Cash-flow Tranching and the Macroeconomy*

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April 5, 2019

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 describe a dynamic model where the effects of changes in the costs and benefits of security creation activities can be characterized and quantified. Reduced tranching costs and increases in foreign appetite for safe assets both create large increases in the volume of costly security creation with positive effects on GDP and wages, but they have completely different welfare implications. Reductions in tranching costs cause yields to rise, which implies that household welfare rises significantly more than output. Conversely, increased foreign demand for safe assets causes yields to fall, which reduces the positive effect of wages. Calibrated simulations of our model show that the net effect of these conflicting forces can be negative. Highly risk-averse households, in particular, see their welfare collapse as foreign appetite for safe assets rises.

Keywords: Endogenous Security Markets; Financial Engineering; Macroeconomic Aggregates
JEL codes: E44; O11

*We thank Julio Suarez at AFME, Sharon Sung at SIFMA and research assistance from Tristan Young. We also thank our discussant Nicolas Caramp, as well as Roozbeh Hosseini, Robert Townsend, Vincenzo Quadrini, Gianluca Violante, André Silva, Grace Li, and seminar participants and attendees at the California Macroeconomics Conference, the Inter-American Development Bank, the Midwest Macro Meetings, the Society for Economic Dynamics meetings, the Society for the Advancement of Economic Theory meetings, the North-American and European and Latin American Econometric Society meetings, the Portuguese Economic Journal Meetings, the University of Georgia, the University of California Riverside, Banco de Portugal, and the Federal Reserve Bank of Atlanta for their generous comments.
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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. At least two concurrent phenomena have fueled the rise of tranching activities. First, technological improvements and regulatory arbitrage have made the activity cheaper.[1] Second, demand for the securities created via tranching – foreign appetite for highly rated assets, in particular – has increased, 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 cash-flow transformation by the corporate sector in which the importance 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 larger effects on economic activity. When foreign demand rises to equal domestic demand for safe assets, GDP and wages rise by almost 15%, on average, in our main calibration in stochastic steady-state.

While the output and wage consequences of reducing security creation costs and of increasing

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

foreign appetite for the safe asset are qualitatively the same, 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 the safe asset, 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 10% as security creation costs drop from being prohibitively high to being negligible, five times more than output. Risk-neutral agents also see their welfare increase by a higher fraction than output – 4% vs. 2% – 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 especially negative for highly risk-averse agents – their welfare falls by 15% in consumption equivalent terms even though aggregate output and wages rise by almost 15% – while risk-neutral investors actually see their welfare go up, albeit by less than wages do.

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 (consume, literally speaking, in our model) 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 US 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 external demand for safe assets.

Producers experience a large increase in their aggregate rents as foreign demand rises since the willingness to pay for the securities they create goes up. We view this prediction of our model as a potential explanation for the vast increase in financial sector rents over the past few decades documented, for instance, by Philippon and Reshef (2012). In our model, producers keep and consume their rents but one could trivially 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 the resulting rents. In such an economy, putting together all our findings, an increase in foreign demand for safe assets would result in a boom in cash-flow transformation activities by the financial sector, a significant decline in safe yields, and an increase in the rents earned by agents engaged in cash-flow transformations, all predictions borne out by the available evidence.

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.[2] 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 instance 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 detri-

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

mental to growth.[3] 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.

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 and type N – that differ in terms of how they value consumption plans, as we will explain below. Denote the fraction of type A households by θ 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 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 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

[3] Philippon and Reshef (2013) make the case that skilled workers in Finance earn excessive rents.

(z_B, z_G) is of productivity z_B during bad times and z_G during good times. The mass of producers in a given Borel set $\mathcal{Z} \subset \mathbb{R}^2_+$ is $\mu(Z)$ in each period. We assume that μ has continuous derivatives and that producer types are public information.[4] In our upcoming numerical simulations, we specify μ so that producers are more productive and their profits are higher, on average, in good times than in bad times, but the economy also contains producers whose profits are counter-cyclical.

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 late consumption. Specifically, a consumption profile for producers born at date t is a triplet $\left(c^P_{y,t}, c^P_{o,t+1}(B), c^P_{o,t+1}(G)\right)$ where $c^P_{y,t}$ is their consumption at the start of the first period of their life while $(c^P_{o,t+1}(B), c^P_{o,t+1}(G))$ is their second-period consumption, which may depend on the realization of the aggregate shock at time t. They rank those consumption profiles according to

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

where ϵ 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

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

where Π 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 the 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– delivering payoffs to the more distant type is costly.[5] In section 5.2.1, we

[4]This is for simplicity only. The case where μ features positive mass points can be handled by introducing lotteries, as in Halket (2014).

[5]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 ζ as proxying for all costs associated with selling securities in distinct markets or managing a more complex capital structure.

will 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

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

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 condition simply says that the proceeds from selling securities must cover funding needs at the start of the period. Clearly, producers become active when that constraint can be met since in that case – and only in that case – they enjoy non-negative consumption.

Securities, therefore, are mappings from the aggregate state to a non-negative dividend. Allowing 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. More importantly perhaps, cash-flow transformation could not generate private profits if short-sales were unlimited, since any value created by splitting cash-flows could be arbitraged away in the traditional Modigliani-Miller sense.[6] As a result, no costly security creation would take place in equilibrium.

Producers engage in cash-flow transformation themselves as opposed to delegating that activity

[6]See Allen and Gale (1988) for the formal version of this argument.

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.[7] We will return to this equivalence in section 5.3.[8]

Households take as given the set of securities available at the start of a particular period. From their point of view, the menu of securities is a set of gross returns

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

on the security issued by producers of type $z = (z_B, z_G) \in \mathbb{R}^2_+$ 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 η is the realization of the aggregate shock. Formally, given w_t, type N households born at date t solve:

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

[7] As Philippon and Reshef (2012) explain, financial sector rents have increased dramatically as financial engineering activities have boomed.

[8] The fact that production is only subject to aggregate uncertainty implies that combining projects serves no purpose in our model. One could introduce idiosyncratic risk (for instance, projects could be subject to failure) in which case pooling would potentially play a role. However, investors can eliminate this risk on their own so that the resulting model makes identical predictions to ours. This leaves the possibility that investors' ability to diversify is so limited that agents who can pool projects on their behalf serve a quantitatively important purpose but this seems difficult to justify in nations with reasonably developed financial markets.

