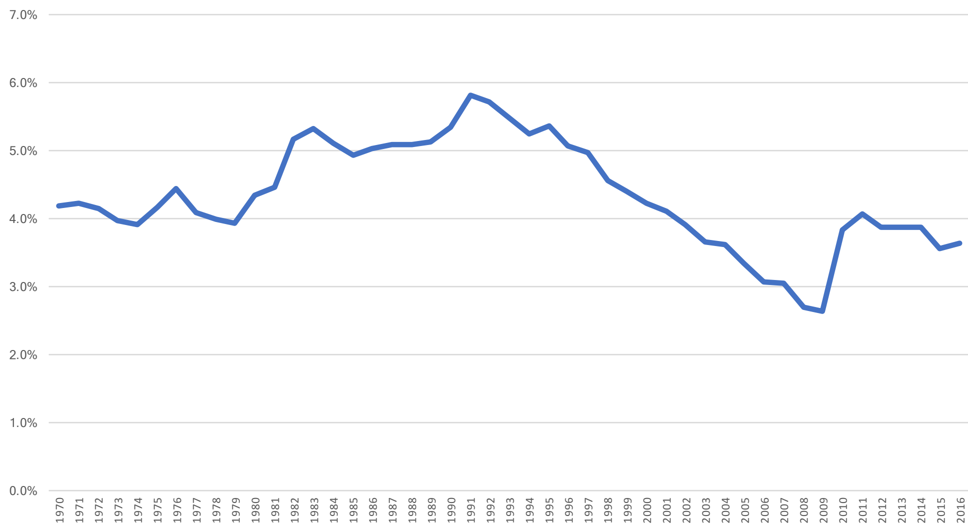
Measuring s is challenging because part of traditional banks also use securitization channeled through special purpose vehicles. To avoid double counting and taking a stand on what should be classified or not, instead of measuring the use of securitization directly we measure it as a residual from traditional activities. First, we compute $(1 - s)$ by the fraction of consumer credit and mortgages to households that is channeled through traditional banks (from Table 110 we divide consumer credit from Line 14 plus mortgages from Line 15 by total consumer credit and mortgages obtained by all households from Table D3). Then, we compute $\widehat{f}$ by the fraction of loans in the portfolio of traditional banks (from Table 110 we divide all the loans from traditional banks from Lines 12, 14 and 15 by all their deposits, checkable and savings, from Lines 23 and 24).

Combining these components, Figure 3 shows the spreads since the seventies. In short,

[18] As not all corporate business are financial intermediaries, we follow Mehra, Piguillem, and Prescott (2011) and assign half of it to the financial sector. We also assign alternatives of 25%, 75% and 100% to the financial sector without any qualitative change, just a change in levels.

right before 1980 spreads were stable at around 4%, there was an increase in the 80s and 90s, and a large decline that reached 3% before the 2008 crisis, to jump again in recent years to pre-1980s levels.

Figure 3: Risk-Adjusted Spread, ϕ



Figures 4 and 5 show the decomposition of the spread. According to our measures, non-traditional institutions (s) increased in importance from 5% in the seventies to more than 50% in recent years, while securitization of traditional institutions (captured in part by $\widehat{f}$) also increased from 80% in the seventies to almost 100% before the crisis, and then collapsed to 70% right after the recent U.S. financial crisis.

Figure 4: SB Intermediaries, s

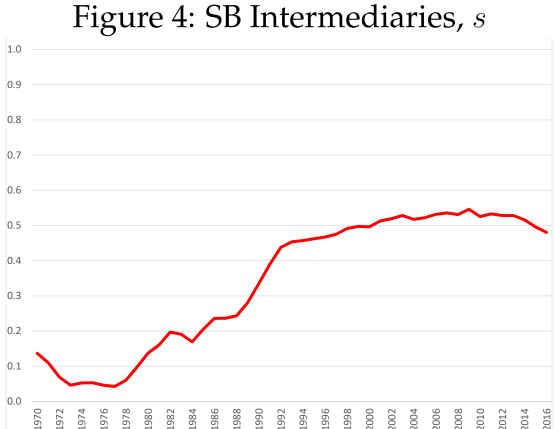
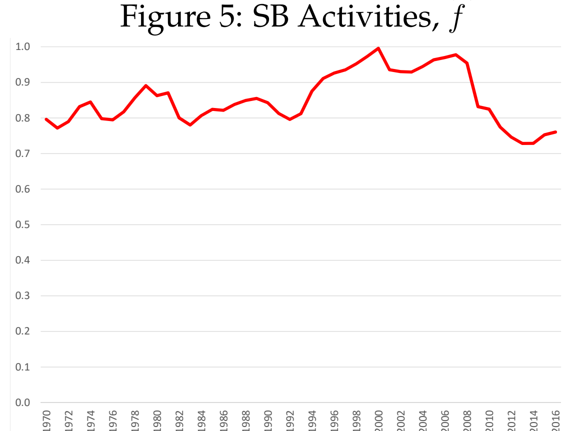


Figure 5: SB Activities, $\widehat{f}$



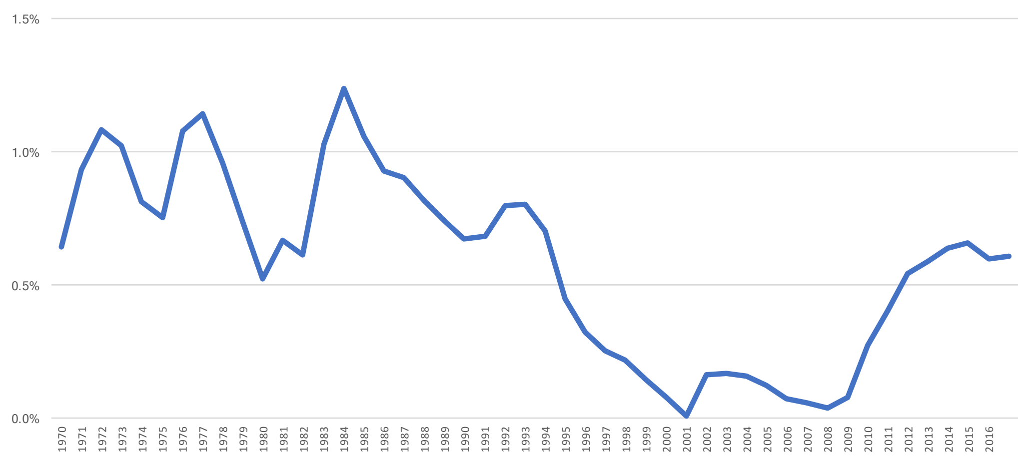
Why did spreads decline in the last decades? Have financial intermediaries improved either their management efficiency or their asset liquidation value? Philippon (2015) performs a thorough calculation of the changes in efficiency of the financial sector in the U.S. during the last century using data on value added. He shows that the technology in the financial intermediation industry exhibits constant returns to scale and $\widehat{\phi}$ has been constant at roughly 2% for more than 100 years.[19]

This result implies that the liquidity premium accounts for most of the observed variation in the risk-adjusted spread. To see this, we define the liquidity premium as

$$\text{Liquidity premium} = (1 - f)(r_e - r_L)$$

This is the difference between the realized spread and the spread if liquidity were not an issue. Figure 6 shows the evolution of this premium during since 1970, which declined from around 1% to almost 0% by 2007. After the recent financial crisis, the liquidity premium of intermediation increased again to almost 0.5%. The pattern in Figure 6 is

Figure 6: Liquidity Premium



surprisingly similar to the pattern documented by Del Negro et al. (2017b) and Corbae and D'Erasmo (2018) in the same timeframe, using very different methodologies. Further, Del Negro et al. (2017a) point to the relevant role played by securitized banks as liquidity providers in increasing the convenience yield and the decline in U.S. natural interest rates.

In short, the three decades before the recent crisis was characterized by a large drop in

[19]Philippon (2015) performs two alternative calculations: one assuming that the composition of the types of loans offered by the financial sector was stable during the sample period and another adjusting for changes in the quality of the loans. When computing the per-unit value added, Philippon (2015) explicitly, and correctly, discards the use of intermediation spreads as measures of value added. As we show in equation (7), intermediation spreads are affected by other factors that, even though not reflect physical costs, deeply affect the cost of financial intermediation.

the financial intermediation spread, almost exclusively led by a reduction in the financial sector's "liquidity premium." Securitization has had a direct impact by improving the assets' tradability, replacing less profitable government bonds on banks' balance sheets by more productive loans, and then improving investment and output.

4 Quantitative Assessment of the Model

To decompose the direct macroeconomic effects of an increase in life expectancy and its indirect effect through transforming the financial system towards more securitization and lower intermediation costs, we first calibrate the economy to replicate the main aggregates for financial intermediation in 1980. Then, we obtain the model's output for 2007 keeping most of the parametrization as in 1980 and we only change the newly observed life expectancy and intermediation costs. We also analyze what would have happened if the United States had to face the demographic transition while forbidding the use of securitization.

4.1 Calibration for 1980

We calibrate the model to yearly data. There are some parameters that are standard in the literature: i) the discount factor $\beta = 0.9975$, ii) capital share $\theta = 0.33$ consistent with a capital income share of output equal to 33%, iii) labor productivity growth, $\gamma = 0.02$ and iv) population growth, $\eta = 0.01$.[20]

In our economy capital includes physical assets other than productive capital that constitute wealth for households, such as housing and land. Including these assets capital-output ratio is about 3.4, which is generated by a depreciation rate of $\delta_k = 0.0271$. Regarding the agents' lifecycle, we assume that they enter the labor force at age 23, retire at age 63 (this is, $T = 40$) and, based on the Survey of Consumer Finances, receive inheritance at age 52 (this is, $T_I = 29$).Regarding μ (the fraction of agents with $\alpha = 0$ who choose to save in banks), we discipline it with the fraction of agents directly participating in capital markets. We measure it with the fraction of financial assets held in corporate and non-corporate equity from the Flow of Funds (the first panel of Figure 1),

[20]The calibrated β parameter is larger than standard values in the literature. The reason is that, for tractability, we have fixed the coefficient of relative risk aversion parameter to 1 (log preferences) and then the discount factor must capture how agents assess, when entering the labor force, the risk of death after retirement. Most of the discounting comes from the probability of death, which is absent in most macroeconomic models. See a related discussion in Krueger and Kubler (2005).

which has been roughly constant in the U.S. at around 28% since the eighties. Accordingly, we calibrate $\mu = 0.72$ such that $1 - \mu = 0.28$. As for the parameters that determine fiscal policies, according to NIPA government spending is 20% of GDP (this is, $g = 0.20$) and in 1980 government debt (federal, state and local) was around 40% of GDP. Since we model a closed economy and around 20% of the government debt was held by foreign investors, we set $D^G/Y = 0.33$.

