# Cash-flow Tranching and the Macroeconomy*

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**Abstract**

The volume of cash-flow transformation activities has grown markedly over the past few decades as a result of technological improvements, regulatory arbitrage, and increased appetite for safe assets, among other factors. We develop a dynamic model where the effects of changes in the costs and benefits of security creation activities can be characterized. Reduced tranching costs and increases in foreign appetite for safe assets can both create large increases in the volume of costly security creation with positive effects on GDP and wages, but they have otherwise very different macroeconomic implications. Reductions in tranching costs counterfactually cause yields to rise, implying that household welfare rises significantly more than output. In contrast, increased foreign demand for safe assets brings yields down and also causes the rents associated with cash-flow transformation to increase. These two features as well as several other subsidiary implications of increased foreign demand in our model, are consistent with recent U.S. data.

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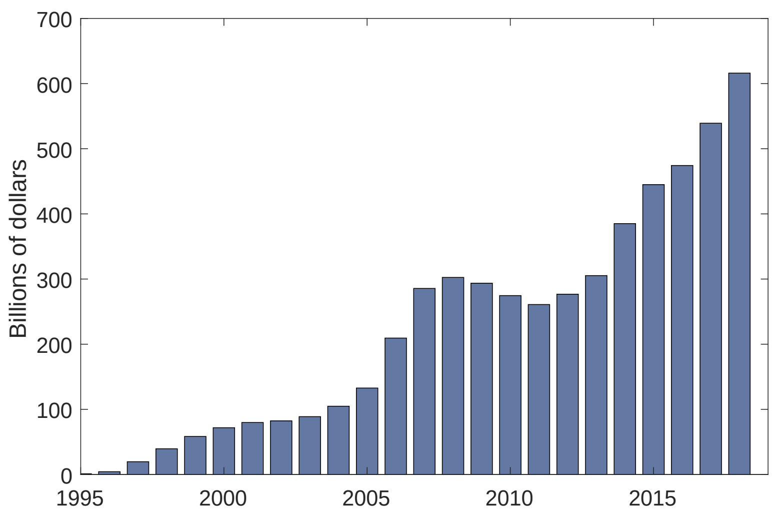
# 1 Introduction

Cash-flow tranching – by which we mean the transformation of cash-flows to create securities that cater to the needs of heterogeneous investors – has grown markedly in importance across the world over the past few decades. In the United States, for instance, cash-flows created by the business sector, such as receivables and business loans, are now routinely tranched into securities with different risk and liquidity characteristics. Figure 1 shows the recent growth in outstanding collateralized loan obligations to a point where they currently represent almost 40 percent of total outstanding asset-backed securities.[1]

Figure 1: **Outstanding U.S. Collateralized Loan Obligations**




Source: Securities Industry and Financial Markets Association

At least two concurrent phenomena have fueled the rise of tranching activities. First, technological improvements and regulatory arbitrage have made the activity cheaper.[2] Second, demand for the securities created via tranching – foreign appetite for highly rated assets, in particular – has increased. This is one of the primary manifestation of the so-called savings glut discussed for instance by Bernanke, Bertaut, DeMarco, and Kamin (2011). In this paper, we propose a simple model of

[1]This total includes other types of consumer asset-backed securities backed, for example, by auto loans, credit card debt or private student loans, but excludes mortgage-backed securities.

[2]See Allen and Gale (1994), for an early review of factors behind the boom in financial innovation over the past few decades.

cash-flow transformation by the corporate sector in which the consequences of these phenomena for macroeconomic aggregates and welfare can be gauged.

The production side of our model is standard, but on the financing side producers engage in costly security creation in the sense of Allen and Gale (1988). In contrast to traditional corporate finance models driven by tax and agency considerations (see e.g. Jermann and Quadrini (2012)), optimal security choices depend only on investors' appetite for various securities and the cost of creating different security menus. The resulting model is ideally suited to simulate the effects of changes in demand for various securities and in the cost associated with transforming cash-flows.

Simulations of calibrated versions of our model show that lowering security creation costs or increasing external demand for safe assets both cause potentially large increases in the volume of costly security creation. Furthermore, this increase in tranching activities results, in both cases, in higher levels of economic activity. Output and wages are 2% higher, on average, in stochastic steady-state, in economies in which tranching costs are negligible compared to economies where those costs are prohibitively high. Increases in external demand for safe assets can have even larger effects on economic activity.

While the output and wage consequences of reducing security creation costs and of increasing foreign appetite for safe assets are qualitatively similar, their welfare consequences are completely different, for a simple reason. A decrease in the cost of creating securities raises yields, particularly safe yields, since it causes an increase in the supply of all securities, particularly safe securities. An increase in demand for safe assets, instead, causes yields to fall (as they have in recent US data), especially safe yields. In the cost reduction experiment therefore, households benefit both because wages go up and because the greater supply of securities ends up raising their investment returns. Risk-averse agents see their welfare increase by much more than what the increase in wages alone would imply, as security creation costs drop from being prohibitively high to being negligible. Risk-neutral agents also see their welfare increase above what the wage increase alone would imply, but benefit less than risk-averse agents since the return on risky securities rises less than safe returns do.

When foreign demand for safe assets rises, households benefit once again from higher wages, but their welfare is negatively impacted by falling yields. Because the negative impact on yields is particularly strong for safe securities, the welfare impact of the saving glut is actually negative for highly risk-averse agents, while risk-neutral investors see their welfare go up, albeit by less than what the increase in wages alone would imply.

The model we use to perform our experiments contains investors (households) who are risk-neutral, as well as investors who are highly risk-averse and have a high willingness to pay for safe securities. Absent transaction costs, it would be optimal for producers to sell the safe part of the stochastic cash-flows they generate to risk-averse households and the residual claims to risk-neutral households. But splitting cash-flows in this fashion is costly. Given this cost, producers choose which securities to create taking their market value – i.e the willingness by households to pay for these securities – as given. Given the resulting security menu at each possible history, households choose a consumption policy which, in turn, pins down their willingness to pay for securities. In equilibrium, it only makes sense to sell risk-free securities to risk-averse households, and producers who do so always issue as much of it as they can. Producers who issue safe securities either retain residual cash-flows or, instead, sell them to risk-neutral households when the value of doing so exceeds the security creation cost. In other words, in our model, as in recent U.S. data, costly security creation activities result primarily in the production of safe securities backed by risky assets.

The impact of costly security creation booms on the real economy can be decomposed into two different channels. On the extensive front, falling tranching costs or greater appetite for safe securities cause some producers to enter and other producers to exit, which affects average productivity and capital formation. Second, as tranching activities increase, selling different securities to investors with different preferences lowers the opportunity cost of capital. As a result, producers tend to operate on a higher scale which boosts capital formation. We find that output gains that follow reductions in security creation costs are almost entirely driven by the intensive margin. In contrast, both the extensive and the intensive margin play a significant role in the larger output effect associated with increases in the external demand for safe assets.

Gennaioli, Shleifer, and Vishny (2013) also present a model where more demand for safe assets results in more securitization, more investment and more output when investors have rational expectations. In their model, security creation is free so that expanding financial engineering has no impact on resource use. Their main point is that when investors fail to take into account small probability events (a behavior they term neglected risk, and a violation of rational expectations), the impact of security creation booms on output becomes qualitatively ambiguous. These booms do lead to more investment and more output during expansions but, on the other hand, result in greater leverage by financial intermediaries which makes recessions more severe.

More generally, a large theoretical literature summarized by DeMarzo (2005) or Duffie and Singleton (2012) models the gains and profits associated with securitization activities as caused by asymmetric information, namely the fact that issuers have superior information about the assets whose cash-flows are transformed via tranching. As DeMarzo (2005) puts it, three potential sources of securitization gains are " transactions costs, market incompleteness, and asymmetric information." Our model focuses entirely on the first two deviations from market perfection. Further, he justifies his exclusive focus on asymmetric information by arguing that "good substitutes already exist for the debt and equity tranches" created via tranching. In contrast, our model is driven by the fact that certain assets, particularly safe assets, are available in limited supply. Under such a view, as Bernanke, Bertaut, DeMarco, and Kamin (2011) put it, "given the strength of demand for safe U.S. assets, it would have been surprising had there not been a corresponding increase in their supply." More intense information frictions or a greater ability to deal with those frictions could have contributed to the same phenomenon, but there should be little doubt that the saving glut played a primary role in the intensification of tranching activities. The vast majority of the securities created in the process are highly rated securities, as Bernanke, Bertaut, DeMarco, and Kamin (2011) document.

Our paper is also related to, although substantially different from, the growing "too-much-finance" literature that argues that the effect of financial development on growth and productivity becomes weaker, if not negative, at high levels of financial development.[3] Arcand, Berkes, and Panizza (2015), for instance, make the empirical case that once private credit reaches 100% of GDP, additional increases in private intermediation have a negative impact on growth. A common explanation for the tapering that occurs at high development levels is that once the allocative benefits of better credit markets are exhausted, the nature of financial activity expansion changes. Whereas at early stages of development credit expansion leads to the funding of new and highly productive projects, eventually financial development emphasizes security engineering activities. Based for in-

[3]See Sahay, Cihak, N'Diaye, Barajas, Pena, Bi, Gao, Kyobe, Nguyen, Saborowski, Svirydzenka, and Yousefi (2015) for a recent review of the empirical literature.

stance on the aforementioned paper by Gennaioli, Shleifer, and Vishny (2013), or classical arguments formalized by, e.g., Tobin (1984) that large financial sectors inefficiently draw skilled human capital away from the production sector, this literature makes the case that too much finance may be detrimental to growth. Our experiments confirm that increases in cash-flow transformation activities are not associated with output gains as large as those found by some papers in the traditional financial development literature (see e.g. Amaral and Quintin (2010)), and that these gains should be particularly small in economies where markets already function well. However, in our model, cash-flow transformation activities serve a fundamental purpose and while making the activity cheaper may not lead to large output gains, doing so cannot lower overall surplus.

Mendoza, Quadrini, and Ríos-Rull (2009) describe a dynamic general equilibrium model where financial integration leads countries with better functioning financial markets to borrow heavily from abroad and invest in high-return risky projects. In so doing, they propose a quantitatively promising theory for the saving glut phenomenon we take as exogenous in our external demand experiment. Financial liberalization increases demand for assets in advanced economies and puts downward pressures on yields in those countries which, in of itself, benefits borrowers but hurts savers. Our paper focuses on different financial frictions (costly security creation rather than limited enforcement), on the issuance of securities that are immune to aggregate risk rather than idiosyncratic risks, and on the impact of shocks on the demand and supply of safe securities on macroeconomic aggregates. In another related paper, Quadrini (2017) describes a model in which, like in our paper, a lower intermediation cost causes a boom in both the financial and the real sectors, changing the supply of assets that provide insurance services to households and firms, and changing the yields that affect borrowers and savers differently. Again, the financial friction of interest in this paper is limited enforcement rather than costly security creation, but the message in these papers is similar to ours: shocks that affect the supply of, and demand for, various types of securities have consequences for the real economy and, by affecting yields, have welfare consequences that can vary significantly across investor types.

## 2 The environment

We consider a discrete time, overlapping generations environment. Each period, a mass one of two-period lived households is born. Each household is endowed with a unit of labor which they deliver inelastically in the first period of their life for a competitively determined wage. There are two types of households – type $A$ (for *averse*) and type $N$ (for *neutral*) – that differ in terms of how they value consumption plans, as we will explain below. Denote the fraction of type $A$ households by $\theta$, while $1-\theta$ is the fraction of type $N$ households born each period.

The economy also contains a large mass of two-period lived producers born at each date $t$. In the first period of their life, each producer can choose to operate a project whose activation requires an investment of $e \geq 0$ units of the consumption good, as well as a commitment of operational capital at the start of the period. An active project operated by a producer of skill $z_t > 0$ yields gross output

$$y\left(k_t, n_t; z_t\right) = z_t \left(k_t^{\alpha} n_t^{1-\alpha}\right)^{\nu}$$

at the end of period $t$, where $\alpha, \nu \in (0,1)$, and $n_t$ and $k_t$ are the non-negative quantities of labor and capital employed by the project.