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

$$\max_{a^A_t(z),c^A_{y,t},c^A_{o,t+1}\geq 0} \log(c^A_{y,t}) + \beta \log\left\{ \min\left\{c^A_{o,t+1}(B), c^A_{o,t+1}(G)\right\} \right\}$$

subject to:

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

Old agents of type A, in other words, are infinitely risk-averse when old and 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

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

as the effective return these agents realize on their investment at the optimal solution to their problem. If $c^A_{o,t}(B) < c^A_{o,t}(G)$ 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 $c^A_{o,t}(B) > c^A_{o,t}(G)$. When $c^A_{o,t}(B) = c^A_{o,t}(G)$, 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 specification of preferences 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.[9]

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 $t = -1$. 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 associ-

[9] Gennaioli, Shleifer, and Vishny (2013) make the same assumption on preferences as we do for this exact reason.

ated 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, finally, pricing kernels $\{q_{A,t}, q_{N,t}\}$ such that:

1. Security purchases and consumption plans solve the households' 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[10]:

$$\int_{Z_t} \theta a^A_t(z) R_{A,t}(z,\eta)d\mu = \int_{Z_t} x_{A,t}(z,\eta)d\mu$$

$$\int (1-\theta)a^N_t(z) R_{N,t}(z,\eta)d\mu = \int_{Z_t} x_{N,t}(z,\eta)d\mu$$

for $\eta \in \{B, G\}$;

6. Pricing kernels 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 $c^A_{o,t}(B) = c^A_{o,t}(G)$,

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

[10] For simplicity we only state an aggregate market clearing condition for each household type. This is without loss of generality since in equilibrium agents are exactly willing to hold each producer's securities. Equivalently, securities of each type can be pooled at no cost.

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

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

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

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 kernels are marginal rates of substitutions but the economic content of the condition is exactly the same. Producers take pricing kernels 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 kernels have to coincide with the kernels 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 η_{t-1}. For every possible value of these three objects we need to find producer capital policies $k_t(z)$, pricing kernels $(q_{A,t}, q_{N,t})$ 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.

Proof. Assume, by way of contradiction, that an equilibrium exists in which, in a given period, the consumption bundle (c_B, c_G) of old risk-averse agents is such that $c_B > c_G$. Then, given their preferences, risk-averse agents pay nothing for the bad-realization 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.

To see why risk-neutral agents must earn a premium assume that the opposite holds. Then producers would earn strictly more on any security sold to risk-neutral agents. But this would contradict the fact that the supply of securities to risk-averse investors must be strictly positive, since they always have strictly positive wealth. Finally, if producers bear the cost in order to sell two securities, the benefit of doing so, compared to selling everything to risk-neutral agents, must be strictly positive. □

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:

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

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.[11]

To ease notation in the statement of our next result, for a particular, active producer, 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 producer at a particular history, and denote the state where the lowest profit is realized as $\underline{\eta}(z)$. By the same token, let

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

be short-hand for the highest possible realization of profits, and $\bar{\eta}(z)$ denote the state where the highest possible profit is realized.[12]

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.

[11] In light of this result, our model appears equivalent to traditional models of corporate finance where producers choose a combination of debt and equity to maximize the overall value of the project. But it is in fact fundamentally different from those models, in the same sense that Allen and Gale (1988) is fundamentally different, and for several reasons. Traditional models of corporate finance (trade-off between the tax advantages of debt and its consequences of manager incentives, pecking order, etc.) can be fully cast in environments with a representative investor or one exogenous pricing kernel. Heterogeneity plays no role whatsoever in those approaches. Our model, in contrast, relies on designing securities with features that appeal to investors with different tastes, which is arguably the driving force behind the recent increase in financial engineering. Furthermore, the key distinction in our model between the two broad types of securities it generates is that one type is safe whereas the other is risky. Our model thus maps to highly rated securities vs other securities, not to debt vs equity. Again, this seems appropriate because the primary outcome of securitization activities is to create highly rated securities collateralized by risky assets.

[12] In our numerical simulations, producers are more productive and their profits are higher, on average, in good times than in bad times, but the economy also contains producers whose profits are counter-cyclical.

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

Proof. Consider a producer that paid creation cost ζ 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 one type of securities and consume any remainder. The result follows. □

This result is a consequence of a fundamental feature of environments in the spirit of Allen and Gale (1988) such as ours: producers take state prices as given, hence have a linear objective defined over a convex set, which, leads to bang-bang financial policies. This has nothing to do with the fact that our investors are either fully risk-neutral or fully risk-averse. Producer problems solve a linear problem simply because they are small, hence their actions have no impact on pricing kernels. 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 ζ. 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 $\underline{\Pi}(z)\left(\frac{1}{\bar{R}_{A,t}}-\frac{1}{\bar{R}_{N,t}}\right)\geq\zeta$. 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

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

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

Figure 1 illustrates these ideas by displaying producer policies given the parameter values we will use in our 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 cost, ranging from zero to a level such 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 (shown in white in all the panels of Figure 1. 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 in exclusivity is weakly dominated by issuing both types of securities, 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 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 black area in the panels 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 ζ. Second, 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 1. 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*.

4 Comparative statics: a preview

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

Figure 1 shows that reductions in security creation costs have two basic consequences on producer policies. First, the size of the activation region 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 cost 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 ζ but see their profits fall as prices rise. On the other hand, some producers who were inactive become profitable due to the reduction in ζ. 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 policy. This is reflected in the marked reduction of the black area in figure 1 as one moves from panel D to panel A. In our simulations, those producers who change financial policies tend to increase their capital use. To understand why, take a producer who, for high enough security creation costs $\bar{\zeta}$, finds it optimal to issue riskless securities exclusively. Her 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 type may find it optimal to issue both securities and, if that is the case, her 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 this producer uses, and consequently her 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.

Both the extensive and the intensive effect of changes in security creation costs should result in increased output and capital formation. Because the extensive effect involves marginal producers, we expect its magnitude to be small. Section 5.2.1 will confirm this intuition by showing that in an economy where all producers are constrained to use the same level of capital, changes in security creation costs have little to no effect on output and wages. The intensive margin has a larger effect 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 this channel.

The other fundamental experiment we perform in our simulations concerns the effect of exogenous increases in demand for the safe asset. Obviously, this experiment also has 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 ζ 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, we run two types of experiments. First, we compare economies that differ only in security creation costs. Starting with an economy where security creation costs are prohibitively high, and therefore no costly security creation takes place, we lower these costs until they are zero and all producers engage in costly security creation. In the second experiment, in contrast, we study the impact of introducing external demand for safe securities to simulate the main aspect of the global saving glut.

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 therefore 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) or Gourio (2013).[13] Correspondingly, we set the elements of the aggregate state's

[13]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).

transition matrix T so that the probability of remaining in the good state is $T_{GG} = 0.9$ and the probability of remaining in the bad state is $T_{BB} = 0.12$. This implies that the economy spends close to 90 percent of the time in the good state.