Finally, two parameters remain to be calibrated: i) the bequest motive, $\widehat{\alpha}$, and ii) the fraction of the last wage that the government transfers as Social Security after retirement, ss_i. Since there is no direct counterpart of these parameters, we normalize $ss_C = 0$ (no social security for investors in capital markets) and choose ss_B and $\widehat{\alpha}$ to replicate two moments in the data: i) government debt to GDP ratio of 0.33 in 1980 and ii) household debt to GDP ratio of 1 in 1980. This implies $\widehat{\alpha} = 4.64$ and $ss_B = 0.55$. To assess the validity of these parameters notice that: i) $\widehat{\alpha}$ of around 4.6 generates in the model a level of savings consistent with the findings from De Nardi, French, and Jones (2015) and ii) ss_B of 55% of the last wage implies a ratio of Social Security of 34% of the average wage, which is consistent with information from the Social Security Administration.[21]

The two counterfactual parameters that we will modify between 1980 and 2007 are: i) the survival probability after retirement, δ, which captures life expectancy and ii) the spread between borrowing and lending, ϕ, which captures the role of securitization in reducing intermediation costs. We start by calibrating $\delta = 0.072$ for 1980 (which implies a life expectancy of 13.9 years after retirement, as in 1980) and decrease it in the counterfactual to $\delta = 0.052$ (which implies a life expectancy of 19.23 years after retirement, as in 2007).Based on Section 3, we calibrate $\phi = 0.04$ for 1980 and decrease it in the counterfactual to $\phi = 0.03$, as computed in 2007.

4.2 Decomposing the Roles of Aging and Securitization

We now perform a counterfactual exercise, decomposing the effects of the change of life expectancy (aging) and the change in intermediation costs (securitization) on asset accumulation, output and welfare, from 1980 to 2007, before the crisis.

What parameters do we use for the counterfactual on 2007? Most parameters have not changed, but some have. First, the population growth rate fell to 0.7% in 2011, so we set $\eta = 0.007$ for 2007. Second, we maintain a government debt of 33% as a ratio of GDP in

[21] Monthly average payments per retired beneficiary were around $1,250 per month in 2015. Given an average annual wage of $57,000 in 2014, this implies a ratio of 27%. This is lower than the ratio generated by the model, but does not include Medicare and Medicaid.

2007. Even though the ratio increased to 62%, around 45% of U.S. federal debt was held by non-U.S. residents, and then the provision of government bonds was not relevant domestically.[22] Third, as in the data, we maintain the replacement ratio (that is, the proportion of wages obtained from the government after retirement) and allow labor taxes to adjust in order to satisfy the government budget constraint. In the Appendix we provide a robustness alternative, keeping the labor tax constant and allowing the government debt to change.

In Table 1, the first column shows the calibration results for 1980. The last column introduces a counterfactual in which life expectancy increases (captured by a reduction in δ from 0.072 to 0.052) and agents move bank's savings from traditional to securitized banks. Because of Proposition 1, there are two levels of utility costs to sign a contract with securitization, $0 < \underline{\kappa} < \bar{\kappa}$ such that if $\kappa \in [\underline{\kappa}, \bar{\kappa}]$, it is optimal for agents to choose traditional banks when $\delta = 0.072$ and securitized banks when $\delta = 0.052$. Due to the move from traditional to securitized banks, the intermediation spread falls from $\phi = 0.04$ to $\phi = 0.03$, as we observe in the data and the model in Section 3.

Comparing the first and last columns the model generates a large increase in the output steady-state level (of around 7%), an increase in the capital to output ratio (from 3.4 to 3.9) and a large increase in households' total financial assets (from 1.33 to 1.94 of GDP). Even though the data counterparts of the first two figures are difficult to observe, we obtain a proxy for the households' total financial assets from the Flow of Funds, which grew from 1.36 of GDP to 2.33 of GDP, very close to the model's prediction.[23] Finally, the model's prediction of the change in the amount intermediated, measured by the household debt to GDP ratio, accounts for more than 90% of the observed change (the model generates 1.62 compared to 1.66 in the data).

Now we can decompose the effects of the aging and securitization by suppressing one at a time. The second column of Table 1 shows the counterfactual *without securitization*. We compute the model with life expectancy increasing in the same magnitude as observed in the data, but assuming that $\kappa > \bar{\kappa}$, so that the migration toward securitization does not happen and, spreads remain at 1980 levels. In this case the increase in the capital to output ratio and steady state output would have been around 50% of the total increase with securitization, the capital to output ratio would have increased from 3.4 to 3.65 instead of to 3.9, while output would have increased from 1 to 1.035

[22] See http://www.treasury.gov/resource-center/data-chart-center/tic/Pages/ticsec2.aspx.

[23] We use Table L100 to measure the increase of households' financial assets. Subtracting from the total domestic non-financial assets (Line 1, Table L100) the corporate equity (Line 16, Table L100) and the equity on non-corporate businesses (Line 23, Table L100), we obtain these figures.

Table 1: Counterfactual to 2007 (Fixed D^G)

Economy	1980 Benchmark	Larger δ $\kappa > \bar{\kappa}$	Same δ $\kappa < \underline{\kappa}$	δ & ϕ change $\kappa \in [\underline{\kappa}, \bar{\kappa}]$
Interm. Cost (ϕ)	4%	4%	3%	3%
Survival prob. (δ)	0.072	0.052	0.072	0.052
Interest Rates				
Borrowing Rate (r)	0.030	0.023	0.034	0.028
Lending Rate (r_e)	0.070	0.063	0.064	0.058
National Accounts				
Output	1.00	1.035	1.031	1.070
Capital to output ratio	3.40	3.65	3.62	3.90
Net Worth				
Total	3.73	3.98	3.95	4.23
Equity (Plan C)	2.40	2.68	2.08	2.28
Bank Debt (Plan B)	1.33	1.30	1.86	1.94
Data (FF: Table L100)	*1.36*			*2.33*
Bequest/Y	0.049	0.049	0.040	0.039
Government Debt/Y	0.33	0.33	0.33	0.33
Household Debt/Y	1.00	0.96	1.53	1.62
Data (FF: Table D3)	*1.00*			*1.66*
Change in welfare at birth	-	-	0.3%	0.4%
Plan C	-	-	-4.3%	-4.8%
Plan B	-	-	2.5%	2.8%

instead of to 1.07. Also, absent securitization we would have not observed any change in the financial households' net worth (roughly constant at 1.3), nor in household debt over GDP (roughly constant at 1). Finally, aging without securitization would have increased the demand for savings without an increase in supply, generating a reduction in savings returns (r declines from 3% to 2.3%) but still generating more funds channeled to investment opportunities, so equity return declines (r_e declines from 7% to 6.3%).

Finally, the third column of Table 1 is a thought experiment *without aging*, where we assume that κ falls below the lower bound $\underline{\kappa}$, still inducing a movement towards securitization. With securitization but no aging, the increase in capital to output ratio and steady state output would have been between 40% and 50% of the total increase with higher retirement needs, the capital to output ratio would have increased from 3.4 to

3.62 instead of to 3.9, while output would have increased from 1 to 1.031 instead of to 1.07. That is, securitization without an increase in the demand of savings would have generated a permanent increase in GDP of almost 3% instead of 7%. We would have observed, however, a large increase in households' financial net worth in terms of GDP (from 1.33 to 1.86 instead of to 1.94) and household debt over GDP (from 1 to 1.53 instead of to 1.62), almost accounting for the full observed change. Finally, securitization without aging would have increased the supply of savings without an increase in the demand for savings, inducing an increase in savings returns (r increases from 3% to 3.4%) but since more funds are channeled to investments, the equity return still declines (r_e declines from 7% to 6.4%).

When there are changes to "preferences" (in our case life expectancy), welfare comparisons are hard to interpret, but we can make comparisons using consumption equivalent changes when fixing δ. We compute the welfare effects of securitization by comparing columns 1 and 3 (when $\delta = 0.072$) and columns 2 and 4 (when the economy has a higher life expectancy, with $\delta = 0.052$). In the first case we observe a net increase in welfare of 0.3%. This increase, however, is not without redistribution consequences. While B-agents (who represent almost 70% of the agents) experience a consumption equivalent increase of 2.5%, C-agents experience a drastic decrease of 4.3%. In the second case, with aging, securitization improves welfare by 30% more (from 0.3% to 0.4%), with stronger redistribution consequences.