The skill level, $z_t$, of a particular producer is subject to aggregate uncertainty. Producers must decide whether to activate their project and what level of operational capital to commit before knowing whether aggregate conditions $\eta \in \{B, G\}$ are good ($G$) or bad ($B$). The aggregate shock follows a first-order Markov process with known transition function $T : \{B, G\} \to \{B, G\}$.

Producer types, therefore, are characterized by a pair, $z = (z_B, z_G) \in I\!R_+^2$ of skill levels. A producer of type $(z_B, z_G)$ is endowed with productivity $z_B$ during bad times and $z_G$ during good times. The mass of producers in a given Borel set $\mathcal{Z} \subset I\!R_+^2$ is $\mu(Z)$ in each period. In our upcoming numerical simulations, we specify $\mu$ so that the implied producer profits are higher, on average, in good times than in bad times, but the economy also contains producers whose profits are countercyclical.

Producers have linear preferences and can either consume at the beginning of the first period of their life or at the beginning of the second period, although they heavily discount second-period consumption. Specifically, a consumption profile for producers born at date $t$ is a non-negative triplet

$\left(c_{y,t}^P, c_{o,t+1}^P(B), c_{o,t+1}^P(G)\right)$ where $c_{y,t}^P$ is their consumption at the start of the first period of their life, while $(c_{o,t+1}^P(B), c_{o,t+1}^P(G))$ is their second-period consumption, which depends on the realization of the aggregate shock at time $t$. They rank these consumption profiles according to

$$c_{y,t}^P + \epsilon E\left(c_{o,t+1}^P(\eta)|\eta_t\right),$$

where $\epsilon$ is a small but positive number. After the aggregate shock is realized, conditional on having activated a project with capital $k_t$, and taking the wage rate $w_t$ as given, a producer of talent $z$ chooses her labor input by solving

$$\Pi(k_t, w_t; z) \equiv \max_{n>0} y\left(k_t, n; z\right) - nw_t,$$

where $\Pi$ denotes net operating income.

Active producers finance the resources they need to become active by selling securities, i.e. claims to their end-of-period output, to households. Selling one type of security is free, but selling two different types of securities carries a fixed cost $\zeta > 0$. One interpretation of this cost is that household types are physically separated from one another. Producers must decide whether to locate near one household type or near the other. Delivering payoffs to the closer type is free – this is a mere normalization – while delivering payoffs to the more distant type is costly.[4] In Appendix C, we consider a different environment where the security creation cost depends on the production scale.

As in Allen and Gale (1988), producers are small hence, when considering which securities to issue, they take as given households' willingness to pay for marginal investments in the associated payoffs. Formally, let $q_{N,t}(x_B, x_G)$ be the price at which a marginal amount of a security with payoffs $(x_B, x_G) \geq (0, 0)$ at date $t$ can be sold to type $N$ households, where payoffs may depend on aggregate conditions. Similarly, let $q_{A,t}$ be the price at which contingent securities can be sold to type $A$ households. Active producers of type $(z_B, z_G)$ choose capital, and non-negative security payoffs to maximize

$$c_{y,t}^P + \epsilon E\left(c_{o,t+1}^P(\eta)|\eta_{t-1}\right)$$

[4]Micro-foundations based on contractual frictions such as limited commitment, asymmetric information or costly verification can also justify this cost structure. We broadly think of $\zeta$ as proxying for all costs associated with selling securities in distinct markets, or managing a more complex capital structure.

subject to:

$$\begin{aligned}
c^P_{y,t} &\leq q_{A,t}\left(x_{A,t}(B), x_{A,t}(G)\right) + q_{N,t}\left(x_{N,t}(B), x_{N,t}(G)\right) - k - e - \zeta 1_{\{x_{A,t}>0, x_{N,t}>0\}}, \\
c^P_{o,t+1}(B) &\leq \Pi(k_t, w_t(B); z_B) - x_{A,t}(B) - x_{N,t}(B), \\
c^P_{o,t+1}(G) &\leq \Pi(k_t, w_t(G); z_G) - x_{A,t}(G) - x_{N,t}(G),
\end{aligned}$$

where the indicator $1_{\{x_{A,t}>0, x_{N,t})>0\}}$ takes value one when a non-zero payoff is sold to both household types. The first constraint simply says that the proceeds from selling securities must cover funding needs at the start of the period. Producers become active when that constraint can be met since in that case – and only in that case – they enjoy non-negative consumption.

A strong assumption we are making is that the distribution of potential projects, $\mu$, is exogenous. Changes to the financial environment could in principle impact innovation. For instance, agents could invest in research and development given what they expect future conditions to be. The calculations we perform in this paper abstract from this type of endogenous growth channel. But since producer participation is endogenous, changes in the financial environment do still have direct effects on aggregate productivity, as we will discuss at length in what follows.

Securities are mappings from the aggregate state to a non-negative dividend.[5] Producers engage in cash-flow transformation themselves as opposed to delegating that activity to financial intermediaries. One could easily introduce intermediaries that would pool and tranche projects on behalf of producers and distribute cash-flow realizations to households of each type. Since this does not have any impact on equilibrium allocations, we dispense with this modeling layer to simplify the exposition. One area where this choice matters is in the interpretation of producer rents. If intermediaries have the market power to pay producers the value of their outside options (here, zero), they would be the agents consuming the resulting rents. We will return to this equivalence in section 5.4.

Households take as given the set of securities available at the start of a particular period. From

[5] Allowing for negative dividends would be formally similar to allowing households to short-sell securities. As is well known, doing so can lead to non-existence, even in one-period versions of the environment we describe. See Allen and Gale (1988) for the formal version of this argument. What matters for our purposes is that the agents' ability to short sell is not unlimited.

their point of view, the menu of securities is a set of gross, conditional returns

$$R_{i,t}(z,\eta) = \frac{x_{i,t}(z,\eta)}{q_{i,t}(x_{i,t}(z,B), x_{i,t}(z,G))}$$

for the securities issued by producers of type $z = (z_B, z_G) \in I\!R^2_+$ for household type $i \in \{A, N)$ with the convention that $R_{i,t}(z) = 0$ if type $z$ is inactive.

Consider a household of type $N$ born at date $t$. They earn wage $w_t$ when young. They consume a part $c^N_{y,t}$ of those earnings and enter the second period of their life with wealth $w_t - c^N_{y,t}$. They allocate that wealth to the securities available at that time by choosing a quantity $a^N_t(z) \geq 0$ to invest in the securities produced by each producer type $z$. Investment decisions are made before uncertainty is realized in the final period of their life. At the end of that second period, they consume portfolio proceeds $\int a^N(z)R_{N,t}(z,\eta)d\mu$, where $\eta$ is the realization of the aggregate shock. Formally, given $w_t$, type $N$ households born at date $t$ solve:

$$\max_{a^N_t(z), c^N_{y,t}, c^N_{o,t+1} \geq 0} \log(c^N_{y,t}) + \beta \log \left\{ E\left(c^N_{o,t+1}(\eta)|\eta_t\right) \right\}$$

subject to:

$$\begin{aligned} c^N_{y,t} &= w_t - \int a^N_t(z)d\mu, \\ c^N_{o,t+1}(B) &= \int a^N_t(z)R_{N,t}(z,B)d\mu, \\ c^N_{o,t+1}(G) &= \int a^N_t(z)R_{N,t}(z,G)d\mu, \end{aligned}$$

where $\beta > 0$.

Given these preferences, type $N$ households consume a fixed fraction of their earnings in the first period of their life. Once they become old, they have risk-neutral preferences over the remaining consumption plans. As a result, old type $N$ agents invest all their wealth in those securities whose expected return is highest. Therefore, letting

$$\bar{R}_{N,t} = \max_z T\left(B|\eta_{t-1}\right) R_{N,t}(z,B) + T\left(G|\eta_{t-1}\right) R_{N,t}(z,G),$$

old risk-neutral agents are willing to pay:

$$q_{N,t}(x(B),x(G)) = \frac{T\left(B|\eta_{t-1}\right)x(B) + T\left(G|\eta_{t-1}\right)x(G)}{\bar{R}_{N,t}}$$

for a marginal investment in a security with payoff $(x(B),x(G))$ at date $t$.

Similarly, type $A$ agents born at date $t$ solve

$$\max_{a_t^A(z),c_{y,t}^A,c_{o,t+1}^A\geq 0} \log(c_{y,t}^A) + \beta\log\left\{\min\left\{c_{o,t+1}^A(B), c_{o,t+1}^A(G)\right\}\right\}$$

subject to:

$$\begin{aligned}
c_{y,t}^A &= w_t - \int a_t^A(z)d\mu, \\
c_{o,t+1}^A(B) &= \int a_t^A(z)R_{A,t}(z,B)d\mu, \\
c_{o,t+1}^A(G) &= \int a_t^A(z)R_{A,t}(z,G)d\mu.
\end{aligned}$$

Old agents of type $A$, in other words, try to maximize the value of worst-case scenario consumption. Their preferences are also such that they save a fixed fraction of their earnings when young.

Consider an old household of type $A$ alive at date $t$. Define

$$\bar{R}_{A,t} = \frac{\min\left\{c_{o,t}^A(B), c_{o,t}^A(G)\right\}}{a_{t-1}^A}$$

as the effective return these agents realize on their investment at the optimal solution to their problem. If $c_{o,t}^A(B) < c_{o,t}^A(G)$ at the optimal solution, their willingness to pay for a marginal investment in a security with payoffs $(x(B),x(G))$ is

$$q_{A,t}(x(B),x(G)) = \frac{x(B)}{\bar{R}_{A,t}}.$$

Indeed, they only value marginal payoffs in the lowest consumption state in that case. The symmetric property must hold when $c_{o,t}^A(B) > c_{o,t}^A(G)$. When $c_{o,t}^A(B) = c_{o,t}^A(G)$, which we will soon argue must hold in equilibrium at all dates,

$$q_{A,t}(x(B),x(G)) = \frac{\min(x(B),x(G))}{\bar{R}_{A,t}}.$$

By assuming extreme differences in the attitudes towards risk between investors and precluding short-sales entirely, we are giving cash-flow transformation activities the greatest chance to matter. This preference specification has the added advantage that, as we prove in the next section, producers engage in cash-flow transformations in order to extract as much safe claims as they can from the stochastic output they generate. This accords well with the empirical evidence discussed by Bernanke, Bertaut, DeMarco, and Kamin (2011). The recent rise of securitization in the United States has been largely motivated by the need to increase the supply of highly-rated securities.

Having stated every agent's optimization problem, we can now define an equilibrium. Old households of type $i \in \{A, N\}$ enter date 0 with wealth $a_{i,-1} > 0$. The aggregate state of the economy at date 0 is fully described by $\Theta_0 = \{a_{A,-1}, a_{N,-1}, \eta_{-1}\}$ where $\eta_{-1} \in \{B, G\}$ is the aggregate shock at date $t = -1$. Producers only produce when young hence do not accumulate resources. All active producers must therefore raise all the funds they use from old households.