We set the support of project productivities to $\mathcal{Z} = [0,1] \times [0,1]$, and assume that μ 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.[14] We then normalize mean producer productivity in the bad state to $\bar{z}_L = 0.05$.

The production function coefficients are ν, regulating the share of producer rents, and α regulating the share of the remaining income accruing to capital. We set the latter to $\alpha = 0.4$ and calibrate the former below. We make $\epsilon = 0$ so that producers fully discount old period consumption. We interpret this value as vanishingly small in the sense that ties between consuming left-over output and selling it for nothing are broken in favor of the first option.

This leaves us with six parameters to calibrate: the productivity mean in the good state, $\bar{z}_G$, the parameter controlling the productivity variance, ς, the household discount factor, β, the share of risk averse agents, θ, the parameter controlling entrepreneurial rents, ν, 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:

1. Output in bad times is 15% below output in good times, which is the value Barro and Ursua (2008) use as a cut-off for their empirical definition of a disaster;

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%;

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

4. The interest rate spread is approximately 3.5%, which is the average, from 1998 to 2018, of the spread between the ICE BofAML US Corporate B Index and Moody's seasoned Aaa corporate bond yield;

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 $\bar{z}_G = 0.047$, $\varsigma = 12.5$, $\beta = 0.92$, $\theta = 0.52$, $\nu = 0.73$, $e = 0.025$. 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 in our model.[15] To obtain statistics for all endogenous variables in this stochastic steady-state, we adopt a traditional Markov chain Monte Carlo approach.[16] Specifically, our algorithm is as follows:

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

2. Draw a 100-period sequence of aggregate shocks $\{\eta_t\}_{t=1}^{100}$ using the Markov transition matrix T and record the value of all endogenous variables starting from an arbitrary value of aggregate wealth;

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.

[15] See Brock and Mirman (1972).
[16] See Tierney (1994).

To facilitate comparisons across economies with different costs, 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.

5.2 Varying security creation costs

In our first experiment, we compare economies that differ in terms of the security creation cost only by varying ζ from value so high that no costly security creation takes place ($\zeta = 50$) to zero. Panel A of figure 2 shows that doing so has a big impact on the volume of security creation which rises to over 20% of GDP as ζ 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 ζ falls. This generates big changes in aggregate spending on security creation, shown in panel D. However, the relationship between ζ 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 roughly half a percent of output at their peak.[17]

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 3). To better understand what is behind these changes in output as security creation costs change it is instructive to look at what happens to the extensive and intensive margins. Starting with the extensive margin, the relationship between security creation costs and the share of active producers is non-monotonic, as shown in panel B of Figure 2. As we discussed in section 4, producer participation is affected by two offsetting forces: 1) the direct, partial equilibrium effect of changes in ζ 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.

[17]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, 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.

The fact that the strength of general equilibrium effects eventually tapers off as ζ falls is evident in panel A of figure 3 which shows the relationship between security creation costs and wages. Panel C of the same figure shows that a fall in ζ also increases the returns expected by each household type hence the opportunity cost of capital. As ζ becomes small, factor and security prices respond less, hence the direct effect of ζ on participation starts dominating and participation begins to increase.

The relationship between ζ and output can be decomposed in two stages. As security creation costs drop from $\zeta = 50$ to $\zeta = 0.05$ output increases in spite of the sizeable decline in producer participation we discussed above. The economy where $\zeta = 0.05$ features 10% fewer producers than the economy with $\zeta = 50$. But the intensive margin more than makes up for this shortfall. The output gains come from the producers that switch from issuing just one security to issuing both, in particular from those that switch from just issuing risky securities to issuing both risky and safe 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 3) and wages (panel A of Figure 3). During that stage, TFP (as it is conventionally measured, see appendix A) increases because marginally productive managers exit and because relatively productive managers choose to employ more capital.

In the second stage, as security creation costs drop from $\zeta = 0.05$ to zero, 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 $\zeta = 0.05$. Conventionally measured TFP increases slightly because capital becomes more concentrated among relatively productive producers but this effect is muted by the fact that the added participation lowers the average productivity of producers.

Overall, this experiment suggests that that even large 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) for a discussion). The typical financial development experiment involves relaxing exogenous borrowing constraints producers face which has a direct, obvious impact on the allocation of resources. In our model, holding prices the same, cutting security creation cost can reduce our producers' cost of capital as they become able to tap into cheaper sources of funds but that turns out to have a relatively small impact on capital use and producer participation. These predictions are broadly consistent with the evidence discussed for instance by Arcand, Berkes, and Panizza (2015) that among nations with already well developed financial markets, additional gains in financial development do not not seem to be associated with large output effects.

The rates of return earned by both types of households increase as security creation costs fall. To see 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, which drives security prices down and interest rates up (panel C of Figure 3). The risk-free rate increases relatively more than the risky rate, which has important welfare consequences, as we will see below in section 5.4. 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 of financing and interest rates.

Aggregate producer rents are, from an accounting perspective, 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 3 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 2), 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.

5.2.1 Sensitivity analysis

The quantitative findings we just summarized are robust to even massive changes in parameters. Take the size of aggregate shocks, first. Since the economy suffers a bad shock once in roughly every 10 periods and each period represents 25 years, a fall in output that is calibrated to 15 percent may seem small. Gourio (2013) uses the same 15 percent, but the probability of disaster in his model economy is 2 percent a year, much higher than in our calibrated model. To show that this does not affect our main results, we recalibrate the mean skill level in bad times to yield a 30 percent difference in output relative to good times. The resulting output is shown in panel A of Figure 4, which also shows an economy calibrated to yield a shallower recession period (2.5 percent). The connection between security costs and output is practically unchanged.

In panel B of the same figure 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 $\varsigma = 12.5$ in the benchmark. Here we use values of $\varsigma = 15$ and $\varsigma = 10$. Even large changes in the skill distribution fail to have a substantial effect on the results.

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 ζ 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 C of Figure 4 shows, changes in security creation costs matter little for output when operating through the extensive margin alone.[18]

This experiment confirms that the extensive margin we discussed in section 4 has a very limited impact on output and wages. Almost all the overall effect of security creation costs on output we report above comes from the intensive margin. In fact, the effect of varying security creation costs on output may even be non-monotonic absent the intensive margin, as shown in panel C of figure 4. The reason for this is that in this economy the effect of changes in security creation costs on wages, and hence on security spending, is very small. As a result, the non-monotonicity in security creation costs shown in panel D of figure 2 can lead to a non-monotonicity in capital formation as well, hence

[18]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.

in output.

Finally, 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 ζk. Even though this is a very substantial change to the cost structure, the overall effect of cutting creation costs on output is unchanged, as shown in Panel D of Figure 4.