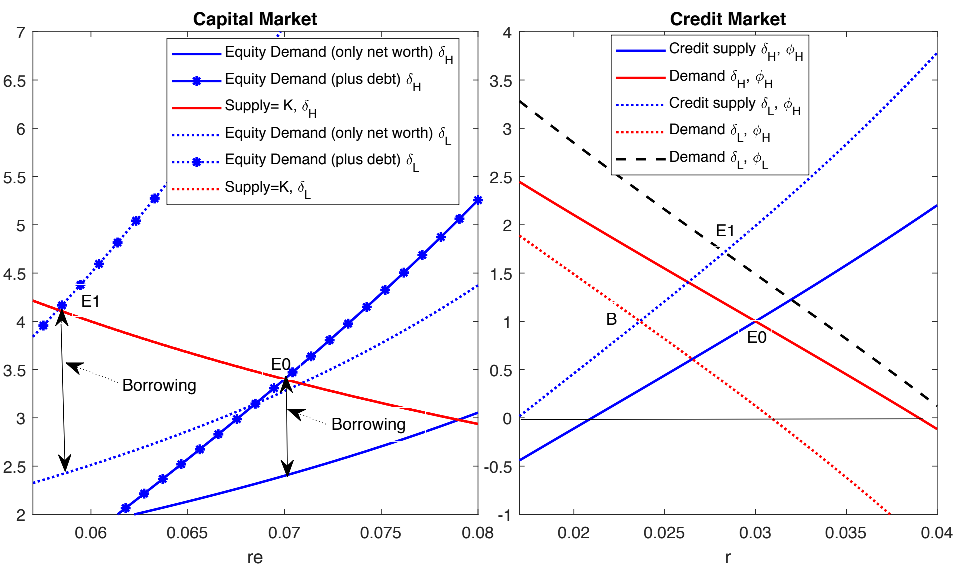
Partial equilibrium intuition of the decomposition results: To build intuition about the forces behind the previous decomposition, we show in Figure 7 the partial equilibrium effects of changes in both life expectancy and intermediation costs on interest rates, capital and credit.

In the left panel we depict the equilibrium in *capital markets*. The decreasing solid line shows the *supply of capital*, which is the level of K that technologically satisfies: $r_e = f'(K) - \delta_k$, hence independent of either demographics or financial technology. The increasing solid curve with dot markers is the *demand for capital*. This can be decomposed between: i) *direct demand with own funds* by C-agents (the net worth that agents of type C are willing to accumulate at a given interest rate r_e, given by $\mathbb{W}^C(r_e)/(1+r_e)$,) depicted as the increasing solid curve without markers, and ii) *indirect demand with borrowed funds*, which is the amount of funds that banks channel to C-agents to buy capital. This second component, is determined by the operation of banks, which we denote next as the credit market.

In the right panel of Figure 7 we depict the equilibrium in *credit markets*. The *credit* *supply*, depicted by the increasing solid blue function, is given by the net worth that B-agents accumulate at an interest rate r, not held in government bonds (that is, $\mathbb{W}^B(r)/(1+r) - D^G(r)$). The solid decreasing red curve, $\Upsilon(r+\phi) \equiv K(r+\phi) - \mathbb{W}^C(r+\phi)/(1+r+\phi)$, is the *credit demand* to buy capital, which cannot be bought by C-agents with their own funds. As is clear, both markets are interlinked and cannot be solved separately.

The solid lines in both panels of Figure 7 are computed assuming $\delta = 0.072$, as in the first column of the 1980 benchmark, and equilibrium in both markets is represented by $E0$. In credit markets this implies a ratio of debt over GDP of 1 and $r = 0.03$. In capital markets this implies a capital to output ratio of 3.4 and a return on capital of $r_e = 0.07$. These are the results in the first column of Table 1, consistent with $\phi = r_e - r = 0.04$.

Figure 7: Partial effects



What happens in this partial equilibrium analysis when life expectancy increases? This counterfactual is shown with dotted lines. In credit markets, since B-agents expect to live longer, they accumulate more assets in banks, increasing the supply of credit in the economy. C-agents also expect to live longer and assign more of their own wages to buy stocks, reducing the demand of credit. As a result, the *new partial equilibrium* is at point B, with approximately the same amount of private debt (around 1), but with a much lower credit rate ($r = 0.022$). In capital markets, while the supply of capital is not affected (as it is just a technological function), the demand increases because C-agents save more. Intuitively, the higher general demand of savings for retirement generate an increase in both the demand and supply for credit, reducing returns and increasing capital, but not changing the total amount of credit.

The increase in credit comes because of the securitization generated by aging. A fall in ϕ does not directly affect capital markets, but it does affect the functioning of credit markets. A fall in intermediation costs reduces the cost of credit for C-agents, increasing their demand of credit. The new "partial" equilibrium is at point $E1$, with a higher intermediate interest rate r, more credit and an even higher level of capital, all of which could not be generated by just changing δ.

We emphasize the partial nature of this intuitive analysis, as changes in these two markets will feedback to each other via the quantity of capital in the economy and the accumulation of net worth. In particular, the slopes of demand and supply functions depend on general equilibrium forces. These general equilibrium effects are fully accounted for in the table, but the figure is useful to understand the underlying mechanisms and interactions between agents.

4.3 Transitions

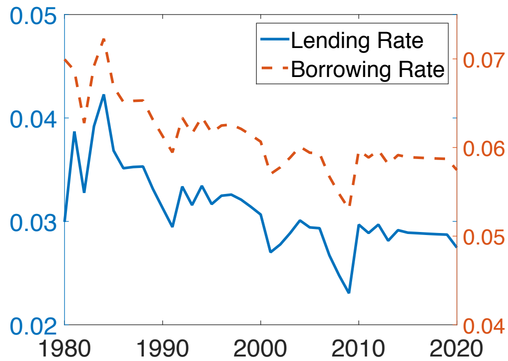
Since it can take many years for an economy to converge to a new steady state, comparing two steady states may not be the best way to assess the impact of aging in a four decade span. We show here that convergence indeed happens quite fast: by 2010 most of the increase in debt (around 90%) had already taken place. We also show that cyclical movements of productivity have played an important role in accommodating the slow growth in private debt observed during the early 80s and the subsequent speeding up during the 2000s.

The computation of the transition presents several challenges. First, as there is a distribution of agents indexed by age and assets at the time life expectancy increases, who is affected by the shock? We assume that all working-age agents experience in 1980 a decline in the survival probability to $\delta = 0.052$, while there is no change for retired agents. Second, as some agents were already involved in a banking contract, what happens with those contracts? We assume that after the shock all existing contracts are renegotiated to take into account the new survival probability.[24] Third, what happens with the government budget? We assume that lump-sum transfers remain at the same absolute value as before the shock and the government still follows a policy of maintaining the debt to output ratio constant and equal to 0.3, adjusting labor taxes correspondingly during

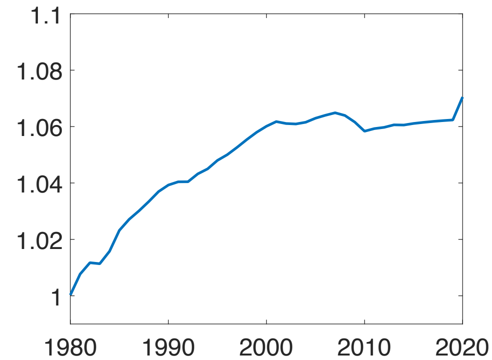
[24]Although we have assumed that in a stationary equilibrium rebalancing costs are large enough to prevent agents from switching saving strategies over their lifetime, here we assume that the discrete change in life expectancy is large enough to justify the switch.

the transition to maintain government's budget balanced. Finally, what happens with retirement payments? We assume they do not change for those already retired in 1980.[25]

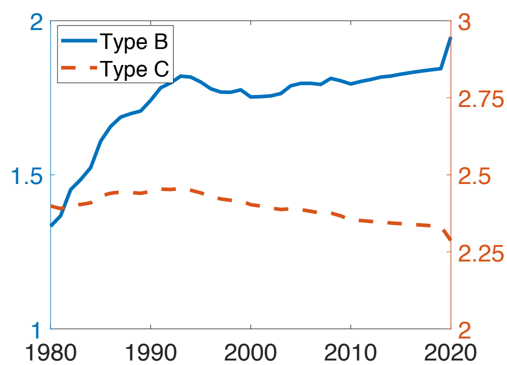
Figure 8: Transition Dynamics: Observed TFP



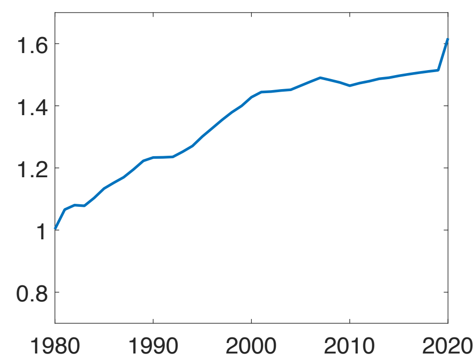
(a) Interest rate



(b) Output



(c) Assets



(d) Household Debt/Output

In Figure 8 we compute transitions using the actual path for TFP (measured by the Solow residual in the data) when both life expectancy increases and intermediation costs decline. Using actual TFP is informative as it shows how the recessions in the early 80s and early 90's slow down the convergence during the 80s, and how debt speeds up in the second half of the 90s. In panel (a), we see that the spread falls drastically on impact and then increases slowly until reaching the new steady state.[26] The increase in capital induces a continuous increase in output (panel b) and the net worth of B-agents. Interestingly, the net worth of C-agents declines (panel c) in spite of the increase

[25]These assumptions speed up transitions. Assuming, more realistically, that improvements in life expectancy are gradual over cohorts or that only newborn agents (those entering labor markets) could re-optimize their saving strategies would slow down the transition. Unless these changes happen very gradually, a large fraction of the new stationary equilibrium would still be reached after three decades.

[26]The lending rate converges non-monotonically because the capital stock is low with respect to its desired value when agents expect to live longer. Thus, the return on savings suddenly increases and then slowly converges to the new lower level as capital increases.

in capital because of the increase in leverage (panel d). For convenience, in the panels we show the new steady state in the last period (in 2020) to get a sense of how complete the convergence is 40 years after the changes.