An equilibrium is, for all dates and for all possible histories of aggregate shocks, a list of security payoffs $\{x_{i,t}(z,\eta_t)\}$ for each household type, producer type and aggregate shock; the associated returns $\{R_{i,t}(z,\eta_t)\}$; consumption plans and security purchases $\{c^i_{y,t}, c^i_{o,t+1}(B), c^i_{o,t+1}(G), a^i_t(z)\}$ for each household type; consumption profiles $\left(c^P_{y,t}, c^P_{o,t+1}(\eta)\right)$ for each producer type; a set $Z_t \in \mathcal{Z}$ of active producers and their corresponding capital $\{k_t(z)\}$; wage rates $\{w_t(\eta)\}$, and; payoff pricing functionals $\{q_{A,t}, q_{N,t}\}$, such that:

1. Security purchases and consumption plans solve each household's problem;

2. Security menus and consumption plans solve each producer's problem;

3. The goods market clears:

$$\begin{aligned}\int_{Z_t} y(k_t(z)_t, w_t(\eta); z)d\mu &= \theta\left(c^A_{y,t} + c^A_{o,t}\right) + (1-\theta)\left(c^N_{y,t} + c^N_{o,t}\right) + c^P_{y,t} + c^P_{y,t} \\ &+ \int_{Z_{t+1}} k_{t+1}(z) + e + \zeta 1_{\{x(z)_{A,t+1}>0, x(z)_{N,t+1}>0\}} d\mu;\end{aligned}$$

4. The market for labor clears:

$$\int_{Z_t} n^*(w_t(\eta); z) d\mu = 1 \text{ for } \eta \in \{B, G\};$$

5. The market for each security type clears, i.e., for $\mu$-almost each producer type $z$:

$$\begin{aligned} a_t^A(z) &= q_{A,t}\left(x_{A,t}(z,B), x_{A,t}(z,G)\right), \text{ and} \\ a_t^N(z) &= q_{N,t}\left(x_{N,t}(z,B), x_{N,t}(z,G)\right); \end{aligned}$$

6. Pricing functionals are consistent with the household's willingness to pay for marginal payoffs, i.e.:

   (a) $q_{N,t}(x(B), x(G)) = \frac{T(B|\eta_{t-1})x(B)+T(G|\eta_{t-1})x(G)}{\bar{R}_{N,t}}$,

   (b) $q_{A,t}(x(B), x(G)) = \frac{\min(x(B),x(G))}{\bar{R}_{A,t}}$ if $c_{o,t}^A(B) = c_{o,t}^A(G)$,

   (c) $q_{A,t}(x(B), x(G)) = \frac{x(G)}{\bar{R}_{A,t}}$ if $c_{o,t}^A(B) > c_{o,t}^A(G)$,

   (d) $q_{A,t}(x(B), x(G)) = \frac{x(B)}{\bar{R}_{A,t}}$ if $c_{o,t}^A(B) < c_{o,t}^A(G)$,

   for all possible securities $(x(B), x(G)) \geq (0, 0)$ where:

$$\bar{R}_{N,t} = \max_z T\left(B|\eta_{t-1}\right) R_{N,t}(z,B) + T\left(G|\eta_{t-1}\right) R_{N,t}(z,G),$$

   while

$$\bar{R}_{A,t} = \frac{\min\{c_{o,t}^A(B), c_{o,t}^A(G)\}}{a_{t-1}^A}.$$

The final equilibrium condition is similar to the consistency condition imposed by Allen and Gale (1988). Because type A households have Leontieff preferences, we cannot simply write, as they do, that pricing functionals are marginal rates of substitutions but the economic content of the condition is exactly the same. Producers take pricing functionals as given and choose securities to maximize their profits. Consumers, given this menu of securities, choose an optimal consumption plan which implies their marginal willingness to pay of securities. The implied pricing functionals have to coincide with the pricing functionals assumed by producers.

# 3 Properties of equilibria

The state of the economy at the start of a period is fully described by the wealth of old households, $a_{i,t-1} > 0$ for $i \in \{A, N\}$, and the most recent aggregate shock, $\eta_{t-1}$. For every possible value of these three objects we need to find producer capital policies, $k_t(z)$, pricing functionals, $(q_{A,t}, q_{N,t})$, and wage rates, $(w_t(B), w_t(G))$, for each possible state, such that all markets clear and the Allen-Gale condition (equilibrium condition 6) is satisfied. Given the state of the economy, this is a static problem which we characterize in this section. Since households simply save a fixed fraction of their wages in each period, a simple law of motion will then fully describe an equilibrium. The following result greatly simplifies the analysis.

**Lemma 1.** *In any equilibrium, the consumption of old risk-averse agents is risk-free and they only purchase risk-free securities. Furthermore, in any equilibrium, $\bar{R}_{N,t} \geq \bar{R}_{A,t}$, with a strict inequality whenever $\zeta > 0$ and a positive mass of producers issue two securities.*

The proof provided in appendix B is lengthy, but the intuition for the result is simple. Were it the case that the consumption bundle $(c_B, c_G)$ of old risk-averse agents is such that $c_B > c_G$, these agents would pay nothing for the bad-state payoff on any security, as their marginal valuation of consumption in bad times is zero. Moreover, in order for $c_B > c_G$ to hold, a positive mass of securities with higher payoffs in the bad state than in the good state must be sold to risk-averse agents. But those producers would be strictly better-off either selling the bad-state payoff to risk-neutral agents, or simply consuming it themselves. The case in which $c_B < c_G$ can be similarly ruled out.

This result also makes the simplifying role of our assumption that $\epsilon > 0$ transparent. Should $\epsilon = 0$, producers who only sell securities to risk-averse agents would be indifferent between selling excess payoffs to these agents or consuming those excess payoffs themselves. So a strictly positive – however small – $\epsilon$ serves as a tie-breaking device and simplifies our computations by guaranteeing that in all equilibria only safe securities are issued to risk-averse agents.

To ease notation in the statement of our next result, write

$$\underline{\Pi}(z) = \min \{\Pi(k(z), w(B); z_B), \Pi(k(z), w(G); z_G)\}$$

as short-hand notation for the lowest possible realization of profits for a particular active producer of type $z$ given a particular history, and denote the state where the lowest profit is realized as $\underline{\eta}(z)$. By the same token, let

$$\bar{\Pi}(z) = \max\left\{\Pi(k(z), w(B); z_B), \Pi(k(z), w(G); z_G)\right\}$$

be short-hand for the highest possible realization of profits, and $\bar{\eta}(z)$ denote the state where the highest possible profit is realized.[6] The following proposition states that the solution to the producer problem satisfies a simple bang-bang property. Producers that tranche cash flows and issue two types of securities sell as much risk-free securities as possible, as we establish in appendix B.

**Proposition 2.** *In an equilibrium where a positive mass of producers pays the security creation cost $\zeta$, either $x_A(z) = 0$ or $x_A(z) = \underline{\Pi}(z)$ for $\mu$-almost all producer types $z$.*

The proposition says that when producers choose to create some risk-free debt, they maximize the production of such debt. When is it profitable for producers to engage in costly security creation? Recall from lemma 1 that $\bar{R}_{N,t} > \bar{R}_{A,t}$, so that producers earn strictly more gross revenues by selling to both agent types rather than simply dealing with risk-neutral agents. That gain in revenue must exceed the fixed cost $\zeta$. Their expected revenue net of security creation costs is

$$\frac{T(\bar{\eta}(z)|\eta_{t-1})\left(\bar{\Pi}(z) - \underline{\Pi}(z)\right)}{\bar{R}_{N,t}} + \frac{\underline{\Pi}(z)}{\bar{R}_{A,t}} - \zeta,$$

while a producer that sells exclusively to risk-neutral agents has an expected revenue of

$$\frac{T(\bar{\eta}(z)|\eta_{t-1})\bar{\Pi}(z) + T(\underline{\eta}(z)|\eta_{t-1})\underline{\Pi}(z)}{\bar{R}_{N,t}},$$

which implies that a producer will prefer to issue two securities to just catering to risk-neutral agents when

$$\underline{\Pi}(z)\left(\frac{1}{\bar{R}_{A,t}} - \frac{1}{\bar{R}_{N,t}}\right) \geq \zeta. \tag{3.1}$$

[6] In the upcoming numerical simulations, producer profits are higher, on average, in good times than in bad times, but the economy also contains producers whose profits are counter-cyclical.

This happens when the security creation cost is sufficiently low, when the difference between the returns paid to the two types is large enough, and, importantly, when the worst possible profit is large enough. In particular, the decision between tranching cash flows or issuing risky securities exclusively does not depend on the highest possible profit $\bar{\Pi}(z)$.

Issuing two security types must also dominate issuing riskless assets only. When a producer of type $z$ only issues risk-free assets, her utility is

$$\frac{\underline{\Pi}(z)}{\bar{R}_{A,t}} + \epsilon\left(\bar{\Pi}(z) - \underline{\Pi}(z)\right).$$

Issuing both types of securities is preferable when

$$\left(\frac{T(\bar{\eta}(z)|\eta_{t-1}}{\bar{R}_{N,t}} - \epsilon\right)\left(\bar{\Pi}(z) - \underline{\Pi}(z)\right) \geq \zeta. \tag{3.2}$$

Intuitively, the producers that issue safe securities only are those whose expected profits are sufficiently similar across states.

To further clarify these properties, consider first a simple version of our environment where $\frac{z_G}{z_B}$ is $\mu$-almost surely a constant so that producers are scaled up or scaled down versions of one another. Producer types are then one-dimensional and fully summarized by $z_B$ since

$$z = (z_B, z_G) \equiv z_B \times \left(1, \frac{z_G}{z_B}\right)$$

for any type $(z_B, z_G) \in \mathbb{R}^2_{++}$. In that case, both $\underline{\Pi}(z)$ and $\left(\bar{\Pi}(z) - \underline{\Pi}(z)\right)$ are linear in $z_B$ and it follows that conditions (3.1) and (3.2) hold if, and only if, $z_B$ is large enough. In this simple case therefore, producers issue two securities rather than one if, and only if, they are talented enough, and hence large enough.

In general however, $\underline{\Pi}(z)$ and $\left(\bar{\Pi}(z) - \underline{\Pi}(z)\right)$ need not be positively correlated, much less co-linear. To illustrate the more general case, Figure 2 displays producer policies given the parameter values we will use in the upcoming simulations (see Section 5.1). These policies are drawn for a time period in which the most recent aggregate shock is $\eta = G$ and where the wealth of both households is near their average in stochastic steady-state following a good shock. The four panels correspond to different levels of the security creation cost, $\zeta$, ranging from zero to a level high enough that no costly security creation takes place.

For every level of security creation costs, there is a corresponding mass of projects that is left inactive. Because entry costs are strictly positive, these projects are unprofitable in expected value terms, regardless of the security structure used to finance them. For any given productivity level in the bad state $z_B$, there is a threshold productivity level in the good state, $\bar{z}_G(z_B)$, above which the expected profits cover the entry cost, the cost of capital, as well as any possible security creation costs and, as a consequence, the project is activated. The threshold $\bar{z}_G(z_B)$ is weakly decreasing in $z_B$: as $z_B$ falls, producers, regardless of how they finance their activities, need to be at least weakly compensated by increases in $z_G$.

When security creation costs are zero, issuing either security type in exclusivity is weakly dominated by issuing both types simultaneously, as shown in panel A of the figure. When security creation costs are strictly positive, some producers choose to issue only one type of security. This obviously includes producers who generate the same profits in both aggregates states, since necessary condition 3.2 cannot hold for those producers. Since their output is risk-free, they can simply sell risk-free securities. Those producers live along a ray that has a higher slope than the 45 degree line because wages are higher in the good state. As costs become strictly positive (starting in panel B), a mass of producers adjacent to this ray find it more profitable to issue riskless securities only – the area labeled *Safe only*. This area grows as costs increase further.

Producers who choose to engage in costly security creation have two characteristics. First, they must be productive enough, hence large enough, to justify bearing the fixed cost $\zeta$. Given returns, their worst-case scenario profit has to be large enough for condition 3.1 to hold. Second, by condition 3.2, the gap between their profits in the two states must be large enough, since otherwise they would be better off selling riskless securities only. This yields the tranching region labeled *Both* in panels A, B and C of Figure 2. On the other hand, producers whose productivities are low enough, and sufficiently skewed between the two states, find it more profitable to issue risky securities in exclusivity. This is the area labeled *Risky only*.

A simple way to summarize the cross-sectional predictions of our model is that larger and safer producers are more likely to issue safe securities. Across the various simulations we present in this paper, producers who pay the security creation costs are four to twelve times larger in employment terms than producers who do not. As documented for instance by Rauh and Sufi (2010) or Crouzet (2018), these predictions are borne out by U.S. evidence.[7] Moreover, there is in fact a high correlation between size and debt ratings, as documented, for example, by Corbae and Quintin (2016). In Compustat data for the 1985-2016 time period, nearly three-quarters of non-financial firms in the top asset percentile have an investment-grade bond rating, while fewer than 5% of firms in the bottom asset quartile do.