5.3 The global saving glut

The global saving glut view associated, for instance, with Bernanke, Bertaut, DeMarco, and Kamin (2011) attributes the recent increase 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 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 γ of domestic demand.[19] We then vary γ between zero and one. When $\gamma = 1$ foreign demand for the safe asset is equal to 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 γ, as shown in panel A of Figure 5. To accommodate the increases in foreign demand for risk-free assets, 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).

Panel A of Figure 6 shows that, unsurprisingly, as more foreign capital flows into the economy, GDP increases.[20] When foreign demand doubles the size of domestic investment in safe securities ($\gamma = 1$), gross investment increases by 73%, on average, in stochastic steady-state, while output increases by 14%. This experiment leads to a big increase in producer participation, as mentioned above. The vast majority of the new, lower productivity, entrants finance their projects by issuing

[19]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.

[20]We initially set the level of security creation costs to a value around which the total expenditure in security creation is maximized in the benchmark economy with no foreign savings ($\zeta = 0.05$). To make sure our results were robust to even large changes in ζ, we reran our experiments for $\zeta = 0.01$ and $\zeta = 0.5$ and found that the effects on output were very similar. Those results are available upon request.

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. We view this prediction as support for the global saving glut view of the recent increase in security creation activities since real yields have fallen in the United States across most asset classes. 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 the global saving glut as we model it is 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 while GDP increases little, net payments to foreigners increase markedly as foreign investment rises.

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. This increase in producer rents provides a potential explanation for the vast increase in financial sector rents over the past few decades documented, for instance, by Philippon and Reshef (2012). In our model, producers keep and consume their rents but one could trivially introduce intermediaries that purchase projects, pay producers the value of their outside options, pool and tranche projects as needed, and capture the resulting rents. In such an economy, putting together all our findings, an increase in foreign demand for safe assets would result in a securitization boom, a significant decline in safe yields, and an increase in the rents earned by agents engaged in cash-flow transformations, all predictions borne out by the available evidence.[21]

[21] As in the case of security creation cost reduction, the nature of these results is robust to even large changes in our calibration choices. Those results are available upon request.

5.4 Welfare

So far we have focused entirely on the positive consequences of costly security creation booms on output, capital formation and productivity. This section discusses the consequences of these booms for the welfare of households and producers.

As in Allen and Gale (1988) (or in Gennaioli, Shleifer, and Vishny (2013), when investors have rational expectations) our equilibria are constrained-efficient. A social planner that faces the same security creation costs as producers do would make the same security decisions and could not improve total surplus. However, different agent types are affected differently by changes in security creation costs and in foreign appetite for safe assets. Households benefit in both cases from higher wages, but whereas they also benefit from higher investment returns in the cost reduction experiment, they are negatively affected by falling yields in the saving glut experiment. Figure 7 shows the result of these effects in compensating variation terms (as a fraction of wages in the $\zeta = 0$ economy) in the first experiment while Figure 8 shows the same statistics in the saving glut experiment.

The welfare benefits associated with cutting security creation 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. Their welfare rises by almost 10% 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 result of the wage increase and a relatively small 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.

In the saving glut experiment, yields fall across the board as foreign appetite for safe assets rise, particularly safe yields. This effect offsets the beneficial impact on households of the 14% increase in wages as we go from zero foreign demand for the safe asset ($\gamma = 0$) to an economy where foreign demand matches domestics demand ($\gamma = 1$). Average household welfare goes down in stochastic steady state, as show in Figure 8. Risk-averse agents see their welfare fall by almost 15% despite rising wages, as a result of the collapse in safe yields. The welfare of risk-neutral agents goes up but by less than wages since their expected returns also fall albeit by a much smaller amount.

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, while 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.

These quantitative 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	$\int_{Z_t} \theta a_t^A(z) + (1-\theta) a_t^N(z) d\mu - \int_{Z_t} \left(e + \zeta 1_{\{x(z)_{A,t}>0, x(z)_{N,t}>0\}} + k_t(z)\right) d\mu$

References

Allen, F., and D. Gale (1988): "Optimal Security Design," *The Review of Financial Studies*, 1(3), 229–63.

Allen, F., and D. Gale (1994): "Limited Market Participation and Volatility of Asset Prices," *American Economic Review*, 84(4), 933–955.

Amaral, P. S., and E. Quintin (2010): "Limited Enforcement, Financial Intermediation, And Economic Development: A Quantitative Assessment," *International Economic Review*, 51(3), 785–811.

Arcand, J., E. Berkes, and U. Panizza (2015): "Too much finance?," *Journal of Economic Growth*, 20(2), 105–148.

Barro, R. J., and J. F. Ursua (2008): "Macroeconomic Crises since 1870," *Brookings Papers on Economic Activity*, 39(1 (Spring), 255–350.

Bernanke, B. S., C. C. Bertaut, L. P. DeMarco, and S. B. Kamin (2011): "International capital flows and the returns to safe assets in the United States, 2003-2007," International Finance Discussion Papers 1014, Board of Governors of the Federal Reserve System (U.S.).

Brock, W. A., and L. J. Mirman (1972): "Optimal economic growth and uncertainty: The discounted case," *Journal of Economic Theory*, 4(3), 479–513.

Corbae, D., and E. Quintin (2016): "Asset Quality Dynamics," 2016 Meeting Papers 418, Society for Economic Dynamics.

DeMarzo, P. M. (2005): "The Pooling and Tranching of Securities: A Model of Informed Intermediation," *Review of Financial Studies*, 18(1), 1–35.

Duffie, D., and K. J. Singleton (2012): *Credit Risk Pricing, Measurement, and Management.* Princeton University Press, Princeton, NJ.

Gennaioli, N., A. Shleifer, and R. W. Vishny (2013): "A Model of Shadow Banking," *Journal of Finance*, 68(4), 1331–1363.

Gourio, F. (2013): "Credit Risk and Disaster Risk," *American Economic Journal: Macroeconomics*, 5(3), 1–34.

Halket, J. (2014): "Existence of an equilibrium in incomplete markets with discrete choices and many markets," Unpublished Manuscript, University of Essex.

Jermann, U., and V. Quadrini (2012): "Macroeconomic Effects of Financial Shocks," *American Economic Review*, 102(1), 238–271.

Manconi, A., E. Neretina, and L. Renneboog (2018): "Underwriter Competition and Bargaining Power in the Corporate Bond Market," Working Paper Series in Finance 548/2018, European Corporate Governance Institute.

Philippon, T., and A. Reshef (2012): "Wages and Human Capital in the U.S. Finance Industry: 1909–2006," *The Quarterly Journal of Economics*, 127(4), 1551–1609.

——— (2013): "An International Look at the Growth of Modern Finance," *Journal of Economic Perspectives*, 27(2), 73–96.