Remark on the growth of securitization: Since our counterfactuals just compare scenarios with and without securitization, we are not required to discipline κ. It is outside the scope of this paper to introduce a distribution of κ across agents (capturing, for instance, heterogeneity on the ability to face a crisis or heterogeneity on search and informational costs required to operate with securities) such that agents gradually move from traditional to securitized banking along the transition, as observed in the data. The speed at which securitization is adapted would discipline a distribution of κ.[27]

5 On the Costs and Benefits of Securitization

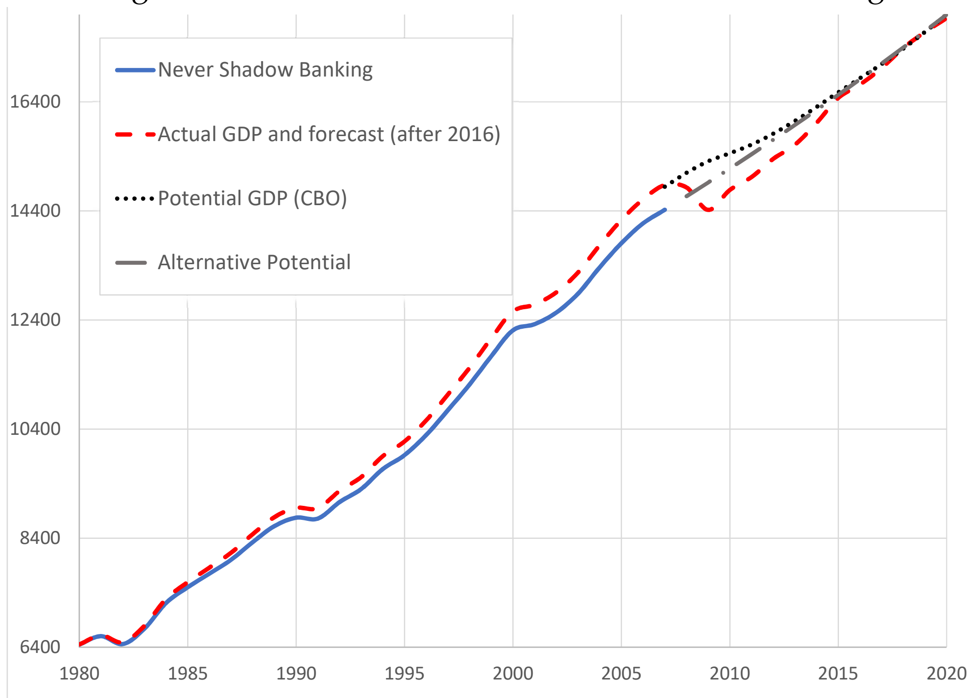
Our goal to understand the rise and benefits of securitization led us to abstract from its potential cost in terms of a potential crisis. The 2008 crisis, however, is a reminder of how large these costs can be. To put the gains from securitization in context, we compare them with the cost of crisis cost obtained by Luttrell, Atkinson, and Rosenblum (2013), and later expanded by Ball (2014) and Fernald (2014), by comparing the realized output with the potential output computed by the Congressional Budget Office (CBO). This work implies that the crisis generated a loss, in present value, of 23% of 2007 GDP. In Figure 9, this number comes from the difference between the dotted back line (potential GDP computed by the CBO) and the dashed red line (realized output) after 2007.

If securitization was the single responsible of the crisis, was it worth it? Was its contribution large enough to compensate its cost? A quick answer is provided by Table 1. Securitization generates a permanent increase in output level equivalent to 2.8% per year in the stationary equilibrium ($1.062 - 1.034$, according to the second and fourth columns of Table 1), a present value of around 3.3GDP of 2007. This is, however, misleading. First, it assumes securitization is permanent and does not generate crises. Second, it overestimates the gains during the transition.

For a more meaningful comparison of the benefits and cost of securitization surrounding the recent crisis, we compute a benchmark economy without securities, without the gains from lower intermediation costs, but without the cost of a crisis either. Formally, we assume a counterfactual in which aging individuals do not adopt securities, and

[27] A distribution of α would also induce a gradual adoption of securitization given a single κ.

Figure 9: The Costs and Benefits of Securitized Banking



spreads remain at the 1980 level of 4%. This counterfactual is the blue solid line of Figure 9 until 2007 and the dashed-dotted grey line after 2007. While the economy gains before 2007, it loses afterwards. The present value of the gap between the benchmark and the realized output from 1980 to 2007 represents 59% of 2007 GDP. The gap between the benchmark and the realized output from 2007 to 2020 represents 13.5% of 2007 GDP. Assuming that securitization solely generated the crisis, the comparison between these two numbers still delivers a net gain from securitization of 45% of 2007 GDP.[28]

6 Conclusions

The recent discussion, both in academic and policy circles, about the demand for safe assets and its macroeconomic effects has focused on the "savings glut" from foreign countries. Simultaneously, the discussion about securitization and other recent financial innovations that supply safe assets has focused on their pervasive role on triggering painful crises. In this paper we argue that these two discussions are intimately related.

[28]Our estimated cost of securitization is lower than the estimated cost of 23% of 2007 GDP that is based on the CBO estimated potential output. The reason is that the initial level of the CBO potential output is the realized output before the crisis, which is misleading as it ignores that output was high at the onset of the crisis because securitization was instrumental in increasing output, confusing the ex-post cost of securitization with its ex-ante value.

While the higher *foreign demand* for safe assets seems to have been accommodated by an increase in government debt, the higher *domestic demand* for safe assets triggered by an increase in life expectancy has pushed an endogenous increase in the supply of safe assets by the private sector, more specifically using securitization. We have explored quantitatively the direct macroeconomic effects of aging, and the indirect effects through inducing financial changes.

Our quantitative analysis allows us to decompose the direct effect of aging from the indirect effect through financial changes. Without securitization the economy would not have experience a credit boom, with capital-output ratio and output increasing only by half of what they did. Our approach allows us also to compute a counterfactual without securitization. The gains from operating with securities from 1980 to 2007 were in the order of 60% of 2007 GDP, more than compensating the cost of 14% of 2007 GDP from the crisis in case we want to assign such event completely to securitization.

These results are relevant to the recent policy discussion about regulating the banking system. Although restricting the use of securitization and other financial innovations may have benefits in terms of reducing the likelihood and magnitude of financial crises, we show that it is also costly in terms of choking-off output. Even though our quantitative estimations are based on a streamlined model, they can be taken as a "proof of concept" that the involved magnitudes are likely to be sizable. Furthermore, even if securitization were to blamed for crises, by increasing borrowing rates in equilibrium, financial innovations give more room to the monetary authority to deal with the effects of those crises by warding the economy off the zero lower bound.

The results are also relevant for policy discussions about the optimality of pension systems, particularly in their relations with financial systems. We have focused on the United States, a country that has promoted private pension saving as a way to fund retirement benefits, but several other countries finance retirement largely by taxing current workers, in so-called pay-as-you- go ("PAYGO") pensions.[29] As long as PAYGO discourage participation in equity markets and reduce capital accumulation (as documented by Scharfstein (2018)), they maintain rates relatively high conditional on longevity. Our paper suggests that this effect may relax the appetite for yields and the pressure for the rise of securitization, possibly having benefits in terms of financial stability that compensate the loses in terms of capital accumulation.

Finally, there are extensions, outside the scope of this paper, that could provide useful insights. First, in recent decades most countries have experienced an increase in life ex-

[29]Scharfstein (2018) provides a comprehensive description of pension systems across countries.

pectancy, which implies that the higher demand of savings for retirement needs is likely a global phenomena. If only some countries, such as the U.S., master the technology of (or is regulatory allowed to use) securitization, the U.S. financial system may benefit other countries while accumulating systemic risk locally. This would call for policies that coordinate the use of securitization across countries. Second, there has also been a reduction in fertility rates, which may have implications for the anatomy of future financial intermediation, since the cost of financial innovation also depends in the relative size of overlapping cohorts. We leave these interesting extensions for future research.

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Appendix

A Proof of Proposition 2:

We first characterize the best banking strategy in a steady state for a general interest rate r. This problem solves:

$$\max_{\{c_j,b_j\}}\left\{\sum_{j=0}^{T}\beta^j\log c_j+\sum_{j=T+1}^{\infty}\beta^j(1-\delta)^{j-T-1}[(1-\delta)\log c_j+\delta\alpha\log b_j\right\}$$

$$s.t.\sum_{j=0}^{T}\frac{c_j}{(1+r)^j}+\sum_{j=T+1}^{\infty}\frac{c_j(1-\delta)^{j-T}}{(1+r)^j}+\sum_{j=T+1}^{\infty}\frac{b_j(1-\delta)^{j-T-1}\delta}{(1+r)^j}\le v_0^B$$

Notice that the price of an annuity payment at age j is $P_j=\frac{1}{(1+r)^j}$ if the agent is alive at age $j\le T$, $P_j=\frac{(1-\delta)^{j-T}}{(1+r)^j}$ if the agent is alive at age $j>T$ and $P_j=\frac{(1-\delta)^{j-T-1}\delta}{(1+r)^j}$ if the agent dies at age $j>T$. Thus, prices are present discounted values of the probabilities of each potential event contingent on age (and only on age).

The first order conditions for this problem generate:

$$c_{j+1}=\beta(1+r)c_j;\quad\forall j$$

$$b_j=\alpha c_j;\quad\forall j>T$$

These two equations imply:

$$c_j=\beta^j(1+r)^jc_0;\qquad\forall j$$

$$b_j=\alpha\beta^j(1+r)^jc_0;\quad\forall j>T$$

Replacing the last two in the budget constraint we can find c_0, by solving:

$$\sum_{j=0}^{T}\frac{\beta^j(1+r)^jc_0}{(1+r)^j}+\sum_{j=T+1}^{\infty}\frac{\beta^j(1+r)^jc_0(1-\delta)^{j-T}}{(1+r)^j}+\sum_{j=T+1}^{\infty}\frac{\alpha\beta^j(1+r)^jc_0(1-\delta)^{j-T-1}\delta}{(1+r)^j}=v_0^B$$

Which gives as $c_0=\bar{c}(\delta)v_0^B$, and then all consumptions are proportional to initial wealth, where

$$\bar{c}(\delta)=\frac{1-\beta}{1-\beta^T+(1-\beta)\beta^T\theta_B(\delta)}.\tag{13}$$

We can simplify the characterization by splitting the problem in two parts: before and after retirement, which is useful in Lemma 2 where agents following strategy S change their pattern of consumption after retirement.