## 4 Comparative statics: a preview

Our primary goal in this paper is to quantify the consequences of various demand and supply shocks for the volume of costly security creation, macroeconomic aggregates, and welfare. Appendix A provides formal definitions of all macroeconomics variables of interest.

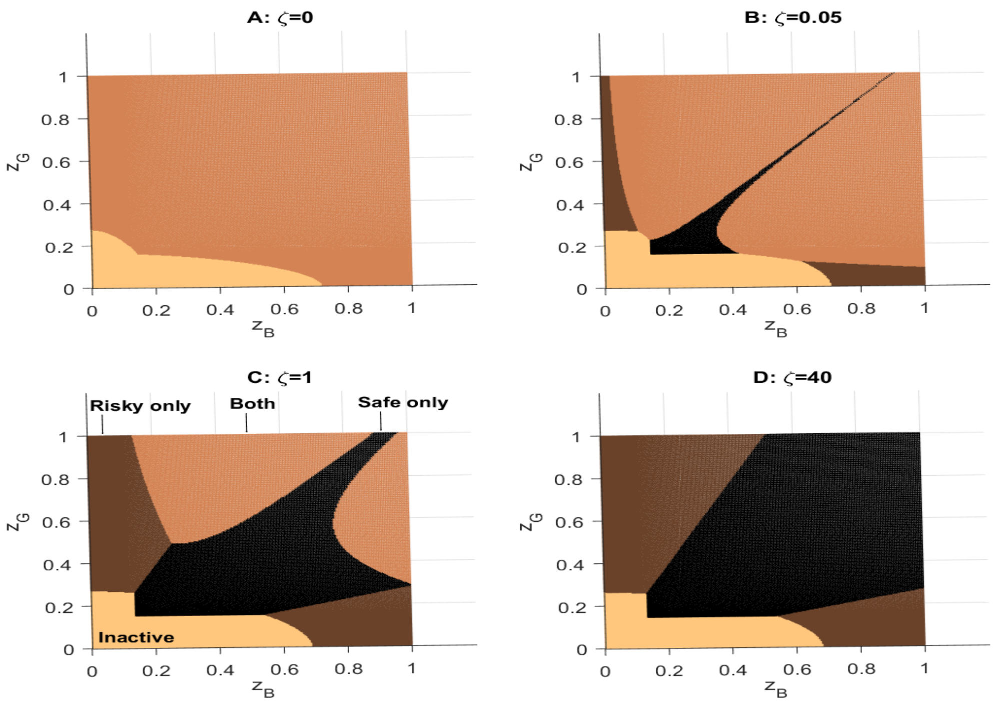
Figure 2 shows that reductions in security creation costs have two basic consequences for producer policies. First, the share of active producers changes. Some producers choose to enter while others choose to exit when security creation costs fall. Second, financial policies change as more producers choose to engage in costly security creation.

Holding prices constant, a reduction in security creation costs would cause an excess demand for labor and capital. So factor prices must rise, and some previously marginally profitable producers choose to exit as a result. This includes producers of marginal talent whose output is risk-free or close to risk-free, since they do not benefit much from the reduction in $\zeta$ but see their profits fall as prices rise. On the other hand, some producers who were inactive become profitable due to the reduction in $\zeta$. These must be producers who engage in costly security creation upon entry. Overall, the fraction of active producers may rise or fall, but the fraction of producers who engage in costly security creation is bound to increase.

On the intensive front, some producers who were active before the reduction in costs choose to remain active but change their financial policies. This is reflected in the marked reduction of the black area in figure 2 as one moves from panel D to panel A. In our simulations, those producers

[7] Crouzet (2018) presents a model where bond-financing is cheaper for firms than bank financing but cannot be restructured in the event of default. As a result, larger and safer firms are more likely to issue bonds. This also happens in our model because safe producers have no incentive to participate in the market for risky securities (their risky residual cash-flows are too small to justify the cost of participating in both markets), while small producers simply cannot cover the fixed cost of participating in two markets.

Figure 2: **Producer policies: changing security creation costs**




who change financial policies tend to increase their capital use. To understand why, take producers who, for a high enough security creation cost find it optimal to issue riskless securities exclusively. Their first-order condition with respect to capital is

$$\bar{R}_A = \frac{\partial \Pi \left(k, w(B), z_B\right)}{\partial k}.$$

In an economy with lower costs, the same producer types may find it optimal to issue both securities and, if that is the case, their first-order condition is instead given by:

$$\bar{R}_N = T(B|\eta)\frac{\partial \Pi \left(k, w(B), z_B\right)}{\partial k} + T(G|\eta)\left(\frac{\partial \Pi \left(k, w(G), z_G\right)}{\partial k} - \frac{\partial \Pi \left(k, w(B), z_B\right)}{\partial k}\right).$$

The different first-order conditions imply that, in general, the amount of capital such producers use, and consequently their output, are different when security creation costs change, even in the absence of general equilibrium effects. An analogous reasoning applies to producers that find it optimal to switch from issuing only risky securities to issuing both, as security creation costs drop. As for producers who do not find it optimal to change financing sources as costs drop, only changes in prices can potentially give rise to changes in their capital and output.

A drop in security creation costs operating through the intensive margin should result in increased output and capital formation. In contrast, the same change operating through the extensive margin does not have the same implication because, as discussed above, some producers exit and some enter. Indeed, absent the intensive margin, changes in securitization costs have non-monotonic effects on output, as we argue in section C of the Appendix. The intensive margin has a quantitatively larger effect and overwhelms this non-monotonicity in part because, unlike the extensive effect, it can help concentrate resources in the hands of more talented producers. In the next section we resort to calibrated numerical simulations to quantify the potential importance of changes in security creation costs.

The other fundamental experiment we perform in our simulations concerns the effect of exogenous increases in demand for the safe asset. Obviously, such changes also have an effect both on producer participation and on financial policies, and this effect can also be broken down in terms of the two margins we described above. A key qualitative difference between the two experiments is that this demand increase puts downward pressure on safe yields, whereas drops in $\zeta$ make it cheaper to issue safe assets and therefore cause safe yields to rise. As a result, and as we will show in detail in the next section, the two experiments have very different welfare implications.

# 5 Quantitative experiments

To investigate the consequences of costly security creation booms for macroeconomic aggregates and welfare, this section describes the effects of drops in security creation costs and of increases in external demand for safe assets both in the long-run and along the transition to a new stochastic steady-state.

## 5.1 Parameterization and algorithm

Our broad strategy for selecting parameters is to make our model's implications for the organization of production, security returns, and the size of producer rents consistent with their data counterparts in the United States when security creation costs are small. In our model economy agents live for two periods. We will think of a period as representing 25 years.

We think of a bad state as a rare, but necessarily protracted event given our period length: a disaster in the sense of Barro and Ursua (2008), who define it as a drop in output, from peak to trough, of 10% or more.[8] In their panel data, economies spend roughly 12% of time in those depressed states. Correspondingly, we set the elements of the aggregate state's transition matrix $T$ so that the model economy spends at most one period in the bad state, $T_{BB} = 0$, and the probability of remaining in the good state is set such that the model economy spends 12% of time in the bad state, implying $T_{GG} = 0.8637$.

We set the support of project productivities to $\mathcal{Z} = [0,1] \times [0,1]$, and assume that $\mu$ follows a truncated bivariate log-normal distribution with mean $\bar{z} = (\bar{z}_G, \bar{z}_B)$ and variance-covariance matrix

$$\Phi = \begin{bmatrix} (\varsigma \bar{z}_G)^2 & 0 \\ 0 & (\varsigma \bar{z}_B)^2 \end{bmatrix}$$

where $\varsigma > 0$. That is, we assume that the two skill levels are uncorrelated at the population level and normalize the two variance terms so that the coefficient of variation of skill is approximately the same in the two aggregate states.[9] We then normalize mean producer productivity in the good state to $\bar{z}_G = 0.05$.

The production function coefficients are $\nu$, regulating the share of producer rents, and $\alpha$ regulating the share of the remaining income accruing to capital. We set the latter to $\alpha = 0.4$ and calibrate the former below. We set $\epsilon = 10^{-6}$ so that ties for producers between consuming left-over output and selling it for nothing are broken in favor of the first option.

This leaves six parameters to calibrate: the productivity mean in the bad state, $\bar{z}_B$, the parameter controlling the productivity variance, $\varsigma$, the household discount factor, $\beta$, the share of risk averse agents, $\theta$, the parameter controlling entrepreneurial rents, $\nu$, and the entry cost, $e$. We choose the values for these six parameters so that, in the stochastic steady-state of our economy with zero security creation costs and on average:

[8] Since in our model, tranching activities mostly result in the creation of securities that are immune to aggregate shocks, focusing on large shocks is appropriate. Highly rated securities are securities designed and expected to withstand even extreme shocks. For instance, data provided by Moody's Investors Services show zero default on AAA-rated corporate bonds issued in the United States between 1920 and today. See e.g. Corbae and Quintin (2016).

[9] Because of the truncation the two coefficient of variations are not exactly the same.

1. Output in bad times is 17% below output in good times, which is the value we obtain for the U.S. economy from the Barro and Ursua (2008) dataset when we detrend output using an exponential trend;[10]

2. The share of employment in the 50% smallest projects is roughly 5%, as in the U.S. establishment data collected by the Census Bureau in its 2015 County Business Patterns Survey;

3. The risk-free rate is approximately 2% in yearly terms;

4. The interest rate spread $(\bar{R}_N - \bar{R}_A)$, is approximately 3.5% in yearly terms, which is the average of the spread between the ICE BofAML US Corporate B Index and Moody's seasoned AAA corporate bond yield between 1998 and 2018;

5. The ratio of producer rents to output is 10%, which matches the approximation for this moment obtained in a similar environment by Corbae and Quintin (2016) using US private corporate sector data;

6. The ratio of entry costs to output is 1%, the value the World Bank's Doing Business project reports for the cost of business start-up procedures as a fraction of GNI per capita in the U.S. in 2018.

The resulting parameter values are $\bar{z}_B = 0.063$, $\varsigma = 16$, $\beta = 0.9417$, $\theta = 0.56$, $\nu = 0.73$, and $e = 0.06$. In our sensitivity analysis, we will consider large variations in these values to gauge the robustness of our key results.

Standard arguments show that our economies eventually converge to a stochastic steady-state, i.e. an invariant distribution of all endogenous variables.[11] To obtain the relevant moments in this stochastic steady-state, we adopt a traditional Markov-chain Monte-Carlo approach. Specifically, our algorithm is as follows:

1. Given parameters, solve for household and producer policy functions for every possible aggregate state of the economy in equilibrium;

[10] We fit an exponential trend to US real GDP from 1870 to 2009 which yields an R-squared of over 98%. The 25-year time period during which GDP is farthest below trend is the 1915-1941 time period. During that period, real GDP is 17.03% below trend. Repeating the same procedure for all nations for which the fit of the exponential trend is 95% or higher, gives an average worst deviation from trend of 16.6%.

[11] See Brock and Mirman (1972).

2. Draw a 110-period sequence of aggregate shocks $\{\eta_t\}_{t=1}^{110}$ using the Markov transition matrix $T$ and record the value of all endogenous variables starting from an arbitrary value of aggregate wealth (in practice we pick a starting value close to the stochastic steady-state average);

3. After dropping the first 10 periods, so that the assumed initial conditions have at most a negligible effect on the value of endogenous variables, compute average values for all endogenous variables.

To facilitate comparisons across economies, we use the same draw of random aggregate shocks throughout our simulations. Our model features quick transitions to steady-state, and we have found that 100 periods suffice to generate stable estimates of the desired moments.

