

Financial Innovation and Financial Fragility

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Abstract

We present a standard model of financial innovation, in which intermediaries engineer securities with cash flows that investors seek, but modify two assumptions. First, investors (and possibly intermediaries) neglect certain unlikely risks. Second (less crucially), investors demand securities with safe cash flows. In the model, security issuance is excessive, and financial markets become extremely fragile. As the previously unattended to risks are recognized, investors fly to safety and the excessive volume of innovation accelerates this flight. Financial innovation can make both investors and intermediaries worse off, and lead to instability even without leverage or fire sales. The model mimics several facts from recent historical experiences, and points to new avenues for possible financial reform.

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I. Introduction.

Many recent episodes of financial innovation share a common narrative. It begins with a strong demand from investors for a particular, often safe, pattern of cash flows. Some traditional securities available in the market offer this pattern, but investors demand more (so prices are high), or perhaps demand securities with slightly higher returns and no extra risk. In response to demand, financial intermediaries create new securities offering the sought after pattern of cash flows, usually by carving them out from existing projects or other securities that are more risky. By virtue of diversification, tranching, insurance, and other forms of financial engineering, the new securities are believed by the investors, and often by the intermediaries themselves, to offer at least as good a risk return combination as the traditional substitutes, and are consequently issued and bought in great volumes. At some point, news reveals that new securities are vulnerable to some unattended risks, and in particular are not good substitutes for the traditional securities. Both investors and intermediaries are surprised at the news, and investors sell these “false substitutes,” moving back to the traditional securities with the cash flows they seek. As investors fly for safety, financial institutions are stuck holding the supply of the new securities (or worse yet, having to dump them as well in a fire sale because they are leveraged). The prices of traditional securities rise while those of the new ones fall sharply.

A notorious recent example of this narrative is securitization of mortgages during the last decade (Coval, Jurek, and Stafford 2009). Various macroeconomic events, including sharp reductions in government debt during the Clinton administration and massive demand for safe US assets by foreigners, created a “shortage” of safe bonds. By pooling and tranching mortgages and other loans, financial institutions engineered AAA-rated Collateralized Debt Obligations (CDOs) that were perceived to be just as safe and slightly higher-yielding than US government bonds. This perception, apparently shared by both

security buyers and intermediaries who engineered them, was justified by historically low default rates on mortgages in the US, and more or less continuously growing home prices since World War II (Gerardi et al. 2008). Trillions of dollars of CDOs were created and sold to investors. Both the holders of these securities and financial intermediaries appeared to be caught by surprise in 2007, when the news of falling home prices and sharply rising mortgage defaults hit the market. As tranching proved to be insufficient to insulate the holders of some AAA-rated securities from default risk, CDOs were downgraded, investors fled back to government bonds, and many financial institutions had to liquidate their holdings to reduce leverage. The collapse of CDO prices precipitated a financial crisis, which required massive government intervention, including purchases of securitized debt.

This recent episode is far from unique in recent US financial history. In the 1980s, investment banks began selling Collateralized Mortgage Obligations (CMOs), securities created out of mortgage portfolios and intended to substitute for government bonds but with slightly better yields. To avoid a possible risk to the value of CMOs resulting from mortgage prepayments by homeowners (which would occur if interest rates fell and people refinanced their homes) and consequent prepayments on the high-yielding bonds, intermediaries engineered CMOs nearly invulnerable to prepayment risk if historical patterns continued. In the early 1990s, however, as the Federal Reserve sharply cut interest rates, prepayments skyrocketed to levels unprecedented by historical standards, so even the values of CMO's most protected against prepayment risk declined sharply. The investors were caught by surprise and dumped the CMOs, turning back to government bonds (Carroll and Lappen 1994). Financial intermediaries were evidently caught by surprise as well, and many (particularly those who sold prepayment insurance) suffered substantial losses. Like the recent collapse of the housing bubble, extreme prepayments appear to have been unanticipated by the market.

A similar narrative describes what happened to money market funds in 2008. The industry was originally created to offer investors a product superior to bank deposits: slightly higher returns, instant liquidity, and no risk. Because investment in money market funds was not protected by deposit insurance, however, these funds were engineered so that their value per share would be extremely unlikely to fall below \$1. The funds were never supposed to “break the buck,” thus providing investors with demanded safety. To slightly raise returns, money market funds invested in generally safe non-government securities, such as commercial paper. The collapse of Lehman Brothers in September of 2008 led to its default on commercial paper, which caused one large holder of that paper, the Reserve Fund, to “break the buck” (Kacperczyk and Schnabl 2010). This event shocked investors and precipitated hundreds of billions of dollars in withdrawals not just from the Reserve Fund, but from the whole money market fund sector, and a return to traditional bank deposits and government bonds. Only government guarantees of money market funds saved the industry.