We guess and verify that the maximum utility after T can be written in recursive way as $\phi_B + \theta_B \log(w_T^B)$. For this to be true, the coefficients ϕ_B and θ_B must satisfy:

$$\phi_B + \theta_B \log(w) = \log(c) + \beta(1-\delta)[\phi_B + \theta_B \log(w')] + \beta\delta\alpha \log(b')$$

The problem after retirement solves:

$$\max_{c,w',b'} \{\log(c) + \beta(1-\delta)[\phi_B + \theta_B \log(w')] + \beta\delta\alpha \log(b')\}$$
$$s.t. \quad c + \frac{1-\delta}{1+r} w' + \frac{\delta}{1+r} b' \leq w$$

which generates the first order conditions

$$w' = \beta(1+r)\theta_B c$$

$$b' = \beta(1+r)\alpha c$$

Substituting these in in the budget constraint we get that ,

$$c\,[1 + (1-\delta)\beta\theta_B + \delta\beta\alpha] = w \tag{14}$$

Now we guess that $c = \frac{w}{\theta_B}$ and verify it for

$$\theta_B(\delta) = \frac{1 + \beta\alpha\delta}{1 - \beta(1-\delta)},$$

confirming that the solutions are proportional to wealth.

Based on this solution, the maximum utility in steady state as a function of δ attainable by an agent who follows a banking strategy (B) that pays an interest r_s, where $s \in \{SB, TB\}$ is the indicator for whether the interest rate corresponds to securitized or traditional banking respectively, such that $r_{SB} > r_{TB}$, as shown in Proposition 1, can be expressed as:

$$U_B(\delta, r_s) = \sum_{j=0}^{T-1} \beta^j \log(c_j^B) + \beta^T [\phi_B + \theta_B \log(w_T^B)]$$

where

$$\begin{aligned}
\theta_B(\delta) &= \frac{1 + \beta\alpha\delta}{1 - \beta(1-\delta)} \\
\phi_B(\delta, r_s) &= \frac{(\theta_B(\delta) - 1)\log(\beta(1+r_s)) - \log(\theta_B(\delta)) + \beta\alpha\delta[\log(\alpha) - \log(\theta_B(\delta))]}{1 - \beta(1-\delta)} \\
c_j^B(\delta, r_s) &= \bar{c}(\delta)\beta^j(1+r_s)^j v_0^B \\
w_T^B(\delta, r_s) &= \theta_B(\delta)\bar{c}(\delta)\beta^T(1+r_s)^T v_0^B
\end{aligned}$$

where $\bar{c}$ is defined in equation (13) and v_0^B in equation (2).

Define $\Delta_B(\delta) = [U_B(\delta, r_{SB}) - \kappa] - U_B(\delta, r_{TB})$. Lemma 1 below shows that, as long as α is not too high, $\frac{\partial \Delta_B(\delta)}{\partial \delta} < 0$, i.e., the utility difference of participating in securitized banking is increasing in life expectancy (decreasing in δ) for all $\delta > 0$.

Lemma 1 *If* $\alpha < \frac{1}{1-\beta}$ *then* $\frac{\partial \Delta_B(\delta)}{\partial \delta} < 0, \quad \forall \delta > 0.$

Proof Using the property of logarithmic functions,

$$\Delta_B(\delta) = \sum_{j=0}^{T-1} \beta^j \log\left[\frac{(1+r_{SB})^j}{(1+r_{TB})^j}\right] + \beta^T \left[\phi_B(\delta, r_{SB}) - \phi_B(\delta, r_{TB}) + \theta_B(\delta)\log\left(\frac{w_T^B(r_{SB})}{w_T^B(r_{TB})}\right)\right] - \kappa$$

where $\phi_B(\delta, r_{SB}) - \phi_B(\delta, r_{TB}) = \widehat{\theta}_B(\delta)\log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)$, defining

$$\widehat{\theta}_B(\delta) = \frac{\beta(1+\delta(\alpha-1))}{[1-\beta(1-\delta)]^2}.$$

Then, we can rewrite the new benefit of securitized banking as

$$\Delta_B(\delta) = \sum_{j=0}^{T-1} \beta^j \log\left[\frac{1+r_{SB}}{1+r_{TB}}\right]^j + \beta^T \log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)\left[\widehat{\theta}_B(\delta) + \theta_B(\delta)\log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)^{T-1}\right] - \kappa$$

Taking derivatives with respect to δ,

$$\frac{\partial \Delta_B(\delta)}{\partial \delta} = \beta^T \log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)\left[\frac{\partial \widehat{\theta}_B(\delta)}{\partial \delta} + \frac{\partial \theta_B(\delta)}{\partial \delta}\log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)^{T-1}\right]$$

where

$$\frac{\partial \widehat{\theta}_B(\delta)}{\partial \delta} = \frac{\beta[(\alpha-1)(1-\beta(1+\delta)) - 2\beta]}{[1-\beta(1-\delta)]^3}$$

and

$$\frac{\partial \theta_B(\delta)}{\partial \delta} = \frac{\beta[\alpha(1-\beta)-1]}{[1-\beta(1-\delta)]^2}.$$

Notice that $\frac{\partial \widehat{\theta}_B(\delta)}{\partial \delta} < 0$ if and only if $\alpha < \frac{(1-\beta\delta)+\beta}{(1-\beta\delta)-\beta}$ and $\frac{\partial \theta_B(\delta)}{\partial \delta} < 0$ if and only if $\alpha < \frac{1}{1-\beta}$. Since the first condition is always satisfied when the second condition is satisfied, then the sufficient condition for $\frac{\partial \Delta_B(\delta)}{\partial \delta}$ is that $\alpha < \frac{1}{1-\beta}$.

Notice that the conditions for an interior δ^* are $\Delta_B(0) > 0$, this is

$$\kappa < \sum_{j=0}^{T-1} \beta^j \log\left[\frac{1+r_{SB}}{1+r_{TB}}\right]^j + \beta^T \log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)\left[\frac{\beta}{(1-\beta)^2} + \frac{1}{1-\beta}\log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)^{T-1}\right]$$

and $\Delta_B(1) < 0$, this is

$$\kappa > \sum_{j=0}^{T-1} \beta^j \log \left[\frac{1+r_{SB}}{1+r_{TB}}\right]^j + \beta^T \log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)\left[\beta\alpha + (1+\beta\alpha)\log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)^{T-1}\right]$$

which is feasible when $1-\alpha(1-\beta) > 0$, or $\alpha < \frac{1}{1-\beta}$. Q.E.D.

Since $U_B(\delta, r_{SB}) - U_B(\delta, r_{TB})$ is independent of κ and $\Delta_B(\delta)$ is just linear in κ it is straightforward from Lemma 1 that, given κ there is a single $\delta^* \in (0,1)$ such that $\Delta_B(\delta^*) = 0$, where $\delta^* = 0$ if $\Delta_B(0) < 0$ and $\delta^* = 1$ if $\Delta_B(1) > 0$. Furthermore, δ^* weakly decreases in κ (strictly except at the corners, where κ is so high that $\delta^* = 0$ or so low that $\delta^* = 1$).

Finally, computing $\frac{\partial\Delta(\delta)}{\partial\alpha}$ it is easy to see that

$$\frac{\partial\Delta_B(\delta)}{\partial\alpha} = \beta^T \log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)\left[\frac{\partial\widehat{\theta}_B(\delta)}{\partial\alpha} + \frac{\partial\theta_B(\delta)}{\partial\alpha}\log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)^{T-1}\right] > 0.$$

This derivative is positive because $\frac{\partial\widehat{\theta}_B(\delta)}{\partial\alpha} = \frac{\beta\delta}{[1-\beta(1-\delta)]^2} > 0$ and $\frac{\partial\theta_B(\delta)}{\partial\alpha} = \frac{\beta\delta}{1-\beta(1-\delta)} > 0$. This implies that, fixing δ and κ, δ^* is weakly increasing in α (strictly increasing except at the corners). QED.

B An interpretation of κ:

Even though we have introduced the cost κ on securitized banking in a reduced form way, here we show that we can write

$$\kappa = -\beta^T \frac{p\log(\zeta)}{1-\beta(1-\delta)} > 0$$

where $p < 1$ is the defined as the yearly probability that the bank cannot pay as promised, in which case the agent just consumes a fraction $\zeta < 1$ of the promised consumption. Notice that we assume that securitization can enter into a crisis ($p > 0$), while traditional banking cannot (see Gorton and Ordonez (2014), for microfoundations of such a crisis due to information opacity and lack of government explicit support). Thus κ can be interpreted as the net cost of securitized banking. Furthermore, the lower the recovery in case of a crisis (lower ζ), the higher the cost.

This expression comes from extending the recursive formulation of the utility conditional on retirement as

$$\begin{aligned}\phi_B + \theta_B\log(w) &= [(1-p)\log(c) + p\log(\zeta c)] + \beta(1-\delta)[\phi_B + \theta_B\log(w')] + \beta\delta\alpha\log(b') \\ &= [\log(c) + \beta(1-\delta)[\phi_B + \theta_B\log(w')] + \beta\delta\alpha\log(b')] + p\log(\zeta)\end{aligned}$$

which adds a constant compared to the previous specification without crises (this is, with $p = 0$ or $\zeta = 1$). As this does not affect the first order conditions, $\theta_B(\delta)$ remains unchanged, but the constant term is affected as

$$\phi_B(\delta, r_s, p, \zeta) = \phi_B(\delta, r_s) + \frac{p \log(\zeta)}{1 - \beta(1-\delta)}$$

and then $\phi_B(\delta, r_{SB}, p, \zeta) - \phi_B(\delta, r_{TB}) = \widehat{\theta}_B(\delta) \log\left(\frac{1+r_{SB}}{1+r_{TB}}\right) + \frac{p\log(\zeta)}{1-\beta(1-\delta)}$.