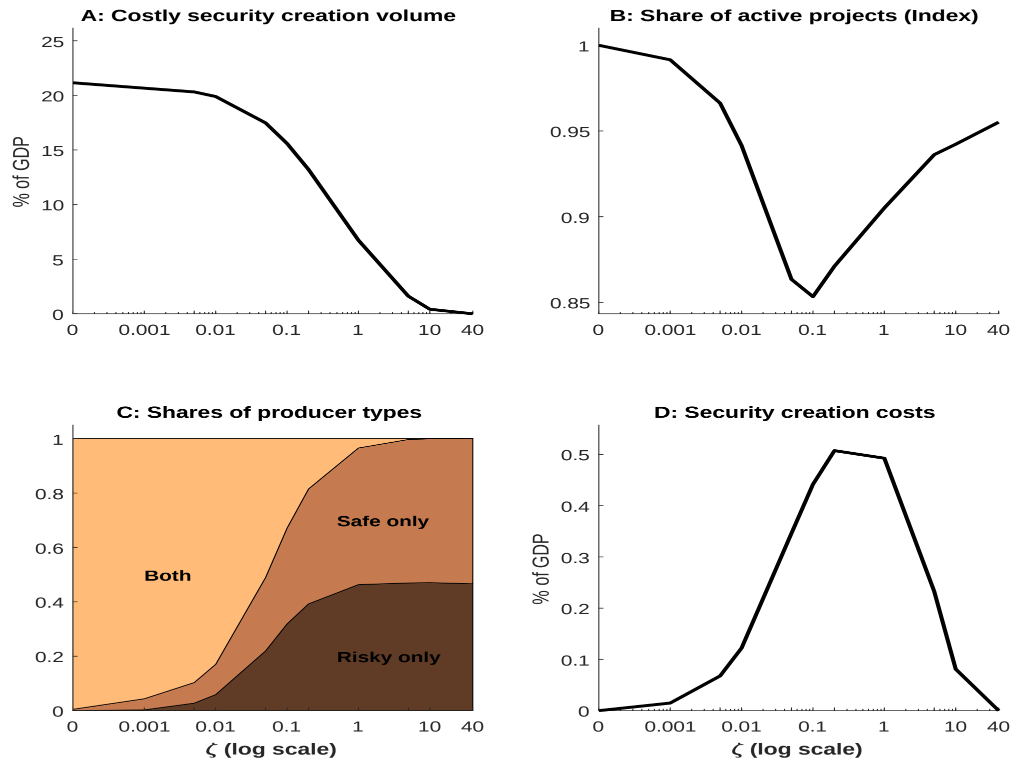
The next two sections describe the long-term consequences of changes in security creation costs and external demand for safe assets. Both experiments cause output and wages to go up but they feature markedly different subsidiary implications, particularly for security returns. We will then combine both exogenous changes into one transition experiment whose qualitative features we compare to recent US data.

### 5.2 Security creation costs

In the first experiment, we compare stochastic steady-states in economies that differ only in terms of the security creation cost. We do so by varying $\zeta$ from a value high enough that no costly security creation takes place ($\zeta = 40$) to zero. Panel A of Figure 3 shows that doing so has a big impact on the volume of security creation which rises to over 20% of GDP as $\zeta$ falls to zero (as we move from right to left along the horizontal axis.) Similarly, as shown in panel C of the figure, the fraction of producers that engage in costly security creation increases rapidly as $\zeta$ falls. This generates big changes in aggregate spending on security creation, shown in panel D. However, the relationship between $\zeta$ and those expenditures is not monotonic. When creation costs are prohibitively high, no producer engages in costly security creation and so expenditures are zero. At the other extreme, when $\zeta = 0$, every producer issues two securities and expenditures are also zero. In between, expenditures are strictly positive and reach about half a percent of output at their peak.[12]

[12] Note that the magnitude of the security creation costs as a fraction of GDP seems reasonable given data proxies, even if not directly targeted. Underwriting fees for corporate debt average roughly 88 basis points (see Manconi,

Figure 3: **Aggregate outcomes I: changing security creation costs**



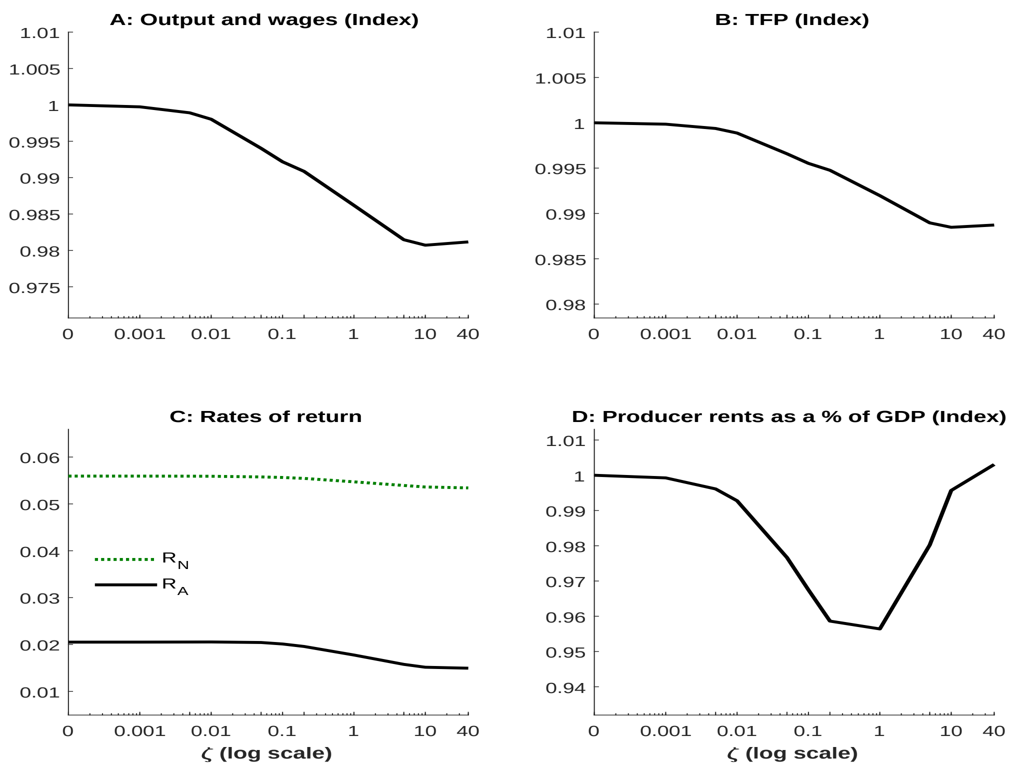

Overall, an economy where security creation costs are prohibitively high has an output roughly 2% lower than an economy where security creation costs are zero (see panel A of Figure 4). The relationship between $\zeta$ and output can be decomposed in two stages. As security creation costs drop to an intermediate level ($\zeta = 0.1$) output increases despite the sizeable decline in producer participation. As we discussed in section 4, producer participation is affected by two offsetting forces: 1) the direct, partial equilibrium effect of changes in $\zeta$ and, 2) its general equilibrium effects on factor prices.

As security creation costs initially start falling from prohibitively high levels, price effects dominate and producer exit dominates entry. Eventually the direct effect ends up dominating. The economy where $\zeta = 0.1$ features about 10% fewer producers than the economy with $\zeta = 40$. But the intensive (capital and labor choice) margin more than makes up for this shortfall. The output gains

Neretina, and Renneboog (2018)). Outstanding non-financial corporate debt in the United States stood at 6.2 trillion USD in the second quarter of 2018 according to the BIS, implying that underwriting fees represented roughly 0.3% of GDP. This, of course, ignores other implicit security creation costs in terms of governance, disclosure and managing a complex capital structure.

come from the producers that switch from issuing just one security to issuing both, in particular from those that switch away from just issuing risky securities. Producer types that do not switch and continue to issue just one security actually produce substantially less because of the increase in interest rates (panel C of Figure 4) and wages (panel A of the same figure). At this stage, and as panel B of Figure 4 shows, TFP (as it is conventionally measured, see Appendix A) increases both because marginally productive managers exit and because relatively productive managers choose to employ more capital.

Figure 4: **Aggregate outcomes II: changing security creation costs**




In the second stage, as security creation costs drop below $\zeta = 0.1$, price effects become smaller and participation increases: roughly 15% more producers are active in the economy with no creation costs than in the economy where $\zeta = 0.1$. Conventionally measured TFP increases only slightly, because even though capital becomes more concentrated among relatively more productive units, this effect is muted by the fact that the added participation lowers average productivity.

The rates of return earned by both types of households increase as security creation costs fall.

To understand why, recall that the log-log preference structure we adopt implies that savings, and therefore the demand for securities by the two household types, are a constant fraction of wages. Costly security issuance increases as security creation costs drop, driving security prices down and interest rates up (panel C of Figure 4). The risk-free rate increases relatively more than the risky rate, which has important welfare consequences, as we will discuss in section 5.5. This happens because, as we noted above, most of the output gains, and consequently most of the financing needs, come from producers that switch from issuing only risky securities to issuing both as costs drop, and therefore increase the supply of riskless securities disproportionately. In addition, the increase in interest rates is much more marked in the first stage, as security costs drop from extremely high levels to intermediate ones. This mirrors the fact that lowering security creation costs beyond a certain point has little effect on output, as most producers are already bearing the security creation cost, and therefore has little impact on financing and interest rates.

Aggregate producer rents are the difference between spending on securities (producer revenues) and total outlays (productive capital, entry costs, and security creation costs), as formalized in Appendix A. These rents are shown in panel D of Figure 4 and exhibit a non-monotonic behavior as a share of output. As security creation costs decrease from very high levels to intermediate levels, the measure of active producers decreases (panel B of Figure 3), so marginal producers are forced to accept lower rents. As security creation costs fall further towards zero, the opposite happens: since there is net entry, producers need to be adequately compensated for activating their projects in the form of higher rents.

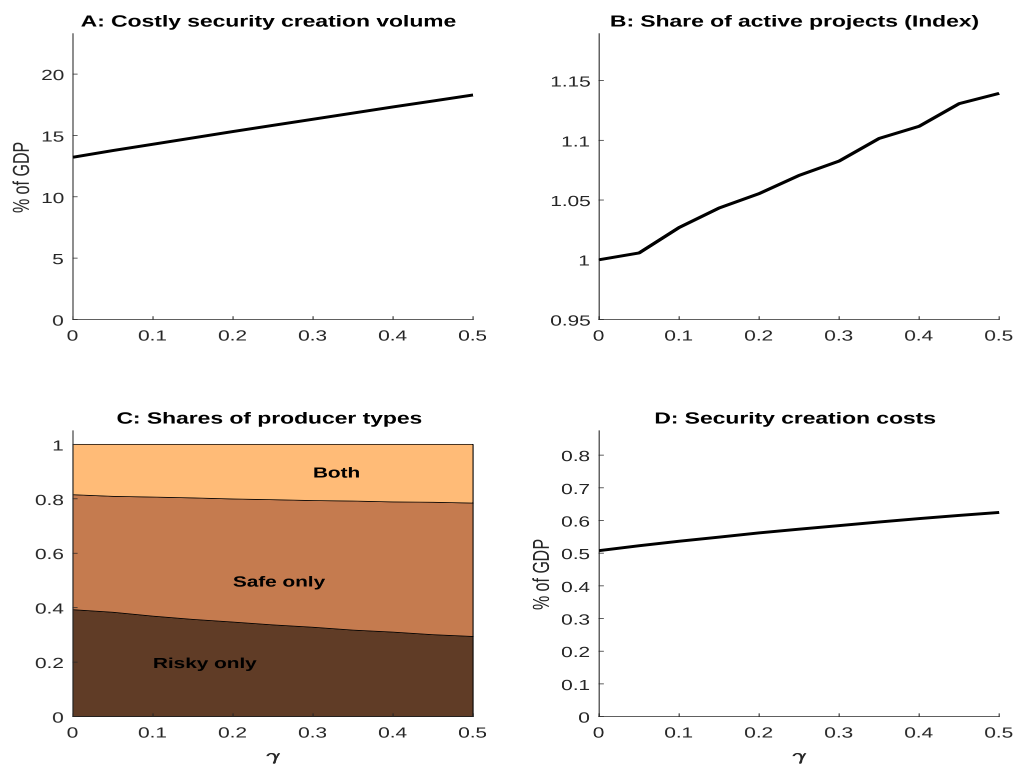
Appendix C makes the case that these properties (as well as those we discuss in upcoming sections) are robust to even drastic changes in our modeling and parameterization approach. This includes making labor supply elastic, relaxing the assumption that security creation costs are fixed, changing the dispersion of producer talent, and changing the severity of recessions.