The large scale issuance of high-yield, so called “junk” bonds in the 1980s pioneered by Drexel Burnham Lambert offer another example of fragility created by financial innovation when expectations are unrealistic, which suggests that the phenomenon is not restricted to supposedly riskless debt. In this case, Drexel convinced investors that junk bonds are not much riskier than 10-year Treasuries and yet offered a substantially higher return. This case was based on a recent history of low returns on high duration government bonds (because of inflation and rising interest rates), as well as low rates of corporate defaults. With higher yields and lower maturity than 10-year Treasuries, junk bonds had lower duration and entailed lower interest rate risk. In the 1980s, these bonds were issued in high amounts, but ended up defaulting faster than investors expected. In 1989 and 1990, junk bonds crashed, underperforming treasuries by 25%, which was arguably much higher underperformance that could be attributed to default losses themselves (Altman 1998).

In this paper, we present a model that captures some of the key elements of this narrative. The model shares with the traditional account of financial innovation, such as Allen and Gale (1994), the view that innovation is driven by investor demand for particular cash flow patterns. This demand allows financial intermediaries to profitably engineer these patterns out of other cash flows. We add two assumptions to this standard story.

First, we assume that both investors and financial intermediaries do not attend to certain improbable risks when trading the new securities. This assumption captures what we take to be the central feature of the historical episodes we described: the neglect of potentially huge defaults in the housing bubble, the neglect of the possibility of massive prepayments in the early 1990s, or the neglect of the possibility that a money market fund can break the buck. We model the neglect of certain states of the world using the idea of local thinking, introduced by Gennaioli and Shleifer (2010), which is a formalization of the notion that not all contingencies are represented in the decision maker's thought process. This assumption unifies many of the central elements of financial innovation we examine.

Second, we make the preferred habitat assumption that investors have a very strong preference for very specific – namely safe -- cash flow patterns even relative to close substitutes. We model this assumption through preferences, namely infinite risk aversion, but it can reflect psychological or institutional characteristics of demand. For example, an alternative way to model such demand might be to consider investors who have lexicographic preferences with respect to particular characteristics of investments (e.g., AAA ratings). This assumption on demand is not strictly necessary for our results, but makes them much stronger. In Section 5, we relax it.

We then examine a standard model modified by these two assumptions, and obtain three main results. First, as in a standard model, there is room for financial innovation to offer to investors cash flow streams that are not available from traditional securities in

sufficient supply. However, when some risks are neglected, securities are over-issued relative to what would be possible under rational expectations. The reason is that neglected risks need not be laid off on intermediaries or other parties when manufacturing new securities. Investors thus end up bearing risk without recognizing that they are doing so.

Second, markets in new securities are fragile. A small piece of data that brings to investors' minds the previously unattended risks catches them by surprise, causes them to drastically revise their valuations of new securities, and to sell them in the market. The problem is more severe precisely because new securities have been over-issued: there are not enough cash flows in the neglected states of the world to make promised payments in full. When investors realize that the new securities are "false substitutes" for the traditional ones, they fly to safety, dumping these securities on the market and buying the truly safe ones.

Third, in equilibrium financial intermediaries end up buying back many of the new securities. But the wealth of financial intermediaries might be much smaller than that of investors as a whole, which limits their ability to absorb the huge supply of the new securities (see point 1). As a consequence, the prices of these false substitutes fall sharply, even without traditional fire sales due to leverage discussed by Shleifer and Vishny (1992, 2010), while prices of traditional securities may rise as investors flee to safety.

The model thus delivers the basic patterns of financial innovation and financial fragility, and does so differently from the available research. The most important contribution is to connect financial innovation, the glut of new securities, surprise about risk, and corresponding financial fragility through a unified model of belief formation. We show that a model in the spirit of Allen and Gale (1994), even modified by a preferred habitat formulation of preferences but without neglect of certain risks, can deliver some aspects of the narrative, but not over-issuance and the risks and fragility it entails. Without a deviation

from rational expectations, one cannot get the basic idea of false substitutes: securities investors believe to be riskless turn out to be risky.

Our model of financial innovation is related to the behavioral finance idea of security issuance catering to investor demand as in Baker and Wurgler (2002) and Greenwood, Hanson, and Stein (2010). Shleifer and Vishny (2010) apply this idea of catering to the financial crisis, but simply assume optimism as the stimulus for security issuance, and pessimism as the shock precipitating a crisis. Here we present a unified model of belief formation that accounts for the whole story. A broader historical perspective on the role of neglect of low probability risks in financial markets is Reinhart and Rogoff (2009).