Therefore, we can rewrite the benefit of securitized banking as

$$\Delta_B(\delta) = \sum_{j=0}^{T-1} \beta^j \log\left[\frac{1+r_{SB}}{1+r_{TB}}\right]^j + \beta^T \log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)\left[\widehat{\theta}_B(\delta) + \theta_B(\delta)\log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)^{T-1}\right] - \underbrace{\left[-\beta^T \frac{p\log(\zeta)}{1-\beta(1-\delta)}\right]}_{\kappa}$$

The rest of the analysis follows, with the only exception that κ in this case also depend on δ (as δ declines the cost of securitized banking also increases). However, the adjusted condition for an interior δ^* are $\Delta_B(0) > 0$, this is

$$-\beta^T p\log(\zeta) < (1-\beta)\left[\sum_{j=0}^{T-1} \beta^j \log\left[\frac{1+r_{SB}}{1+r_{TB}}\right]^j + \beta^T \log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)\left[\frac{\beta}{(1-\beta)^2} + \frac{1}{1-\beta}\log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)^{T-1}\right]\right]$$

and $\Delta_B(1) < 0$, this is

$$-\beta^T p\log(\zeta) > \sum_{j=0}^{T-1} \beta^j \log\left[\frac{1+r_{SB}}{1+r_{TB}}\right]^j + \beta^T \log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)\left[\beta\alpha + (1+\beta\alpha)\log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)^{T-1}\right]$$

which is feasible when $\alpha \underbrace{\left(1 + \log\left(\frac{1+r_{SB}}{1+r_{TB}}\right)^{T-1}\right)}_{>1} < \frac{1}{1-\beta} - \underbrace{\frac{\sum_{j=0}^{T-1} \beta^j \log\left[\frac{1+r_{SB}}{1+r_{TB}}\right]^j}{\beta^T \log\left[\frac{1+r_{SB}}{1+r_{TB}}\right]}}_{>0}$.

This condition is more stringent than with the reduced form κ, but the insight is the same, as δ^* is well defined when agents have relatively low bequest motives, who are the agents who self-select into banking contracts. Also, because in our calibration $\alpha = 0$ and β is close to 1, the condition is satisfied in the quantitative exercise.

C Proof of Proposition 3:

Take a steady state with prices (r, r_e, y_0), tax rate τ, and inheritance $\bar{b}$ to any measure zero individual. Let $U_B(\alpha)$ and $U_C(\alpha)$ represent the maximum attainable utility of an agent of measure zero in this economy who follows strategy B (banking) or C (capital markets) respectively as a function of α. Define $\Delta(\alpha) = U_C(\alpha) - U_B(\alpha)$. Lemma 2 below shows that, as long as δ is not too small, $\frac{\partial\Delta(\alpha)}{\partial\alpha} > 0$, i.e., the utility difference is increasing in the bequest motive, for all $\alpha \geq 0$.

Lemma 2 *If* $\frac{1+r_e}{1+r} > \beta \left[\frac{1-\beta(1-\delta)}{\beta\delta}\right]^{1-\beta(1-\delta)}$ *then* $\frac{\partial\Delta(\alpha)}{\partial\alpha} \geq 0, \quad \forall\alpha > 0.$

Proof The maximum utility as a function of α attainable by an agent who follows a banking strategy (B), taking as given the parameters of the economy, can be expressed as:

$$U_B(\alpha) = \sum_{j=0}^{T-1} \beta^j \log(c_j^B) + \beta^T[\phi_B(\alpha) + \theta_B(\alpha)\log(w_T^B)]$$

where

$$\begin{aligned}
\theta_B(\alpha) &= \frac{1+\beta\alpha\delta}{1-\beta(1-\delta)} \\
\phi_B(\alpha) &= \frac{(\theta_B(\alpha)-1)\log(\beta(1+r)) - \log(\theta_B(\alpha)) + \beta\alpha\delta[\log(\alpha) - \log(\theta_B(\alpha))]}{1-\beta(1-\delta)} \\
c_j^B &= \bar{c}(\alpha)\beta^j(1+r)^j v_0^B \\
w_T^B &= \theta_B(\alpha)\bar{c}(\alpha)\beta^T(1+r)^T v_0^B
\end{aligned}$$

where $\bar{c}(\alpha) = \frac{1-\beta}{1-\beta^T+(1-\beta)\beta^T\theta_B(\alpha)}$ and v_0^B is defined in equation (2).

Similarly, the maximum utility as a type α who saves in capital markets (C) is

$$U_C(\alpha) = \sum_{j=0}^{T-1} \beta^j \log(c_j^C) + \beta^T[\phi_C(\alpha) + \theta_C(\alpha)\log(w_T^C)]$$

where

$$\begin{aligned}
\theta_C(\alpha) &= \frac{1+\beta\alpha\delta}{1-\beta(1-\delta)} \\
\phi_C(\alpha) &= \frac{(\theta_C(\alpha)-1)\log(1+r_e) + (\theta_C(\alpha)-1)\log(\theta_C(\alpha)-1) - \theta_C(\alpha)\log(\theta_C(\alpha))}{1-\beta(1-\delta)} \\
c_j^C &= \bar{c}(\alpha)\beta^j(1+r_e)^j v_0^C \\
w_T^C &= \theta_C(\alpha)\bar{c}(\alpha)\beta^T(1+r_e)^T v_0^C
\end{aligned}$$

Since $\theta_C(\alpha) = \theta_B(\alpha) = \theta(\alpha)$, using the properties of the logarithm function:

$$\Delta(\alpha) = \sum_{j=0}^{T-1} \beta^j \log\left[\frac{(1+r_e)^j v_0^C}{(1+r)^j v_0^B}\right] + \beta^T\left[\phi_C(\alpha) - \phi_B(\alpha) + \theta(\alpha)\log\left(\frac{w_T^C}{w_T^B}\right)\right] \tag{15}$$

Because the first term is independent of α it follows that

$$\frac{\partial \Delta(\alpha)}{\partial \alpha} = \beta^T \frac{\partial(\phi_C(\alpha) - \phi_B(\alpha))}{\partial \alpha} + \beta^T \theta'(\alpha) \log\left(\frac{w_T^C}{w_T^B}\right) \tag{16}$$

where $\theta'(\alpha) = \frac{\beta\delta}{1-\beta(1-\delta)}$ which does not depend on α.

$$\frac{w_T^C}{w_T^B} = \frac{(1+r_e)^T v_0^C}{(1+r)^T v_0^b} = \frac{\sum_{j=0}^{T-1} \frac{(1-\tau)y_0(1+\gamma)^j}{(1+r_e)^{j-T}} + \frac{\bar{b}}{(1+r_e)^{T_I-T}}}{\sum_{j=0}^{T-1} \frac{(1-\tau)y_0(1+\gamma)^j}{(1+r)^{j-T}} + \frac{\bar{b}}{(1+r)^{T_I-T}}} > 1$$

since $r_e > r$, $j < T$ and $T > T_I$. This implies the second term in (16) is positive, i.e., $\beta^T \theta'(\alpha) \log(\frac{w_T^C}{w_T^B}) > 0$

To prove $\frac{\partial \Delta(\alpha)}{\partial \alpha} > 0$, we proceed in three steps showing that:

a) $\lim_{\alpha \to 0} \frac{\partial \Delta(\alpha)}{\partial \alpha} > 0$;

b) $\frac{\partial^2 \Delta(\alpha)}{\partial \alpha^2} < 0$;

c) $\lim_{\alpha \to +\infty} \frac{\partial \Delta(\alpha)}{\partial \alpha} > 0$

Simple algebra yields

$$\frac{\partial(\phi_C(\alpha) - \phi_B(\alpha))}{\partial \alpha} = \frac{\theta'(\alpha)}{1-\beta(1-\delta)} \left[\log\left(\frac{(1+r_e)}{(1+r)\beta}\right) + \log\left(\frac{\theta(\alpha)-1}{\alpha}\right) - \beta(1-\delta)\log(\frac{\theta(\alpha)}{\alpha})\right] \tag{17}$$

From (17) it is readily seen that $\lim_{\alpha \to 0} \frac{\partial(\phi_C(\alpha) - \phi_B(\alpha))}{\partial \alpha} \to +\infty$. This follows since the last term tends to $+\infty$ and all the other terms are bounded. This coupled with the fact that $\beta^T \theta'(\alpha) \log(\frac{w_T^C}{w_T^B}) > 0$ proves that $\lim_{\alpha \to 0} \frac{\partial \Delta(\alpha)}{\partial \alpha} > 0$.

The second derivative $\frac{\partial^2 \Delta(\alpha)}{\partial \alpha^2} < 0$ is negative by direct differentiation,

$$\frac{\partial^2 \Delta(\alpha)}{\partial \alpha^2} = \frac{-\beta^{T+1}\delta(1-\delta)}{\alpha(1-\beta(1-\delta))(1+(\alpha-1)\delta)(1+\alpha\beta\delta)} < 0$$

since the denominator is always positive and the numerator is negative.

Finally it can be shown that $\lim_{\alpha \to \infty} \frac{\partial \Delta(\alpha)}{\partial \alpha} > 0$ under the condition stated in the theorem. Notice that (taking the limit of (17) when $\alpha \to \infty$) equation (16) is positive if and only if

$$\frac{1}{1-\beta(1-\delta)} \log\left(\frac{(1+r_e)}{(1+r)\beta}\right) + \log(\theta'(\alpha)) + \log\left[\frac{(1+r_e)^T v_0^C}{(1+r)^T v_0^B}\right]$$

The last term in the above expression has already been shown to be positive. Thus a sufficient condition for this inequality is

$$\frac{1}{1-\beta(1-\delta)}\log\left(\frac{(1+r_e)}{(1+r)\beta}\right)+\log\left(\frac{\beta\delta}{1-\beta(1-\delta)}\right)>0$$

This inequality can be written as

$$\frac{1+r_e}{1+r}>\beta\left[\frac{1-\beta(1-\delta)}{\beta\delta}\right]^{1-\beta(1-\delta)}$$

Since a), b), and c) are satisfied, it follows that $\frac{\partial\Delta(\alpha)}{\partial\alpha}>0, \forall\alpha\geq 0.$ Q.E.D.