### 5.3 External demand for safe assets

The global saving glut view associated, for instance, with Bernanke, Bertaut, DeMarco, and Kamin (2011) attributes the recent rise in securitization activities to an increase in foreign appetite for safe US assets. This section carries out an experiment that captures the key features of this phenomenon and describes its steady-state consequences in the context of our model economy. We do so by introducing foreign investors who inelastically demand risk-free assets equal to a fraction $\gamma$ of domestic demand.[13] We then vary $\gamma$ between zero and 0.5. When $\gamma = 0.5$ foreign demand for the safe asset is equal to half of domestic demand.

Foreign investment in riskless securities increases gross investment above national savings and leads to an almost linear increase in the volume of costly security issuance as a function of $\gamma$, as shown in panel A of Figure 5. As a result of this demand increase, a significant mass of new projects is activated (panel B of Figure 5), the vast majority of which either issue risk-free securities exclusively or issue both types of securities (panel C of Figure 5).

Figure 5: **Aggregate outcomes I: global saving glut**




Panel A of Figure 6 shows that, unsurprisingly, as more foreign capital flows into the economy, GDP increases.[14] When foreign demand reaches 50% of domestic investment in safe securities, gross

[13] This implies a full correlation between foreign and domestic demand for safe assets. Making foreign demand independent of domestic conditions, but the same on average, does not change the outcome noticeably.

[14] We initially set the level of security creation costs to a value around which the total expenditure in security creation

investment increases by 38%, on average, in stochastic steady-state, while output increases by 8%. This experiment leads to a large increase in producer participation, as mentioned above. The vast majority of the new, lower productivity, entrants finance their projects by issuing safe securities in exclusivity to take advantage of the falling riskless rate. As the average talent of active producers falls, so does TFP, as panel B of Figure 6 shows.

The key difference between this experiment and the security creation cost experiment is the behavior of interest rates. The larger demand for riskless assets naturally brings the risk-free interest rate down (see panel C of Figure 6), but what is worth noting is that the demand for risky securities also increases because of the increase in wages (proportional to the increase in GDP) which brings the risky yield down as well. Importantly, the experiment does generate an increase in the premium a risk-neutral investor earns over safe assets. While the funds they provide do not become scarce in absolute terms, they do become scarce in relative terms.

Yet another interesting, if intuitively clear, consequence of increased external demand as a divergence between national income (GNP, measured as GDP minus interest payments to foreigners) and GDP, as shown in the first panel of Figure 6. This occurs because virtually all of the increase in GDP takes the form of net interest payments to foreigners.

Finally, an increase in capital formation caused by exogenous increases in foreign appetite for safe assets results in the activation of hitherto infra-marginal producers, increasing not only the mass of producers, as argued before, but also raising the overall dispersion in producer talent. Aggregate rents, for both reasons, must increase, as shown in panel D of Figure 6.[15]

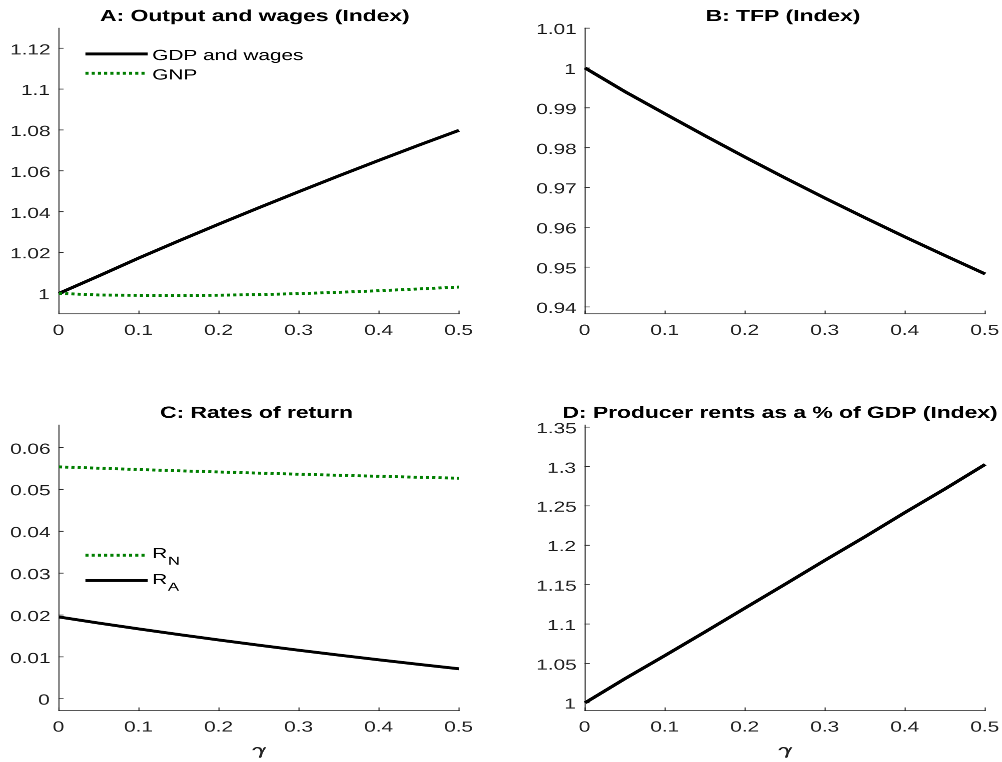
### 5.4 A transition experiment

This section makes the case that a transition towards a steady-state with lower security creation costs and higher external demand for safe assets exhibits qualitative features that are consistent with the recent US experience. The implied year-length of the time period in our environment makes building a tight quantitative mapping from the experiment to this recent evidence difficult. Still, our

is maximized in the benchmark economy with no foreign savings ($\zeta = 0.2$). To make sure our results were robust to even large changes in $\zeta$, we reran our experiments for $\zeta = 0.01$ and $\zeta = 0.5$ and found that the effects on output were very similar.

[15] As in the case of security creation cost reduction, the nature of these results is robust to large changes in our calibration choices.

Figure 6: **Aggregate outcomes II: global saving glut**




results show that a simple costly security creation mechanism can qualitatively rationalize several of the recent trends in US financial markets.

We start in the stochastic steady-state of the economy with the highest possible security creation cost ($\zeta = 40$) and no external demand for safe assets ($\gamma = 0$). Then, over eight model periods, we lower the security creation cost linearly to $\zeta = 0$, while the share of external demand rises linearly to $\gamma = 0.5$. The shape of the resulting transition path obviously depends on the history of aggregate shocks during the transition. The results displayed in Figure 7 are averages over eight possible time paths for the aggregate state, where the aggregate state is always good ($G$) except for one of the eight transition periods.[16] Agents alive in a particular period discover the new value of exogenous parameters at the start of the period.

Combining the two gradual shocks produces a progressive decline in safe rates, as shown in panel

[16]Since the economy spends 12% of the time in the bad state, it averages roughly one trip to the bad state every 8 periods. The approach we adopt is computationally more economical than computing transitions over all possible realizations of the aggregate state, while yielding essentially indistinguishable results.

E of Figure 7. This means that in the transition, the external demand increase dominates the upward pressure on rates implied by the reduction in security creation costs. This is by design: we want to consider an experiment broadly consistent with the well-documented fact that in the United States and much of the global economy, safe rates in general and safe corporate yields in particular have been on a slow decline since at least the mid-1980s. The average real AAA corporate yield fell from around 5% during the 1985-1999 time period, to a post-2010 average of around 2%.[17] Our goal is to evaluate whether the predictions our model makes for other variables during times of falling safe rates are qualitatively consistent with the corresponding evidence.

Along the transition, the model also predicts a slight decline in risky rates, $\bar{R}_N$, and a small increase in the spread, $\bar{R}_N - \bar{R}_A$, between risky and safe rates. In US data, real BAA yields and high-yield returns have fallen essentially in the same way AAA yields have, so that risk spreads on fixed income instruments have been roughly flat. Standard measures of the equity premium are likewise mostly flat as well during the same time period.[18] In this sense, our experiment appears to underpredict the decline in risky yields.

As in our long-run experiments, this combination of shocks results in a boom in tranching activities hence, in our model, a boom in the issuance of safe assets. In the United States, the outstanding stock of fixed income securities almost quadrupled (from 57% to 182%) as a ratio of GDP between 1980 and 2007, with half of this growth coming from securitization activities.[19] Flow of Funds data show that, in the non-financial corporate sector, the ratio of the stock of corporate bonds to value-added more than doubled from 12% in 1980 to around 27% in 2016. According to data available from the Securities Industry and Financial Markets Association (SIFMA), the ratio of safe (investment grade) corporate issuances to GDP rose from 4.6% on average, between 1996 and 1999, to 5.93% on average after 2000.

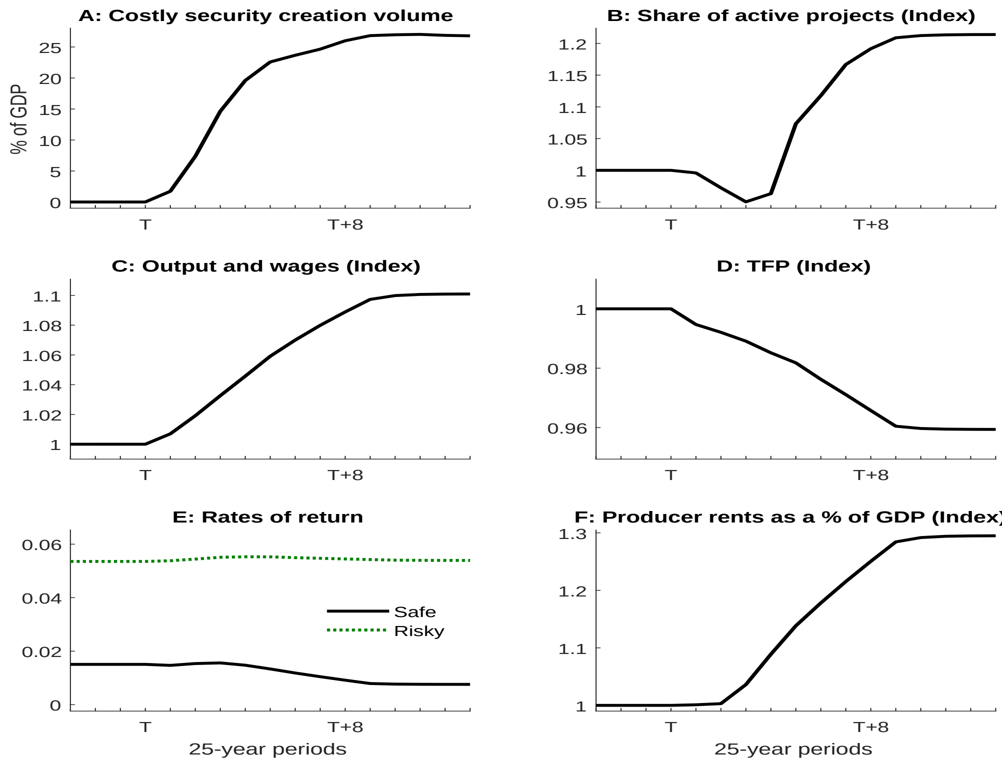
Also consistent with the model's prediction of increased safe issuances is the boom in collateralized loan obligations (CLO) shown in Figure 1. This phenomenon has largely resulted in the repackaging of corporate loans into safe fixed income securities. Of the 6,100 CLO tranches rated by Standard and Poor's between 1994 and 2013, only 25 tranches have defaulted, for an overall default

[17] Details for all those calculations are available upon requests. All our yield calculations are based on quarterly seasoned yield series available from Moody's.

[18] This includes the value-weighted return computed by Fama and French (2015).

[19] See Greenwood and Scharfstein (2013).