Our paper is also related to an important theme in the literature on financial fragility, namely that both banks and the shadow banking system create “private money” or liquidity that investors demand (Gorton and Metrick 2010). It is usually assumed in this research that such creation of liquidity is socially valuable, but entails systemic risks due to leverage and resulting asset fire sales (Shleifer and Vishny 2010, Stein 2010). While we recognize the benefits of financial innovation, we take a more skeptical view about the social value of liquidity creation when investors neglect certain risks. In such a system, security issuance can be excessive and lead to fragility and welfare losses, even in the absence of leverage and fire sales. In this respect, our paper is closer to Rajan’s (2006) prescient analysis of the risks of financial innovation, although we emphasize neglect of unlikely events leading to over-issuance of securities rather than incentive problems as a source of instability.

In the next section, we present a benchmark rational expectations model of financial innovation in a pure exchange economy in the spirit of Allen-Gale. Section 3 modifies this model to allow for local thinking, and derives our main results on financial innovation and financial fragility. In Section 4, we study a production economy, which enables us to consider how innovation under local thinking can lead to investment distortions. In Section

5, we discuss welfare in both the exchange and the production economies. In the exchange economy, innovation under local thinking may benefit intermediaries and harm investors; in a production economy, because innovation distorts investment, it can leave everyone worse off. Section 6 examines two extensions of the model: the case of fully rational intermediaries dealing with locally-thinking investors, and the case of risk-averse investors. Section 7 discusses some broader implications of our work. All proofs are collected in the Appendix.

2. The Model

There are three dates $t = 0, 1, 2$ and two assets, B and A , which pay off at $t = 2$. The assets stand for cash flows from projects. Asset B pays $R > 1$ for sure. Asset A pays y_i with probability π_i where $i = g$ (for growth), d (for downturn), r (for recession). We assume:

A1: $y_g > 1 > y_d > y_r$, and $\pi_g > \pi_d \geq \pi_r$.

Growth is the most likely outcome and the downturn is more likely than a recession (in the most interesting case, only marginally so: π_d is close to π_r). These probabilities are meant to capture moments of economic stability with periodic but moderate output declines, such as the US in the three decades before 2008.

There is a representative, patient risk neutral intermediary. At $t=0$, the intermediary owns both assets and sells claims on their returns. These “traditional” claims are a riskless bond on B that yields R at $t = 2$, and risky shares in A , which yield y_i at $t=2$. When available securities are limited to the traditional claims, some beneficial trades do not occur. Financial innovation improves trading opportunities by splitting up the cash flows of asset A .

A representative investor endowed with wealth w maximizes his utility:

$$U = C_0 + C_1 + Eu(C_2), \quad (1)$$

where C_t is consumption at t . Denote by C_{2i} consumption in state i . We assume

$$Eu(C_2) = \theta \cdot \min(C_{2g}, C_{2d}, C_{2r}). \quad (2)$$

Investors are infinitely risk averse with respect to C_2 but, since $\theta > 1$, wish to postpone some consumption to $t = 2$. To do so, at $t = 0$ investors must buy claims on A and B . In contrast, an investor can freely transfer resources from $t = 0$ to $t = 1$ without purchasing claims, so $t = 0$ and $t = 1$ should be viewed as being close together. Formally, the initial endowment perishes right after $t=1$.¹ Infinite risk aversion in equation (2) conveniently captures investors' preference for riskless bonds, which creates opportunities for financial innovation.

The timing of the model is as follows. At $t = 0$, financial claims on A and B are traded and consumption-savings decisions are made. Financial markets are competitive; under a traditional claim structure, they pin down the price p_A of a share in A and the price p_B of a bond issued on B . At $t = 1$, after portfolios are formed and consumption had taken place at $t = 0$, agents observe a noisy signal $s \in \{\underline{s}, \bar{s}\}$ of payoff y , where $\bar{s} > \underline{s}$. The signal is characterized by $\Pr(\underline{s} | y_g) = 1 - \gamma$, $\Pr(\underline{s} | y_d) = \delta$, and $\Pr(\underline{s} | y_r) = \rho$, where $\rho > \delta > \gamma \geq 1/2$. That is, \underline{s} reduces the probability of growth and is a stronger signal a recession than of a downturn. The latter feature is captured by $\rho > \delta$ and plays a central role in our analysis. Our results are starkest when the signal is mildly informative, i.e. $\rho \approx 1/2$. Finally, in the end period $t = 2$ asset payoffs are realized and distributed to the holders of the financial claims.