Sahay, R., M. Cihak, P. M. N'Diaye, A. Barajas, D. B. A. Pena, R. Bi, Y. Gao, A. J. Kyobe, L. Nguyen, C. Saborowski, K. Svirydzenka, and R. Yousefi (2015): "Rethinking Financial Deepening; Stability and Growth in Emerging Markets," IMF Staff Discussion Notes 15/08, International Monetary Fund.

Tierney, L. (1994): "Markov Chains for Exploring Posterior Distributions," *The Annals of Statistics*, 22(4), 1701–28.

Tobin, J. (1984): "On the Efficiency of the Financial System," *Lloyd's Bank Review*, 153, 1–15.

Figure 1: **Producer policies: changing security creation costs**

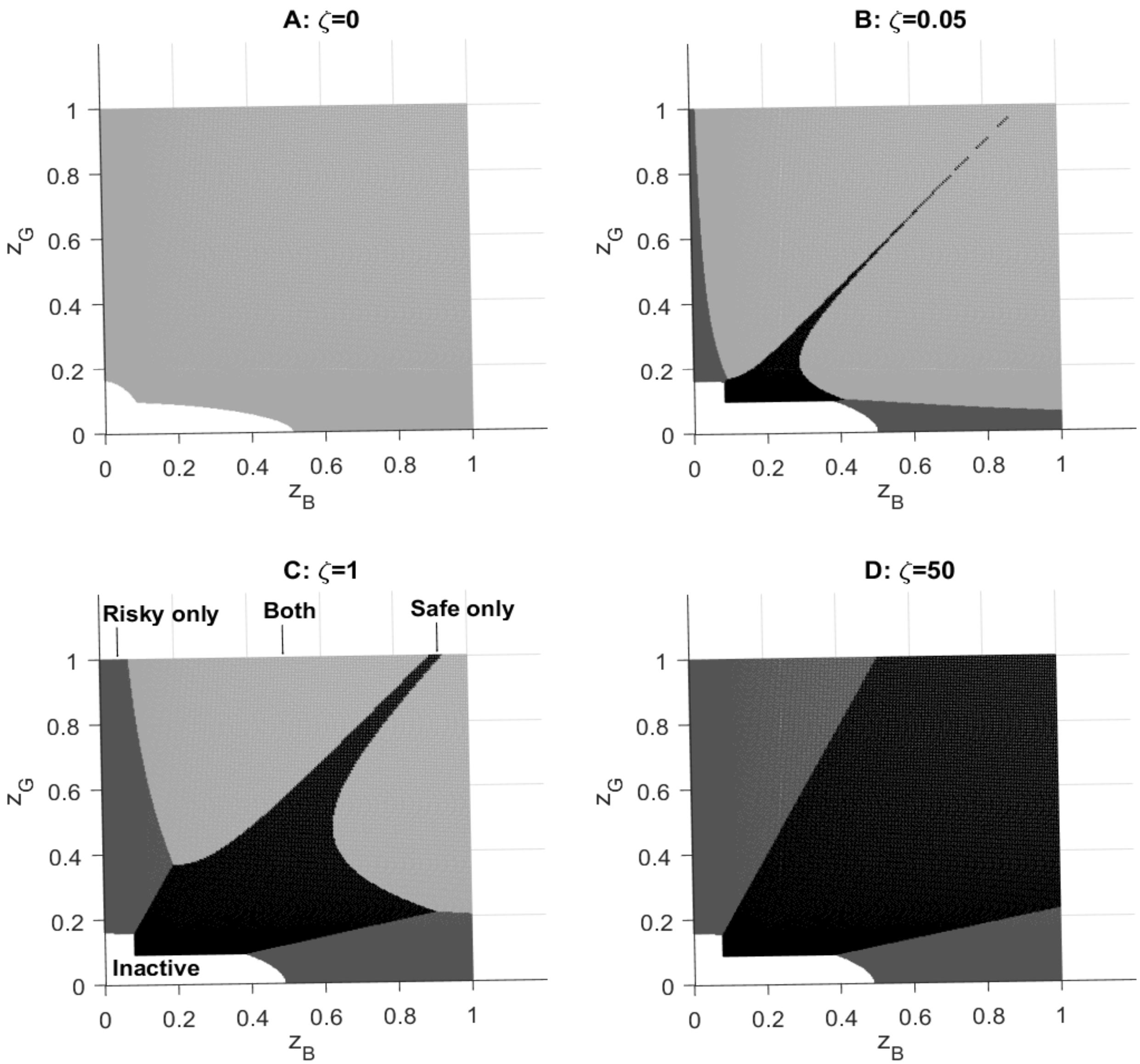