On the one extreme, if $r_e=r$, insurance is free and all agents would prefer to follow strategy B. Thus, $\Delta(\alpha)<0, \forall\alpha\geq 0$. On the other extreme, as $r_e-r\rightarrow+\infty$, the returns from self-insurance are so large that $\Delta(\alpha)>0\ \forall\alpha\geq 0$. Because $\Delta(\alpha,\phi)$ is continuous in ϕ it follows that there exist $\underline{\phi}$ and $\bar{\phi}$ with $\underline{\phi}<\bar{\phi}$ such that there is a unique $\alpha^*(\delta)$ for which $\Delta(\alpha^*)=0$. Then the Lemma 2 that we prove below delivers the existence and uniqueness of the threshold $\alpha^*(\delta)$. QED

Online Appendix

Robustness: Flexible Government Debt:

In the main text quantitive analysis, we have maintained D^G fixed. In Table 2 below we consider alternative scenarios, with changing D^G. The first column just replicates the calibration in Table 1, while the second column replicates the counterfactual for 2007 when allowing both retirement needs and intermediation costs to vary (the last column of Table 1). The third column shows what the equilibrium would have been if life expectancy had increased, the spread had decreased to 3% and the government were allowed to freely choose the level of debt without changing taxes. In this case, the government would have chosen a similar level of tax-debt combination, which is due to the similar expenses due to the social Security System. As a consequence, in this scenario the main variables would have remained very similar to just fixing debt to the 1980 level.

By changing the government debt to GDP ratio, we can also shed light on what would have happened in the U.S. without an international saving glut contemporaneous with the domestic savings glut. Justiniano et al. (2013 and 2015) relate the credit boom experienced before the crisis to the international savings glut, claiming the fall in interest rates and between a fourth and a third of the higher U.S. household debt can be attributed to the influx of foreign funds. The last column assumes that the debt to GDP ratio moves from 0.33 (as in 1980) to 0.62, the domestic supply of government bonds in 2007 if foreign nations were not holding any U.S. Treasuries.

The direct effect of more government debt is an increase in interest rates, r, by 20 basis points. This result is consistent with half the estimate of the elasticity of U.S. Treasury yields to U.S. government debt provided by Krishnamurthy and Vissing-Jorgensen (2012) (they estimate that doubling U.S. government debt roughly increases Treasury interest rates by 40 basis points).[30] This change in interest rates induces a decline in private credit (household debt to GDP ratio) with respect to the case in which there is no global savings glut, to 1.49GDP instead of 1.62GDP. This result implies that the international demand for U.S. Treasuries would account for around 21% of the generated increased in the credit boom. This number is very close to the interval provided by Justiniano, Primiceri, and Tambalotti (2013) for the contribution of the international savings glut to the credit boom in the 2000s. However, in our setup the channel is different. There is no *direct* supply of foreign funds (lenders) generating incentives that stimulate households borrowing. Instead, the foreign demand for U.S. Treasuries crowds out the domestic demand for safe assets.

[30] In our setting, the spread ϕ remains constant as we do not model the convenience yield of government bonds.

Table 2: Counterfactual to 2007 (alternative D^G)

Economy	1980 Benchmark	2007 Calibration	Free D^G	All D^G Domestic
Interm. Cost (ϕ)	4%	3%	3%	3%
Survival prob. (δ)	0.072	0.052	0.052	0.052
Interest Rates				
Borrowing Rate (r)	0.030	0.028	0.027	0.029
Lending Rate (r_e)	0.070	0.058	0.057	0.059
National Accounts				
Output	1.00	1.070	1.071	1.060
Capital to output ratio	3.40	3.90	3.91	3.85
Net Worth				
Total	3.73	4.23	4.21	4.47
Equity (Plan C)	2.40	2.28	2.28	2.36
Debt (Plan B)	1.33	1.94	1.93	2.11
Data (FF: Table L100)	*1.36*	*2.33*		
Bequest/Y	0.049	0.039	0.039	0.041
Government Debt/Y	0.33	0.33	0.30	0.62
Household Debt/Y	1.00	1.62	1.63	1.49
Data (FF: Table D3)	*1.00*	*1.66*		

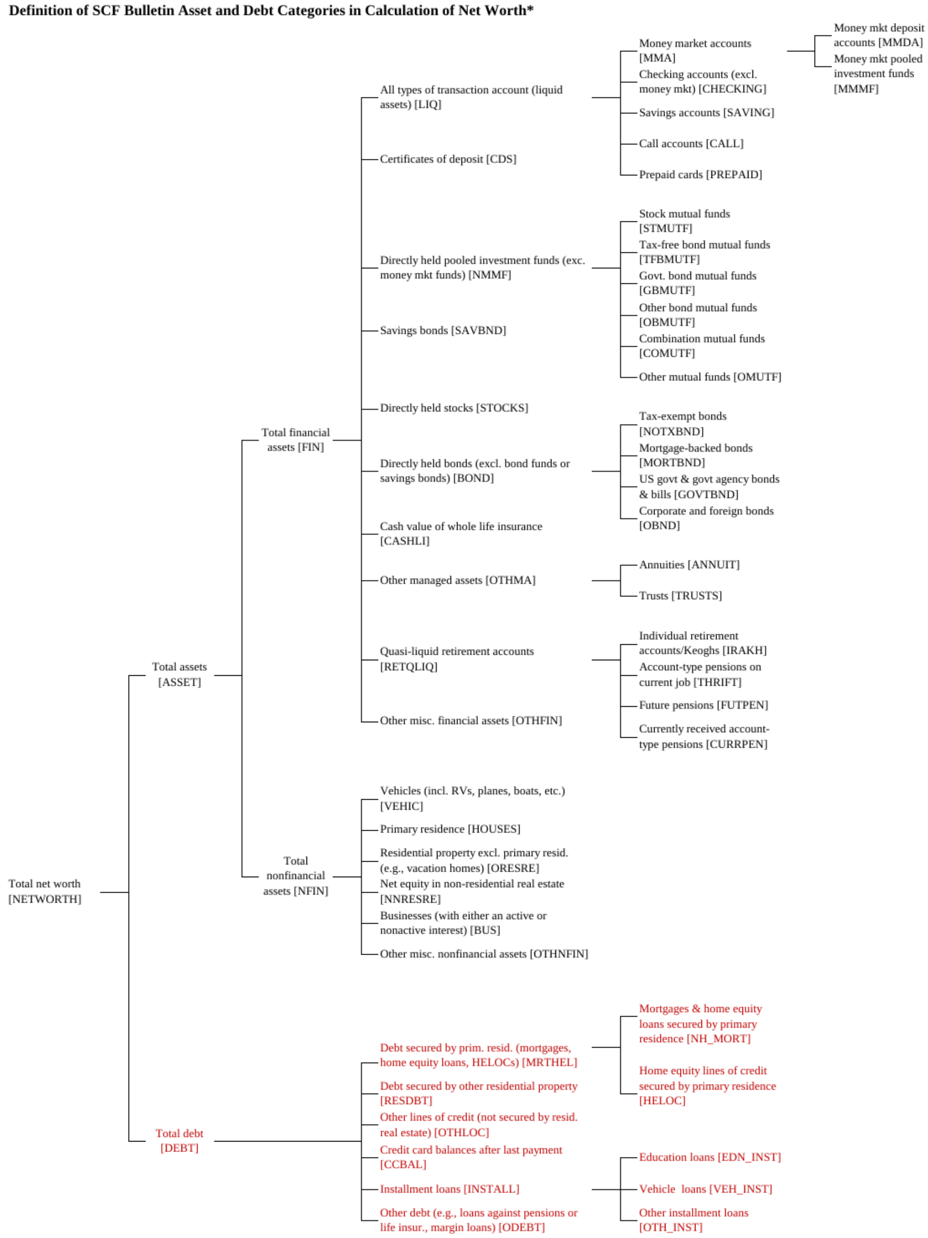
In summary, without a foreign savings glut, the U.S. economy would have experienced a smaller increase in capital-output ratio and in output (on the order of 15% lower steady state output), as there would have been a larger supply of safe assets that forced an increase in the return on capital and less investment.

Evidence on the Life Cycle Evolution of Wealth for Different Savings Portfolio Strategies

The Survey of Consumer Finances (SCF) is conducted by the Federal Reserve Bank (FRB) interviewing around 6000 households about their financial holdings, once every three years starting from 1989. Our goal is to track the evolution of net worth over the life cycle of individuals who save in an *equity portfolio* (type C in our model) and for individuals who save in a *non-equity portfolio* (type B in our model). More specifically, we will keep track of the ratio *NetWorth/WageIncome* for different ages, using the definition of Net-Worth (NETWORTH) as in the accompanying flowchart and of the variable

WAGEINC as constructed by the SCF using yearly wages.[31]

Definition of SCF Bulletin Asset and Debt Categories in Calculation of Net Worth*



*Names in brackets refer to variables in the SCF Bulletin extract data
For precise variable definitions, please see the documentation and programs on the SCF website.