The timing of the financial markets is graphically represented in Figure 1:

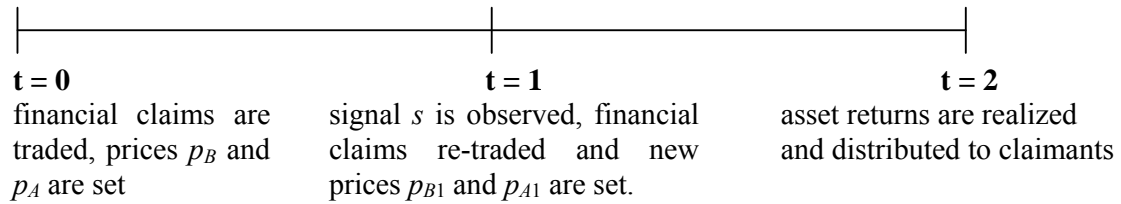


Figure 1

Agents consume some resources at $t = 0$, more at $t = 1$, and the rest at $t = 2$. Aside from consumption, period $t = 1$ allows investors to reassess their portfolios after observing s .

¹ As of $t=0$ agents are indifferent between consuming at $t = 0$ and at $t = 1$. Our results become even stronger if resources cannot be transferred from $t = 0$ to $t = 1$.

2.1 Rational Expectations Equilibrium with Traditional Claims

In choosing how many bonds b and shares a to buy at $t = 0$ (and thus implicitly the initial and future consumption levels C_0, C_1, C_2), the investor solves:

$$\begin{aligned} \max_{b,a} \quad & w - p_A a - p_B b + \theta(Rb + y_r a) \\ \text{s.t.} \quad & w - p_A a - p_B b \geq 0 \end{aligned} \quad (3)$$

The infinitely risk averse investor cares about his time 2 consumption only in the worst state, a recession. The solution to program (3) relies on two intuitive ideas. First, the investor saves all of his wealth (setting $C_0 = C_1 = 0$) when the risk adjusted price dividend ratio of at least one claim is lower than the rate of time preference, namely when $p_B/R < \theta$ or $p_A/y_r < \theta$, or both. The infinitely risk averse investor computes the risk adjusted price-dividend ratio at the asset's lowest return. Second, for a given amount of savings, the investor prefers to buy bonds over shares if and only if bonds have a lower risk-adjusted price-dividend ratio; formally if and only if $p_B/R < p_A/y_r$.

At $t = 0$, the intermediary supplies b bonds and a shares to maximize:

$$\max_{a,b} \quad \Pi \equiv p_A a + p_B b + R(1-b) + Ey(1-a), \quad (4)$$

The intermediary supplies any bond (i.e., $b > 0$) if and only if $p_B \geq R$ and any share (i.e., $a > 0$) if and only if $p_A \geq Ey$, where Ey is the average return of A . We assume:

A2: $Ey > \theta \cdot y_d$ and $w > \underline{w} \equiv \max[\theta(R + y_r), (R + y_d)]$.

The first part of A.2 ensures that the investors value shares less than the intermediaries even at their reservation price $p_A = \theta \cdot y_r$; the second part of A.2 ensures that investors are wealthy enough to absorb the total supply of bonds even at their reservation price $p_B = \theta \cdot R$ (in fact, $\underline{w}/\theta \cdot R > 1$). We can show that under A.2 the equilibrium at $t = 0$ is described by:

Lemma 1: Under rational expectations and a traditional claim structure, the financial markets equilibrium at $t = 0$ is characterized by $a = 0$, $b = 1$, $p_A = Ey$, $p_B = \theta \cdot R$.

In this equilibrium, the investor absorbs all bonds, the price of the bond is maximal and shares are not traded ($p_A = E y$ guarantees that there are no trades among intermediaries).