Figure 7: **Transition towards lower security creation costs and higher external demand**




loss rate of just 0.4%. Nearly 50% of CLO tranches are rated AA or above in those same data and none of these highly rated issues experienced any default.[20]

On the real side of the economy, output and wages increase during the transition but TFP falls. As in Section 5.3, growing external demand results in the entry of marginal producers over time, putting downward pressure on aggregate productivity.[21] This simple mechanism may have contributed to the post-2005 productivity growth slowdown documented, for instance, by Fernald (2012).

The final salient feature of this transition experiment is a sharp increase in producer rents and security creation costs. Put another way, the share of spending on securities that does not flow to capital formation becomes larger as external demand for safe assets rises. This prediction of our

[20] See S&P Global Ratings Credit Research. "Twenty Years Strong: A Look Back At U.S. CLO Ratings Performance From 1994 Through 2013" Jan 31, 2014.

[21] In the first periods of the transition, however, the mass of active producers falls because the decline in security creation costs dominates the increase in external demand. This is analogous to the phenomenon shown at the right-end of panel B of Figure 3.

model accords well the vast increase in financial sector rents over the past few decades documented, for instance, by Philippon and Reshef (2012). According to their estimates, until 1990, employees in the financial sector earned no significant premium, on average, relative to workers of similar education in other sectors. By 2006, financial sector employees earned a premium of 50% relative to comparable workers in other sectors. For top executives, the premium can reach 250%. Greenwood and Scharfstein (2013) calculate that the Financial Services value added share of GDP had risen from 4.9% in 1980 to over 8% in 2004, with the securities and credit intermediation being responsible for the lion's share of the increase.

In our model, producers keep and consume their rents, but one could introduce intermediaries that purchase projects, pay producers the value of their outside options, pool projects and tranche the resulting cash-flows as needed, and capture at least part of the resulting rents. In such an economy, putting together all our findings, the transition we model would result in a boom in cash-flow transformation activities by the financial sector, a significant decline in safe yields, a productivity slowdown, and an increase in the rents earned by agents engaged in cash-flow transformations, all predictions borne out by the available U.S. evidence.

### 5.5 Welfare

So far we have focused entirely on the positive consequences of costly security creation booms for macroeconomic aggregates and prices. This section discusses the consequences of these booms for the welfare of households and producers.

To measure type-specific welfare effects we compare utilities across stochastic steady-states in compensating variation terms. Taking security creation costs first, we start from an economy with no security creation costs and ask what income change (as a fraction of wages in the zero-cost economy) would restore a specific type's average utility in stochastic steady-state. Figure 8 shows the resulting welfare effects as we change security creation costs. The benefits associated with cutting costs are significantly larger for households than the 2% increase in output and wages. This is particularly true for risk-averse agents since safe yields rise the most. As panel A shows, their welfare rises by roughly 9% as we move from an economy with prohibitively high security creation costs to an economy with negligible security creation costs. Meanwhile, risk-neutral agents see their welfare go up by about

4% as a result of the wage increase and a relatively smaller increase in the expected return on risky securities. The average welfare of producers follows the path of producer participation; in particular, it is not monotonic (panel B).

Figure 8: **Security creation costs and welfare**

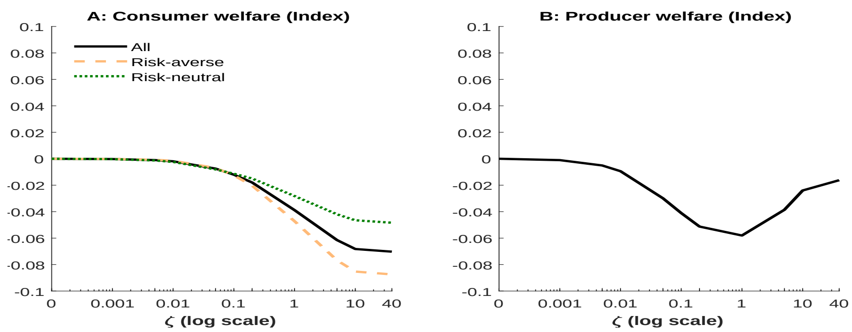
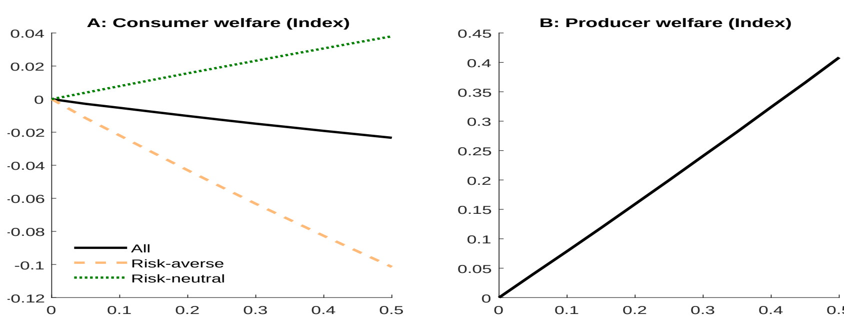



Figure 9 shows the same statistics for the saving glut experiment, where the compensating variation is measured with respect to an economy with no external demand ($\gamma = 0$). In this case, yields fall across the board as foreign appetite for safe assets rise, particularly safe yields. This offsets the beneficial impact on households of the 9% increase in wages as we go from zero foreign demand for the safe asset ($\gamma = 0$) to an economy where foreign demand is half of its domestic counterpart ($\gamma = 0.5$). Average household welfare actually decreases (panel A), but this masks considerable type heterogeneity. Risk-averse agents see their welfare fall by over 10%, despite rising wages, as a result of the collapse in safe yields. The welfare of risk-neutral agents goes up, but by considerably less than wages do, since their expected returns also fall.

Figure 9: **The global saving glut and welfare**




Producers, for their part, unambiguously benefit from the saving glut since increased demand for safe securities means more producers can profitably operate and that talent dispersion, hence average profits, rise. These gains come at the expense of households since they stem from the reduction in yields. In fact, rebating producer rents evenly to all households would suffice to erase the negative impact of the saving glut on average household welfare. In this sense, the saving glut does not lower overall surplus so much as it reallocates this surplus towards the agents who engage in cash-flow transformation at the expense of highly-risk averse households. As we already mentioned, we view this prediction of our model as broadly consistent with the massive increase in financial sector rents over the past few decades, documented by Philippon and Reshef (2012).

## 6 Conclusion

We have described a dynamic model of costly security creation where producers engage in cash-flow transformation to create securities that cater to the needs of heterogenous investors. When security creation costs fall or when foreign appetite for safe assets increases, the volume of costly security creation rises, as do output and wages. These two potential explanations for the growing importance of cash-flow tranching have very different welfare implications, however. Security creation cost reductions cause the supply of securities, hence yields, to rise. In contrast, greater foreign demand for safe assets causes yields, especially safe yields, to fall. Rising yields reinforce the beneficial impact of higher wages for households, but falling yields have the opposite effect on welfare, and we find that it can more than offset the impact of higher wages when foreign demand for safe assets rises.

We combine these two motives to generate a transition from a steady-state with low foreign demand for safe securities and high securitization costs to one where the state of affairs is precisely the opposite. When the strength of the two effects is such that it results in a fall in yields, this simulated transition is able to capture salient features of the U.S. economy in the last few decades, namely a boom in the supply of safe securities, a productivity slowdown, and an increase in financial sector rents.

These predictions are, of course, conditional on our modeling assumptions. For instance, we abstract from asymmetric information frictions in the security creation process and do not explicitly model specific changes in the regulatory and tax environment that may have contributed to the recent boom in financial engineering activities. These alternative models may yield different effects than those we find, but several key aspects of our findings are likely to be robust. First, falling safe yields over the past two decades – a fact with which any reasonable model of the recent cash-flow transformation boom must be consistent – imply that these booms have ambiguous welfare consequences for investors whose portfolio emphasizes safe assets by taste or by constraint. Second, the prediction that rents associated with cash-flow transformation activities should rise during such a period seems likewise robust to different views of what causes those booms. As for the level of economic activity, introducing information frictions such as the "neglected risks" emphasized by Gennaioli, Shleifer, and Vishny (2013) could erase the positive effects of security creation booms on output and wages we find in our experiments. We leave performing this quantitative horse race for future work.

# A Definition of macroeconomic aggregates

This section defines the aggregates we report and discuss in our quantitative experiments.

| | |
|---|---|
| Share of active projects | $\int_{Z_t} d\mu / \int d\mu$ |
| GDP ($Y_t$) | $\int_{Z_t} y(k_t(z)_t, w_t(\eta); z) d\mu$ |
| Capital formation ($K_t$) | $\int_{Z_t} k_t(z)_t d\mu$ |
| Measured TFP | $Y_t / K_t^{\alpha}$ |
| Security creation costs | $\int_{Z_t} \zeta 1_{\{x(z)_{A,t}>0, x(z)_{N,t}>0\}} d\mu$ |
| Costly security creation volume | $\int \left[\theta a_t^A(z) + (1-\theta) a_t^N(z)\right] 1_{\{x(z)_{A,t+1}>0, x(z)_{N,t+1}>0\}} d\mu$ |
| Volume of risk-free securities | $\int_{Z_t} \theta a_t^A(z) d\mu$ |
| Volume of risky securities | $\int_{Z_t} (1-\theta) a_t^N(z) d\mu$ |
| Producer rents | $\int_{Z_t} \theta a_t^A(z) + (1-\theta) a_t^N(z) d\mu - \int_{Z_t} \Big(e + \zeta 1_{\{x(z)_{A,t}>0, x(z)_{N,t}>0\}} + k_t(z)\Big) d\mu$ |

# B Proofs

## B.1 Proof of lemma 1

If $T(B|\eta_{-1}) = 0$ then all securities are risk-free and the lemma holds trivially. So we will assume for the remainder of this proof that $T(B|\eta_{-1}) > 0$. Assume, by way of contradiction, that for some date $t$, $c_{o,t}^A(B) > c_{o,t}^A(G)$. Then by equilibrium condition 6,

$$q_{A,t}(x(B), x(G)) = \frac{x(G)}{\bar{R}_{A,t}}.$$

Now consider the resulting maximization problem for a producer of type $(z_B, z_G)$ at date $t$ who issues both types of securities, after dropping time subscripts to reduce clutter:

$$\max_{\{x_A(B), x_N(B), x_A(G), x_N(G), k, e \geq 0\}} c_y^P + \epsilon E\left(c_o^P(\eta)|\eta_{-1}\right)$$

subject to:

$$\begin{aligned} c_y^P &\leq \frac{x_A(G)}{\bar{R}_A} + \frac{T\left(B|\eta_{-1}\right) x_N(B) + T\left(G|\eta_{-1}\right) x_N(G)}{\bar{R}_N} - k - e - \zeta, \\ c_o^P(B) &\leq \Pi(k, w(B); z_B) - x_A(B) - x_N(B), \\ c_o^P(G) &\leq \Pi(k, w(G); z_G) - x_A(G) - x_N(G). \end{aligned}$$

Because the producer has strictly monotonic preferences over consumption as long as $\epsilon > 0$, we may rewrite this problem as a maximization of:

$$\frac{x_A(G)}{\bar{R}_A} + \frac{T(B|\eta_{-1})\,x_N(B) + T(G|\eta_{-1})\,x_N(G)}{\bar{R}_N} - k - e - \zeta$$
$$+\epsilon\left\{T(B|\eta_{-1})\left(\Pi(k,w(B);z_B) - x_A(B) - x_N(B)\right) \quad + \quad T(G|\eta_{-1})\left(\Pi(k,w(G);z_G) - x_A(G) - x_N(G)\right)\right\}$$

subject to:

$$\begin{aligned} x_A(B) + x_N(B) &\leq \Pi(k,w(B);z_B), \\ x_A(G) + x_N(G) &\leq \Pi(k,w(G);z_G). \end{aligned}$$

Let $\lambda_1$ and $\lambda_2$ be the non-negative Lagrange multipliers associated with the two constraints. A necessary condition for $x_A(B) > 0$ to solve this problem is

$$-\epsilon T(B|\eta_{-1}) - \lambda_1 \geq 0$$

which cannot be since both since $\epsilon T(B|\eta_{-1})$ is strictly positive while $\lambda_1$ is non-negative.