Figure 2: **Aggregate outcomes I: changing security creation costs**

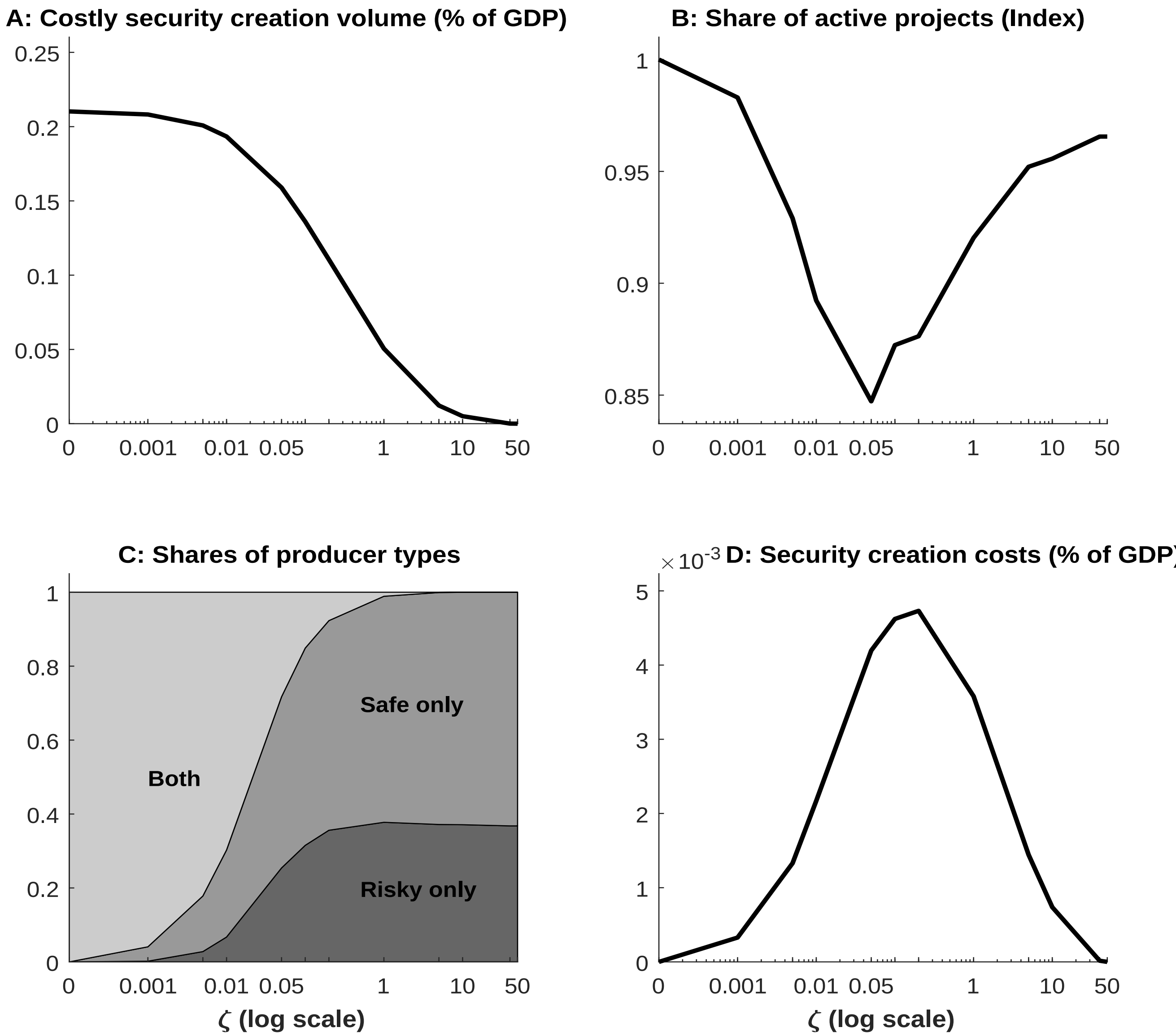

Figure 3: **Aggregate outcomes II: changing security creation costs**

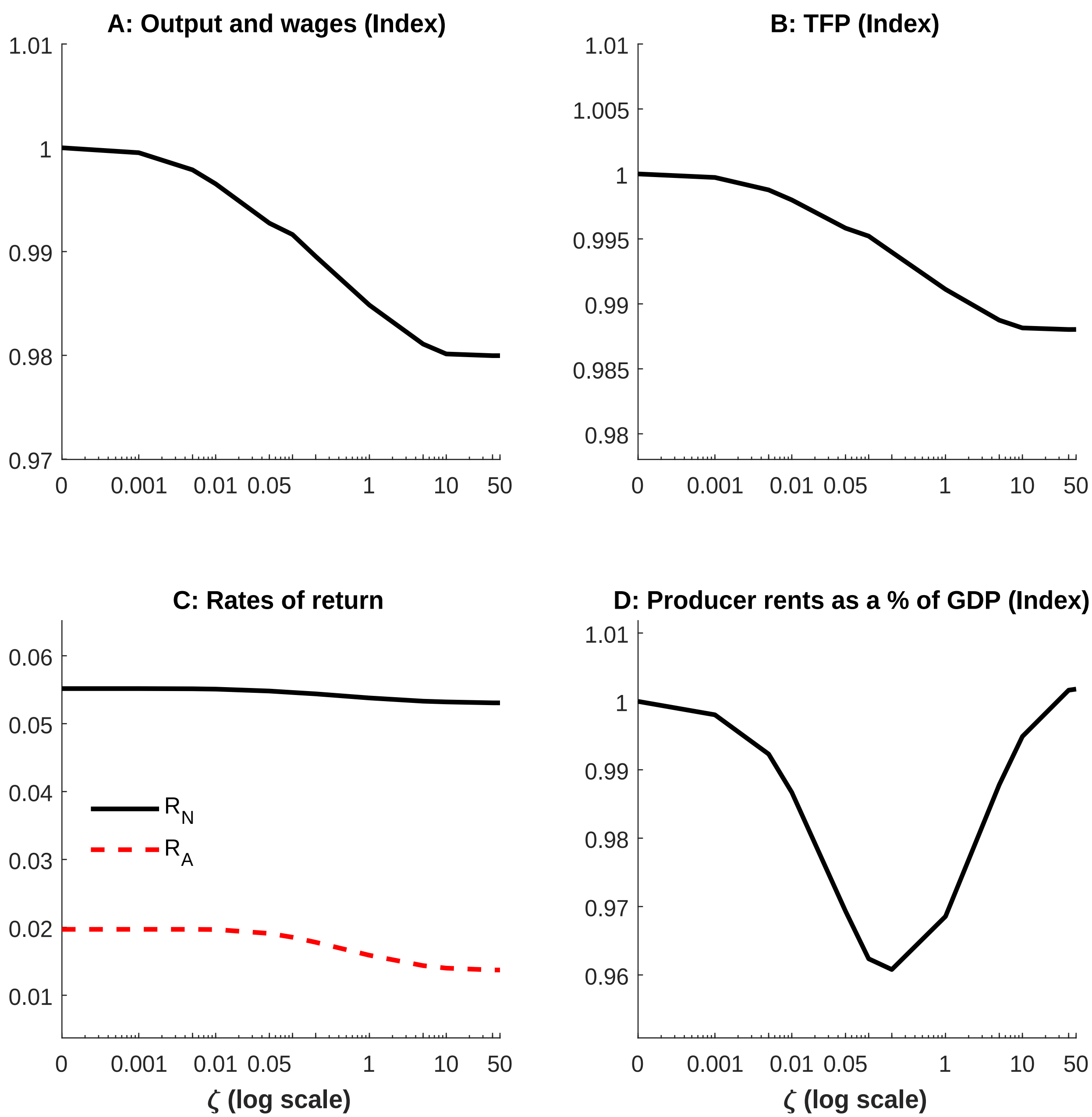

Figure 4: **Sensitivity analysis**

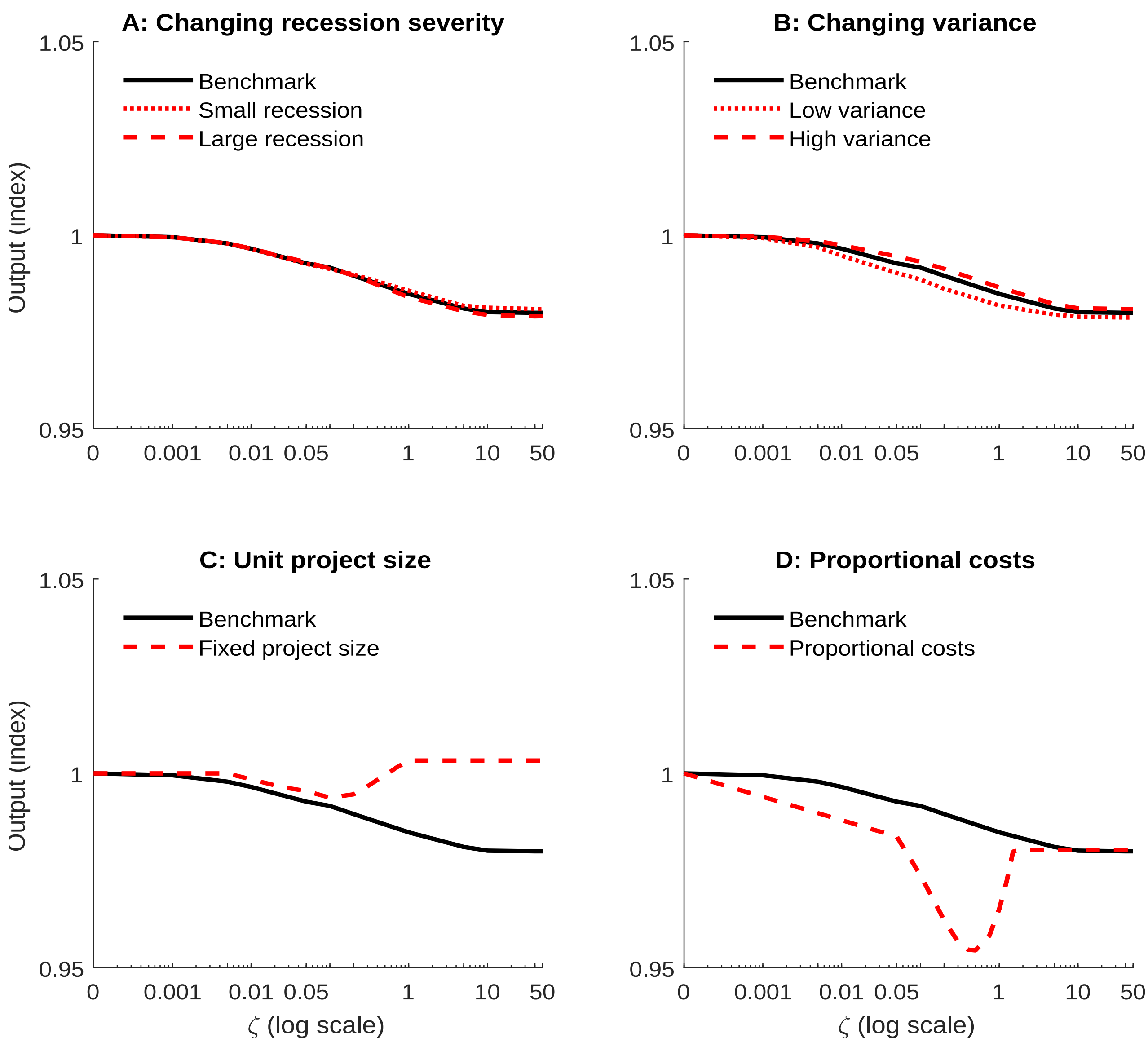