The equilibrium in the bond market is displayed in Figure 2:

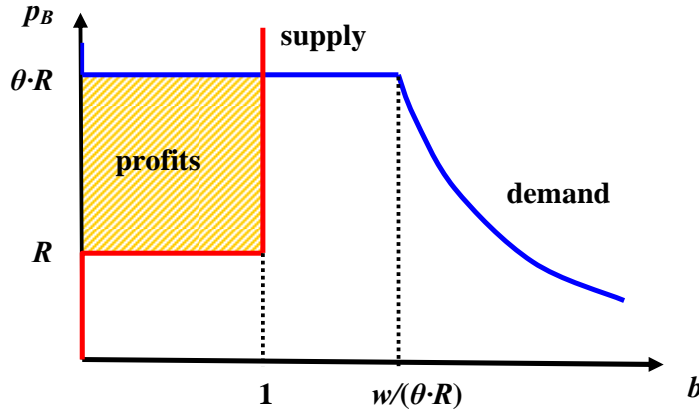


Figure 2

A.2 directly implies that there is a “shortage” of a safe store of value; this shortage drives up p_B allowing intermediaries to earn a unit profit $(\theta - 1) \cdot R$ from bond sales. Investors’ total payoff at $t = 0$ is $U_1 = w$, intermediaries’ total payoff is $\Pi = \theta \cdot R + E y$.

After a signal s is observed at $t = 1$, nothing happens to portfolios and consumption. Investors keep the bonds purchased at $t = 0$, the price of which stays constant at $p_B = \theta \cdot R$. Share prices fluctuate with the expected return of asset A since $E y$ is affected by the signal s , but no trading in shares takes place. In this equilibrium, it is irrelevant how consumers and intermediaries divide their $t = 0$ income between C_0 and C_1 .

2.2 Rational Expectations Equilibrium with Financial Innovation

We view financial innovation as the repackaging by intermediaries of the payoff on A so as to relax the “shortage” of bonds. The intermediary carves out of the risky asset a new claim having the same cash flow pattern as a riskless bond, namely promising to repay R in all states of the world. The amount of these new riskless claims the intermediary can issue is limited by the lowest possible return y_r of A , since the maximum aggregate repayment the

intermediary can pledge in all states of nature under the new claims is precisely y_r . As a consequence, the volume f of the new riskless claims issued in this way must satisfy:

$$f \leq f^{RE} = y_r / R. \quad (5)$$

If $f > y_r/R$, the new claim is risky because in a recession intermediaries cannot pay out the promised return R to all claim-holders. If $f \leq y_r/R$, the new claim is riskless: even in the worst state, intermediaries can repay R to all claimants. Unlike the bond, which is necessarily riskless because it pledges B 's riskless return, the new claim is paid out of a risky return, and is therefore riskless only if issued in a sufficiently low volume.² Financial innovation is thus modelled here as the creation of substitute securities mimicking exactly the cash flows of bonds that are demanded by investors but are in short supply. After having issued f new claims, the residual risky return $y - fR$ from A is pledged to the shareholders.

Consider now the market equilibrium. Denote the $t=0$ price of the new claim by p_N . If innovation occurs, the new claim must fetch the same price as a bond (i.e. $p_N = p_B$), since the two securities have identical cash flows. Financial innovation boosts the supply b of bonds by the amount y_r/R . The new equilibrium in the market for riskless claims is shown in Figure 3:

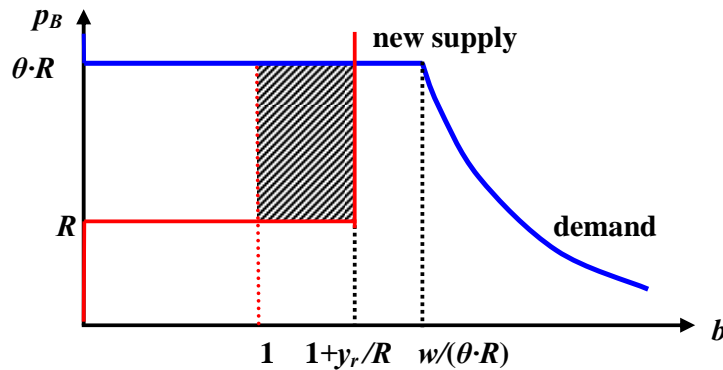


Figure 3

Under A.2, the boost in the supply of riskless claims triggered by financial innovation reduces but does not eliminate this shortage, because $w / \theta R > 1 + y_r / R$. It is still the case that

² This new claim can also be created by introducing in the traditional asset structure the possibility for investors to purchase an option to buy the realized return of A at price $y - y_r$.

$p_N = p_B = \theta \cdot R$, investors' reservation price, because the wealth of investors is sufficiently high to absorb all new claims at that price. Share prices are now equal to $p_A = Ey - y_r$ because the volume of innovation is maximal and so the risky asset's lowest payout is pledged to the holders of the new claim. We assume that innovation is costless for the intermediary. In the equilibrium depicted in Figure 3, the intermediary's profit from innovation is equal to:

$$f^{RE} \times (\theta - 1)R \equiv y_r(\theta - 1). \quad (6)$$

The intermediary's profit rises when y_r is higher, since more securities can be issued, and when investors' time preference θ is strong, since the price of the new securities is higher.