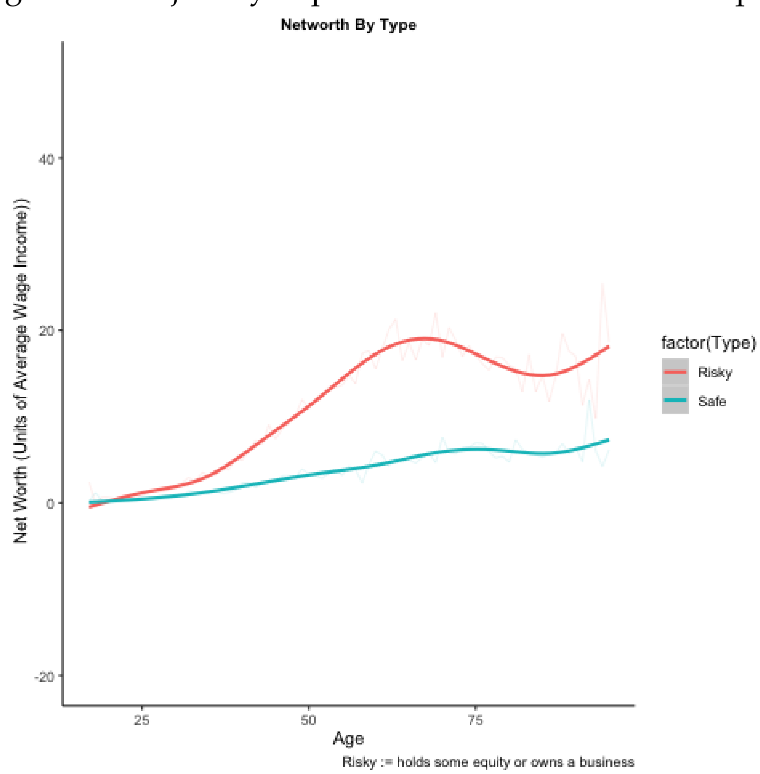
[31]For further detail about the wage income variable, see the definition in Variable Definition Macro, which may be supplemented by the full questioner appearing in SCF Code Book 2016.

We then divide households in two groups, according to the importance of equity holdings in their portfolio, defining the variable *Equity/Assets*, with Equity = STOCK+ BUS + OTHNFIN and Assets = ASSET according to the flowchart. Note that equity includes both stock holdings (financial) as well as private equity in non-financial assets (BUS includes business ownership and OTHNFIN other investments). Consistently, total assets includes both financial and non-financial assets.

Based on this ratio, we define equity-portfolio (or *risky portfolios*) as those who hold some equity and non-equity-portfolio (or *safe portfolios*) as those who do not hold any equity. To perform this division we approximate for the networth of each type in each age group and each year. Let $(X, A, Y), X \in \{"Equity", "Non-equity"\}, A, Y \in \mathbb{Z}_+$ be a vector defining a group of individuals of type X, aged A, which were surveyed in year Y. We then define the net worth and wage for each group (X, A, Y) weighted by the weights provided by the SCF.[32]

Using all surveys, the life cycle trajectory of wealth for risky and safe portfolio strategies is shown in Figure 10.

Figure 10: Trajectory of portfolios with and without equity

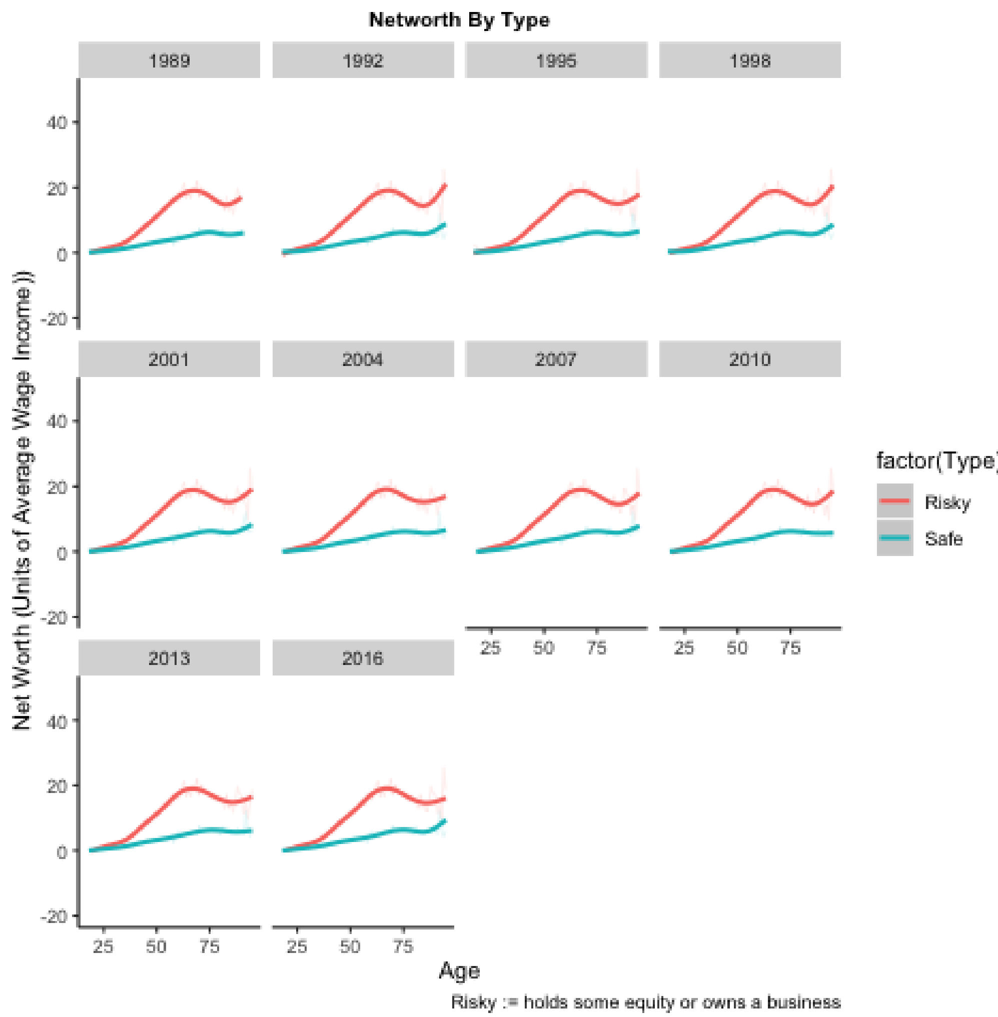


Note that, as predicted by our model, households who hold equity on their portfolio see a larger increase in net-worth until retirement, followed by a decline after retirement.

[32]For each household, five different observations are generated using multiple imputations (MI) to fill in unanswered questions. To adjust the variance to the use of MI, the Federal Reserve Bank provides replicate weights, which are the ones we use.

In contrast, households who do not hold equity experience a more timid increase in wealth, but not decline after retirement, providing evidence of a sorts of annuity effect on such portfolio strategy. The observed increase in networth after the age of 83 may be due to a survival bias, this is, households who are alive and capable of taking the survey after 83 may be, on average, wealthier. In the next section we show this is indeed the case by controlling by wealth levels. This pattern is robust on all individual survey years, as shown in Figure 11.

Figure 11: Trajectory of portfolios with and without equity per survey



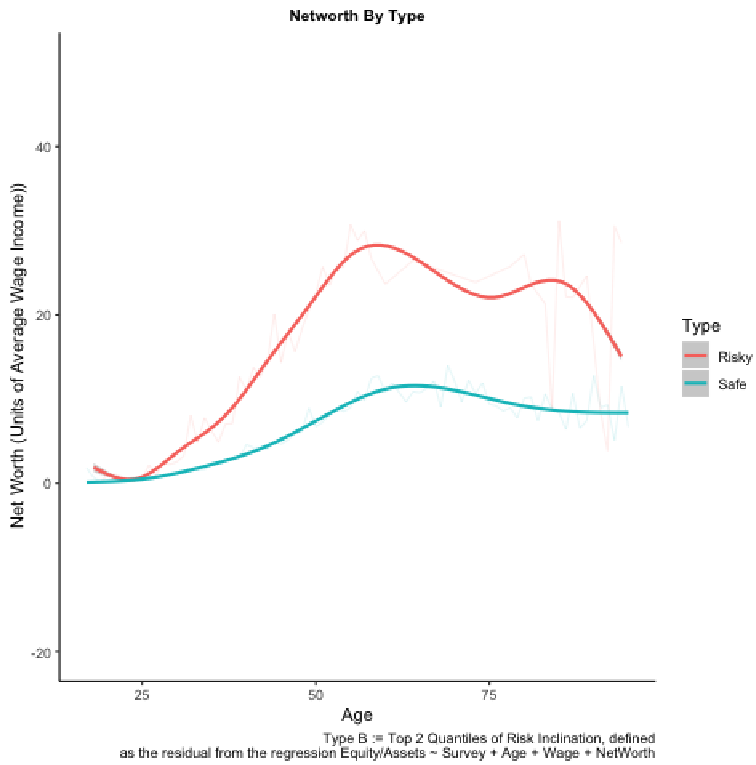
A Robustness Check Controlling for Wealth

Last, we control for a correlation between wealth level and the inclination to hold equity. We begin by taking out all households that have zero assets. Then, we run the following regression on the remaining sample:

$$\frac{Equity}{Assets} = \beta_0 + \beta_1 * AGE + \beta_2 * WAGEINC + \beta_3 * NETWORTH$$

The residual from the regression captures unobservables that induce individuals to hold equity, over and above what would have been predicted given his/hers other characteristics. We define equity-portfolio (*risky households*) in this case as those in the top 2 quantiles of this residual and *safe portfolios* the rest. The remaining parts of the analysis remain the same. Figure 12 shows the trajectory of wealth per age of these two types for all surveys combined.

Figure 12: Trajectory of portfolios with and without equity controlling for wealth



Again, we find that equity-portfolio individuals display a hump shaped trajectory of wealth accumulation, while those without equity display lower growth of wealth but a smoother trajectory. The main difference of redefining equity holders in this particular way is among individuals older than age 83, which reinforces the view that the increase in wealth after 83 in the benchmark exercise is indeed likely the result of a survival bias, which is controlled in this robustness check.