The condition says that since raising the payoff to risk-averse agents in the bad state has no market value, doing so cannot increase producer consumption when young. But it must decrease their consumption when old and reduce the producer's ability to sell promises in the bad aggregate state to risk-neutral agents. In other words, making $x_A(B)$ positive must reduce the producer's objective when doing so has no market value.

So we must have $x_A(B) = 0$ for all producers who issue two securities. The argument is similar for producers who only issue securities to type $A$ agents. But then $R_{A,t}(z,B) = 0$ almost surely so that

$$c^A_{o,t}(B) = \int a^A_t(z) R_{A,t}(z,B)\,d\mu = 0,$$

which contradicts the premise that $c^A_{o,t}(B) > c^A_{o,t}(G)$. The symmetric argument rules out $c^A_{o,t}(B) < c^A_{o,t}(G)$.

Given this result, it must be that in any equilibrium

$$q_{A,t}(x(B), x(G)) = \frac{\min(x(B), x(G))}{\bar{R}_{A,t}}$$

where

$$\bar{R}_{A,t} = \frac{\min\{c^A_{o,t}(B), c^A_{o,t}(G)\}}{a^A_{t-1}}.$$

Furthermore, since it only makes sense to issue risk-free securities to risk-averse agents, active producers of type $z$ whose capital choice is $k(z)$ choose a risk-free payoff $x_A \geq 0$, risky payoffs $x_N \geq 0$ for type $N$ agents, and an end of period consumption plan $c^P_o$ to maximize:

$$\frac{x_A}{\bar{R}_{A,t}} + \frac{T(G|\eta_{t-1})x_N(G) + T(B|\eta_{t-1})x_N(B)}{\bar{R}_{N,t}} - k(z) - e - \zeta 1_{\{x_A>0 \text{ and } x_N>0\}} + \epsilon E(c^P_o|\eta_{t-1}),$$

where feasibility, i.e., the non-negativity restriction on security payoffs imposes:

$$\begin{aligned} x_A &\leq \min\left\{\Pi(k(z), w(B); z_B), \Pi(k(z), w(G); z_G)\right\} \\ x_A + x_N(B) + c_o^P(B) &\leq \Pi(k(z), w(B); z_B), \\ x_A + x_N(G) + c_o^P(G) &\leq \Pi(k(z), w(G); z_G). \end{aligned}$$

The first restriction says that risk-free payoffs must indeed be risk-free and hence have to be deliverable even under the worst-case realization of profits. The other two restrictions are feasibility conditions for each possible realization of the aggregate state.

To establish the second part of the proposition, assume by way of contradiction that

$$0 \leq \bar{R}_{N,t} < \bar{R}_{A,t}.$$

Assume further that at an optimal solution for any given producer, $x_A > 0$. Then, starting from that solution, it is feasible to lower $x_A$ all the way to zero and raise both $x_N(B)$ and $x_N(G)$ by $x_A$. The impact on the objective is at least

$$x_A \left( \frac{1}{\bar{R}_{N,t}} - \frac{1}{\bar{R}_{A,t}} \right) > 0$$

contradicting the fact that $x_A$ was part of an optimal security choice for the producer.[22]

This implies that unless

$$\bar{R}_{N,t} \geq \bar{R}_{A,t},$$

it must be the case by equilibrium condition 5 that

$$a_t^A(z) = \frac{x_t^A(z)}{\bar{R}_{A,t}} = 0$$

for all producer types $z$. But given the preferences of type $A$ agents,

$$\int a_t^A(z) d\mu > 0$$

for any strictly positive value $\bar{R}_{A,t}$, which contradicts the premise that $\bar{R}_{N,t} < \bar{R}_{A,t}$.

There only remains to show that if $\zeta > 0$ and some producers engage in security creation in equilibrium, we must have $\bar{R}_{N,t} > \bar{R}_{A,t}$. Assume otherwise and take any producer type $z$ that issues both securities. For that producer type, for any security choice and after dropping type arguments:

$$\frac{x_A}{\bar{R}_{A,t}} + \frac{T(G|\eta_{t-1})x_N(G) + T(B|\eta_{t-1})x_N(B)}{\bar{R}_{N,t}} \leq \frac{T\left(B|\eta_{-1}\right)\left(x_N(B) + x_A\right) + T\left(G|\eta_{-1}\right)\left(x_N(G) + x_A\right)}{\bar{R}_N}.$$

Put another way, dropping issuances of safe securities to zero cannot lower gross receipts from selling securities. Since doing so enables producers to economize on the security creation cost, issuing two securities must be suboptimal. This contradiction completes the proof.

[22] Since $x_A$ is driven all the way to zero in this argument, this can only lower the security creation cost, possibly strictly.

### B.2 Proof of proposition 2

Consider a producer that paid security creation cost $\zeta$ in a particular period. In light of lemma 1, any solution to her security creation problem must involve $x_A > 0$. Consider any feasible choice $(x_A, x_N, c_o^P)$ such that $x_A > 0$ but $x_A < \underline{\Pi}(z)$. Then, a slight increase in $x_A$ would increase the producer's objective by

$$\frac{1}{\bar{R}_A, t} - \max\left\{\epsilon, \frac{T(G|\eta_{t-1}) + T(B|\eta_{t-1})}{\bar{R}_{N,t}}\right\} > 0.$$

Indeed, lemma 1 guarantees the inequality with respect to the second element of the max operator. Moreover, it must also be the case that $\frac{1}{\bar{R}_{A,t}} > \epsilon$ (and that $\frac{1}{\bar{R}_{N,t}} > \epsilon$ for that matter) since otherwise it would not make sense to pay the security creation cost in the first place, as the producer could simply sell a single security type and consume any remainder. The result follows.

## C Sensitivity analysis

### C.1 Elastic labor supply

Our benchmark economy features a fixed production factor: labor is supplied inelastically. Allowing for flexible labor could amplify the impact of security creation costs on output. To study this possibility, we build a version of the model where household preferences give rise to an aggregate labor supply that features an intensive margin. We do so by incorporating so-called GHH-type preferences (see Greenwood, Hercowitz, and Huffman (1988)). The utility functions of types $N$ and $A$ becomes, respectively:

$$\log\left(c_{y,t}^N - \psi\frac{n_{N,t}^{1+\vartheta}}{1+\vartheta}\right) + \beta\log\left\{E\left(c_{o,t+1}^N(\eta)|\eta_t\right)\right\}$$

and

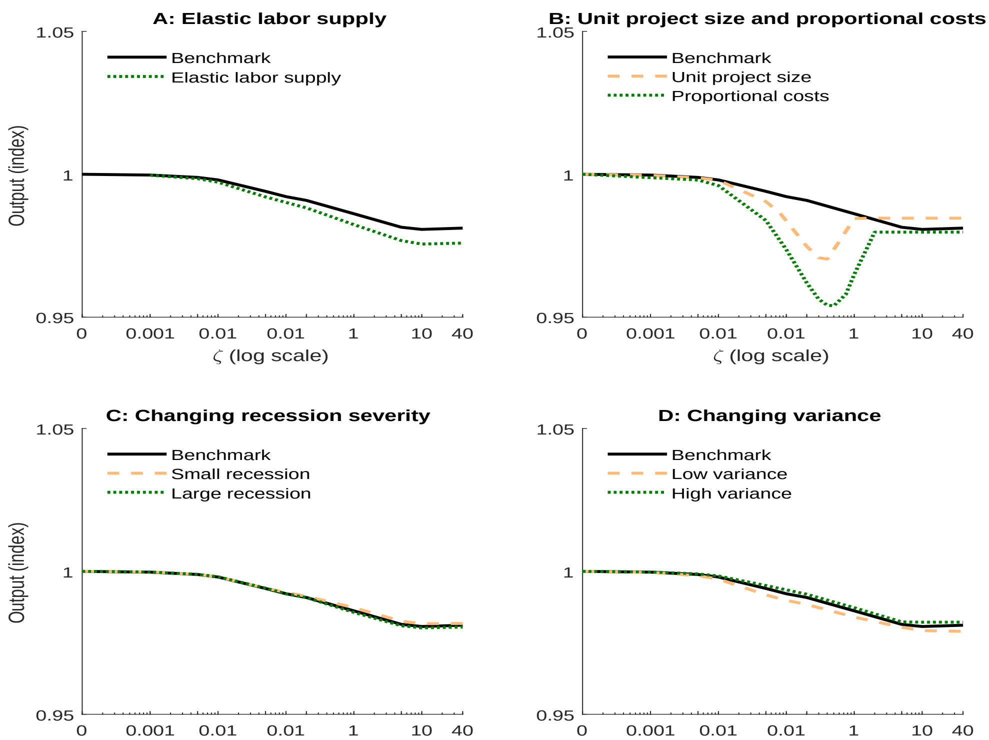
$$\log\left(c_{y,t}^A - \psi\frac{n_{A,t}^{1+\vartheta}}{1+\vartheta}\right) + \beta\log\left\{\min\left\{c_{o,t+1}^A(B), c_{o,t+1}^A(G)\right\}\right\},$$

where $\psi$ is calibrated so that aggregate labor is the same as in the benchmark, and $\vartheta = 2$, so that the Frisch labor supply elasticity is 0.5, a value that is on the upper-end of micro estimates. The resulting relationship between security creation costs and output in a stochastic steady-state appears in panel A of Figure 10 and it does not differ significantly from the benchmark. The introduction of an elastic labor supply results in some minor amplification, but our results are essentially unchanged.

### C.2 Changes to the cost structure

In our benchmark economy, projects vary in capital size as producers optimally choose how much capital to use. An alternative way to think about a project is as a single unit of capital that can be combined with (variable) labor to produce output. Under this approach, capital is akin to a machine, and machines vary in how productive they are – this is what we call here producer skill. In this case, in order to operate a project, a producer needs to install a single unit of capital, and then optimally decides on the labor needed to operate that unit of capital. In terms of financing, nothing changes: there is a fixed cost $\zeta$ that needs to be paid if the project is financed through issuing two asset types instead of just one. In this environment, the intensive margin is absent, as all projects are operated at their optimal labor scale regardless of the source of financing. As panel B of Figure 10 shows, and as discussed above, changes in security creation costs have a non-monotonic effect on output when operating through the extensive margin alone.[23] Moreover, since output falls at most 3%, this experiment confirms that even when operating through the extensive margin alone, changes in security creation costs continue to have limited impact on output and wages.

Figure 10: **Sensitivity analysis**




Next, in order to measure the extent to which our results depend on the assumption that security creation costs are fixed, we consider an environment in which the security creation costs are proportional to the capital size of the project. That is, if the producer chooses capital $k$ and would like to issue both types of assets, then the cost to doing so is $\zeta k$. Even though this is a very substantial change to the cost structure, the overall effect of cutting creation costs on output remains small at under 5%, as shown also in Panel B of Figure 10.

[23]The jointly calibrated parameters are adjusted to guarantee that the economy with no security creation costs continues to hit the same targets as in our benchmark.

## C.3 Changes to technology parameters

Our quantitative findings are also robust to large changes in parameters. Consider the impact of aggregate shocks across good to bad states. In the benchmark economy, a bad aggregate shock causes a drop in output that is calibrated to 17 percent.[24] To show that our main results are not very sensitive to this particular target, we recalibrate the mean skill level in bad times so that a bad aggregate shock causes a drop in output of 25 percent relative to good times. The resulting output is shown in panel C of Figure 10, which also shows an economy calibrated to yield a shallower recession period (8 percent). The connection between security costs and output is practically unchanged.

Finally, in panel D we show the effects of changing the variance of the skill distribution. Recall that our calibration strategy involves using the same coefficient of variation for $z_H$ and $z_L$, which is calibrated to $\varsigma = 16$ in the benchmark. Here we use values of $\varsigma = 20$ and $\varsigma = 12$. Even large changes in the skill distribution fail to have a substantial effect on the results.

[24] See section 5.1 for the rationale behind this target.

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