To summarize the analysis thus far, under A.2 the financial markets equilibrium at $t = 0$ under rational expectations is described by:

Lemma 2: Under rational expectations, equilibrium at $t = 0$ with financial innovation is characterized by $a = 0$, $b = 1 + y_r/R$, $p_A = Ey - y_r$, $p_N = p_B = \theta \cdot R$.

At $t = 1$, financial innovation does not affect the reaction of markets to the signal s . Regardless of the signal observed, the price of riskless claims does not change, neither do portfolios or consumption; only p_A fluctuates with the expected return on A . In this equilibrium, it does not matter whether consumption takes place at $t = 0$ or $t = 1$. As we will see, this is not true with local thinking.

Finally, consider the welfare consequences of innovation. With innovation, the total payoff of investors as of $t = 0$ stays at $U_1 = w$ while the intermediary's payoff becomes $\Pi_{inn} = \theta \cdot R + (\theta - 1)y_r + Ey$, which is the no-innovation profit Π plus the profits from innovation. Social welfare at $t = 0$ is thus higher with innovation, just as in Allen and Gale (1994). The social benefit of financial innovation here consists of relaxing the aggregate shortage of riskless bonds. This benefit in our model accrues entirely to the intermediaries because, in the market equilibrium, investors purchase riskless claims at their reservation price.

Our model builds on the idea that a key feature of financial innovation is to allow intermediaries to cater to investors' demand for particular claims, namely riskless bonds. The initial excess demand for such bonds gives intermediaries the incentive to manufacture an identical riskless security out of a risky cash flow. With infinite risk aversion of investors, our model literally describes innovations expanding the supply of AAA securities, such as securitization, but the general idea is broader and can be applied with less extreme risk aversion to innovations that promise investors higher returns for a given level of risk. With rational expectations, financial innovation allows gains from trade to be realized, and is strictly beneficial. Although this effect of financial innovation shows up in the case of local thinking as well, in that world it can also lead to excessive innovation and financial fragility.

3. Financial Innovation under Local Thinking

We consider departures from rational expectations due to agents' limited ability to represent uncertainty. To do so, we follow Gennaioli and Shleifer's (2010) model of local thinking. This model – which provides a unified explanation of several “anomalies” in judgments but admits Bayesian rationality as a special case – builds on the notion that agents' inferences are made on the basis of a *selected* subset of possible events rather than on the entire state space. Intuitively, not all states of the world come to mind; the agent does not think of everything when imagining the future. Crucially, the selection of events from the state space is shaped by their true underlying probabilities: more likely events are *ceteris paribus* easier to retrieve from memory than less likely ones. This feature allows one to consider how historical frequencies and news combine to create judgement biases, particularly news that change the agent's representations.

We introduce local thinking by simply assuming that an agent does not think of all three possible states $i = g, d, r$ of the risky asset's payoff but only the two most likely ones.

The agent then conditions his inferences about the payoff of A on the two states that come to mind. The remaining state is ignored. We focus on the case in which both investors and intermediaries vulnerable to local thinking; we later examine the case with rational intermediaries.

To see how local thinking works in our model, consider an agent's representation of the future at $t = 0$. Since by assumption $\pi_g > \pi_d \geq \pi_r$, the states that come to mind are g and d , so the agent assesses $\Pr^L(y_g) = \Pr(y_g | y_g, y_d) = \pi_g / (\pi_g + \pi_d)$ and $\Pr^L(y_d) = \Pr(y_d | y_g, y_d) = \pi_d / (\pi_g + \pi_d)$, where superscript L stands for "local." Initially, the local thinker exaggerates the probabilities of growth and a downturn and neglects the possibility of a recession.

After s is observed at $t = 1$, the agent's assessments are revised. What comes to mind at this point depends on the "true" posterior probabilities $\pi_i(s) = \Pr(y_i | s)$ for $i = g, d, r$. Since the prior probability of growth is fairly high and we focus on scarcely informative signals (formally $\rho \approx 1/2$), y_g is still the most likely outcome after s is observed. This implies that state g is always included in the agent's representation. Consider now the probability ranking of a downturn and a recession. If the signal is good, (i.e. $s = \bar{s}$), this ranking does not change as $\pi_d(\bar{s}) > \pi_r(\bar{s})$. Observing a good signal after a history of economic stability confirms the initial representations encoded in assumption A.1. The agent reassesses upward the probability of growth as $\Pr^L(y_g | \bar{s}) = \Pr^L(y_g | y_g, y_d, \bar{s}) = \pi_g(\bar{s}) / [\pi_g(\bar{s}) + \pi_d(\bar{s})] > \Pr^L(y_g)$.