Figure 5: **Aggregate outcomes I: global saving glut**

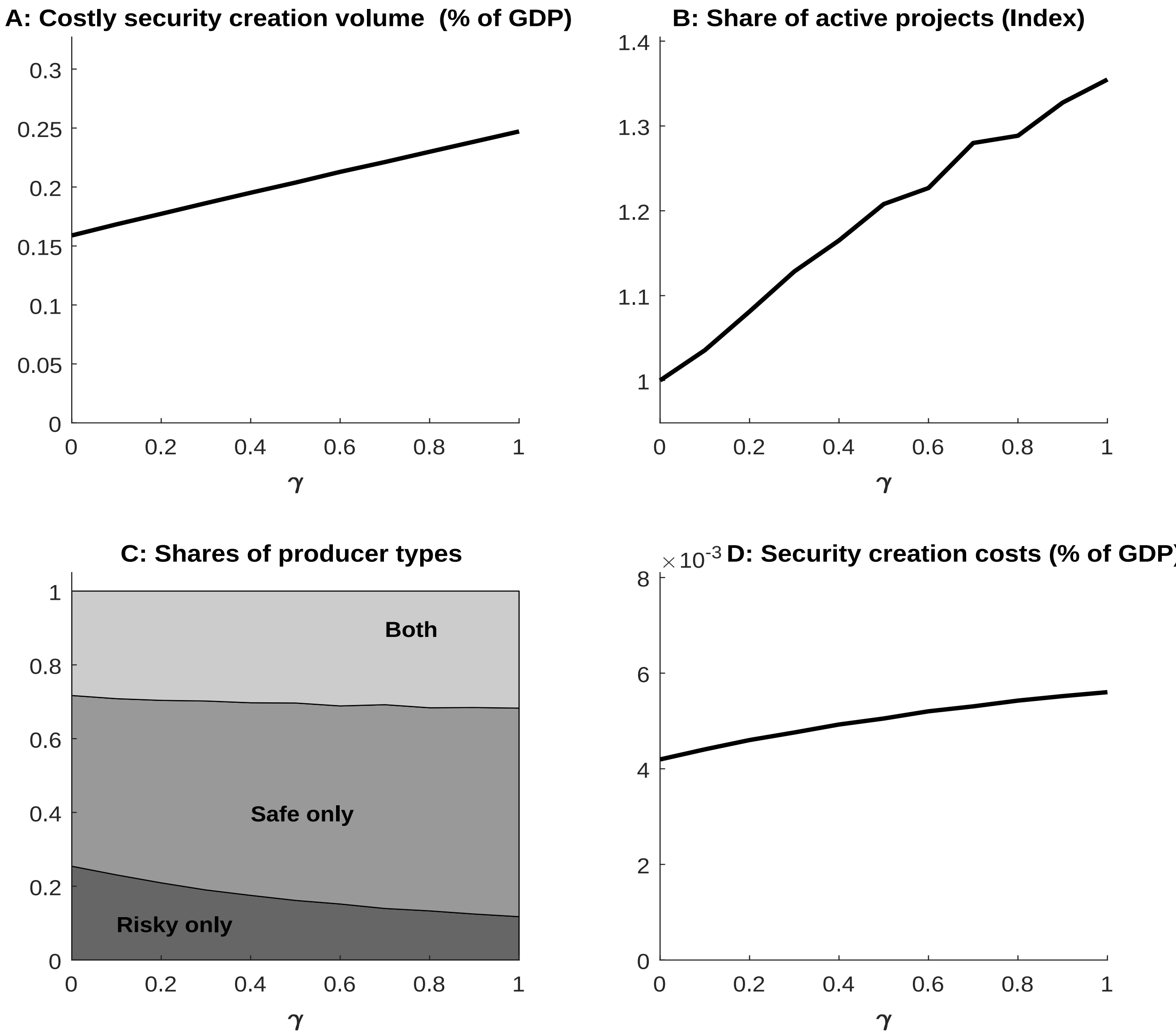

Figure 6: **Aggregate outcomes II: global saving glut**

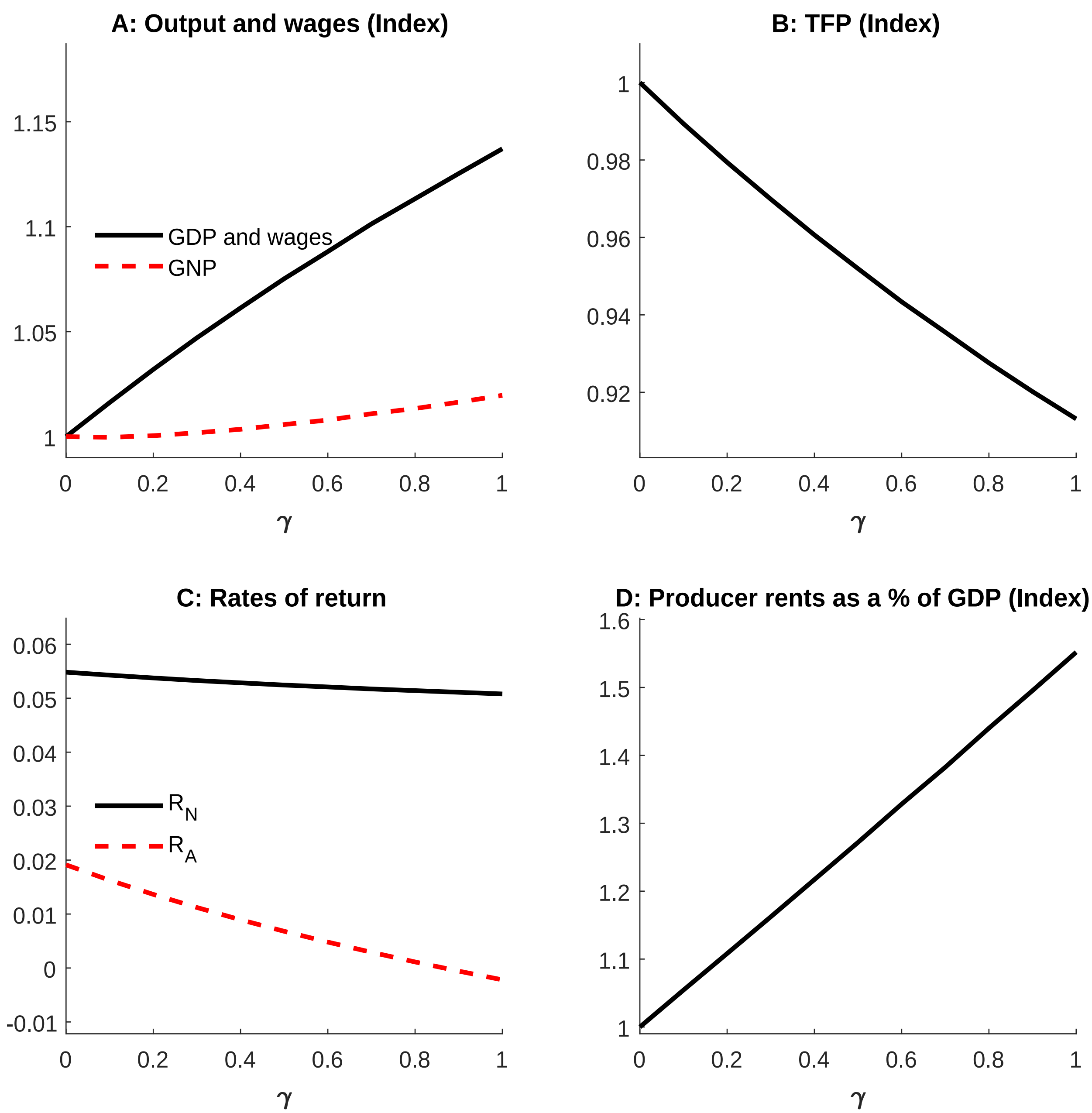

Figure 7: **Security creation costs and welfare**

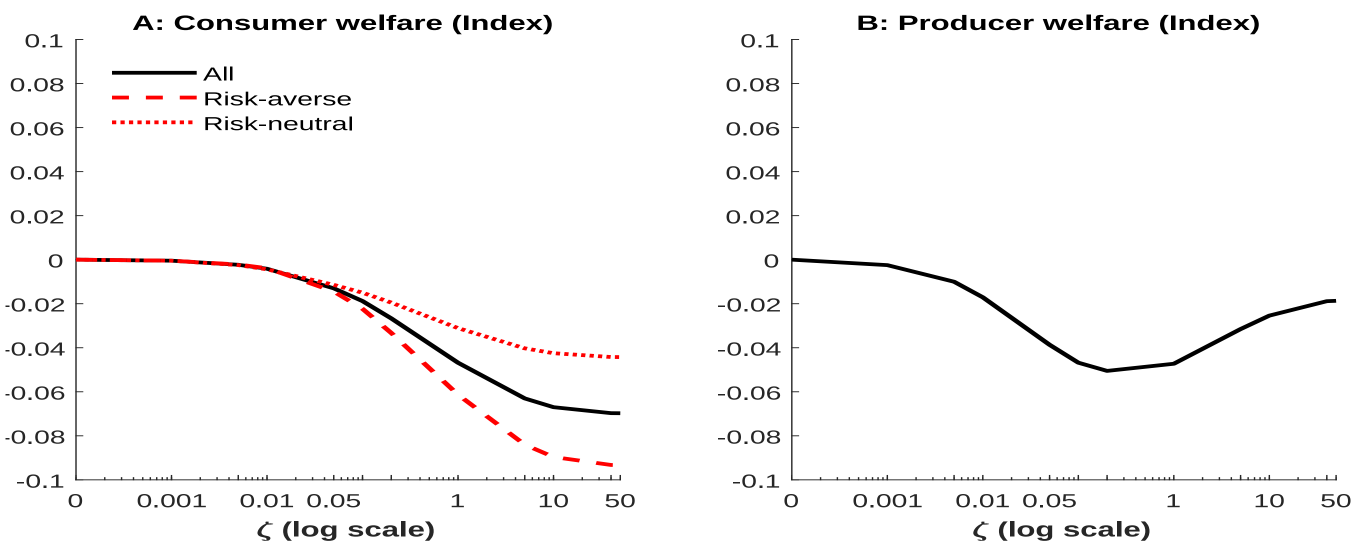

Figure 8: **The global saving glut and welfare**