A bad signal $s = \underline{s}$ in contrast is generally informative of lower growth, but especially about a recession, as formally captured by the assumption that $\rho > \delta$. In this case, so long as:

$$\mathbf{A.3} \quad \rho > \hat{\rho} \equiv \delta \cdot \frac{\pi_d}{\pi_r}, \quad (7)$$

we have that $\pi_r(\underline{s}) > \pi_d(\underline{s})$, namely a recession becomes more likely than a mere downturn. If the prior probabilities π_d and π_r are not far apart, A.3 is met and we henceforth assume that it is. This implies that after $s = \underline{s}$ the representation of uncertainty changes drastically: the agent

now neglects the possibility of a mere downturn by including state r at the expense of d into his representation. Formally, local thinkers assess $\Pr^L(y_g|\underline{s}) = \Pr(y_g|y_g, y_r, \underline{s}) = \pi_g(\underline{s})/[\pi_g(\underline{s})+\pi_r(\underline{s})]$ and $\Pr^L(y_r|\underline{s}) = \Pr(y_r|y_g, y_r, \underline{s}) = \pi_r(\underline{s})/[\pi_g(\underline{s})+\pi_r(\underline{s})]$. Informally, a mere downturn is forgotten and the agent focuses on a recession.

By formalizing the change in agents' representations, local thinking allows us to identify two general, distinct, effects of bad news. The first and most fundamental effect is to prompt the agent to consider the possibility of a recession. Initially, after a period of economic stability, limited representations lead the agent to disregard this unlikely risk. After observing a piece of bad news (such as a bank failure), the initially unattended to possibility of a recession comes to the agent's mind. The second effect of news is that they may induce over-reaction. With limited representations, as the possibility of a recession comes to mind, other, more favourable, states are crowded out of agents' attention and representation. This crowding out leads to over-weighting of the probability of recession, which may (but need not) induce a switch from the initial optimism to pessimism.³

Although over-reaction leads to stronger effects, the main results of our model rely merely on the neglect of the possibility of a recession at $t = 0$. In fact, as we formally show in Proposition 2, the "false substitute" effect arises even if the agent's assessment at $t = 1$ is rational, much as if agents were to learn the true distribution of states after observing \underline{s} .

3.1 Local Thinking Equilibrium and Innovation at $t = 0$

We assume that both investors and intermediaries are local thinkers and hold the same beliefs. In Section 5 we consider the case in which intermediaries hold rational expectations.

³After observing \underline{s} a local thinker estimates an average payoff of $E(y|y_g, y_r, \underline{s})$, which is lower than the rational agent's estimate when $E(y|y_g, y_r, \underline{s}) < y_d$. If $E(y|y_g, y_r, \underline{s}) = y_d$ the local and rational thinker's assessments are identical [the local thinker is optimistic otherwise]. Thus, the switch from optimism to pessimism arises when the recession is very bad, i.e. y_r is low. Pessimism may also arise in our model if the probability of growth is sufficiently low that after \underline{s} state y_g is disregarded. None of our main results change under these alternative specifications. We have chosen the structure of A.1 in order to highlight the fact that the basic mechanism of our model does not require pessimism and may arise even if the local thinker's $t = 1$ assessments are rational.

If the intermediary does not innovate, the equilibrium at $t = 0$ is very similar to the rational expectations case in Lemma 1, except that the share price is now equal to $p_A = E^L y = E(y|y = y_g, y_d)$, which is the value for asset A 's cash flow expected by a local thinker.

When the intermediary innovates, then given agents' representations at $t = 0$, the change from the rational expectations case is substantial. When state r is neglected, the number of new riskless claims that the intermediary can potentially issue is equal to:

$$f^L = y_d / R. \quad (8)$$

Since at $t = 0$ agents do not pay attention to the possibility of a recession, riskless claims can be issued until all cash flow y_d in a downturn is pledged to investors. The potential volume of financial innovation with local thinking is higher than with rational expectations (formally $f^L > f^{RE}$ since $y_d > y_r$) because cash flows in a downturn rather than a recession can now be pledged to create a “substitute” for a riskless bond. If investors are sufficiently wealthy, the price of riskless claims stays at $p_B = \theta \cdot R$ and the extra profit from innovation obtained by the intermediary is equal to:

$$f^L \times (\theta - 1)R \equiv y_d(\theta - 1), \quad (9)$$

which is higher than the profit in Equation (6) under rational expectations. The reason for higher profits is the greater volume of innovation. Of course, if investors' wealth is not so high, innovation can boost the supply of the riskless claim to the point that p_B falls below θR , so the equilibrium lies in the downward portion of investors' demand curve in Figure 4:

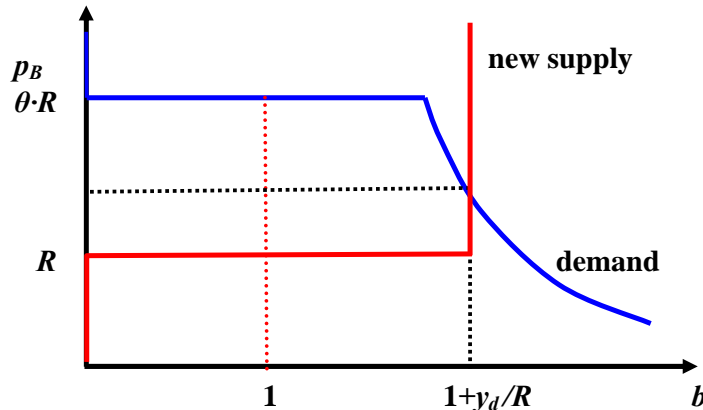


Figure 4

p_B may be so low that an intermediary's profits from innovation falls below the level in Equation (9).⁴ If the price drops to $p_B = R$, investors may be satiated with riskless claims, so their supply would fall short of f^L . A.2 simplifies the analysis by ruling out this case. In fact, $w > \underline{w}$ implies that, when f^L is issued, the equilibrium price $p_B = wR / (R + y_d)$ is above R .

Proposition 1 Under local thinking, the volume of innovation is $f^L = y_d / R$. We also have at $t = 0$ that $b = 1 + f^L$, $a = 0$, and $p_A = E(y | y_g, y_d) - y_d$. We have two cases: 1) If $\underline{w} \leq w < \theta(R + y_d)$, then $p_N = p_B = wR / (R + y_d) < \theta R$; 2) If $w \geq \theta(R + y_d)$, then $p_N = p_B = \theta R$.

When investors' wealth w is high relative to the supply of riskless claims, demand for new claims is high, and so is p_B . The reverse is true when investors' wealth is low relative to the amount of riskless claims issued. In this case, the boost in the supply of riskless assets triggered by innovation can reduce the price of all safe assets, including the traditional bond, below the no-innovation level. In both of the cases of Proposition 1, the intermediary is indifferent between consuming the income obtained by selling claims at $t = 0$ or at $t = 1$. As we will see in section 3.2, the resources of the intermediary at $t = 1$ can affect the reaction of markets to news. To highlight this mechanism, we allow the fraction σ of income carried by intermediaries to $t = 1$ to be anywhere in $[0,1]$. Sections 4 and 5 show that σ can be pinned down by introducing either production or rational expectations of intermediaries.

We conclude this analysis of $t = 0$ by stressing that under local thinking the volume of new claims issued is higher (and the price p_B is lower) than under rational expectations. This is so because locally-thinking intermediaries and investors see asset A as having a smaller

⁴ Under rational expectations this case could not occur by virtue of assumption A.2 which implies that the potential volume of innovation is sufficiently low (relative to investors' wealth) that the price of riskless claims is always equal to investors' reservation value θR .

downside risk than do their rational expectations counterparts. Demand from local thinkers encourages the supply of the new claim, which investors see as a riskless bond. The issuance “glut” created by local thinking has far-reaching implications for financial fragility.

3.2 Local Thinking Equilibrium and Innovation at $t = 1$

We just saw that local thinking boosts the volume of innovation relative to rational expectations. This seemingly minor, merely quantitative, difference profoundly alters the reaction of markets to the signal s at $t = 1$. These effects do not play out if the signal is good. In this case, representations do not change and the effect of news under local thinking is very similar to that under rational expectations. The price for riskless claims is unaffected by news while share prices rise to $p_A(\bar{s}) = E(y | y = y_g, y_d, \bar{s}) - y_d$.

When the signal is bad, matters are very different because now downside risk is represented as a recession with a payoff y_r rather than as a downturn with a payoff y_d . Investors now realize that the new claims are not riskless! This is so because the volume of new securities issued is $f^L = y_d/R$, so the total repayment promised to investors is equal to y_d , which exceeds the resources available in a recession. In a recession, intermediaries can repay to each holder of the new claim an amount equal to:

$$\frac{y_r}{y_d} \cdot R < R. \quad (10)$$

The large volume f^L of new securities issued under local thinking plays a critical role here. It is because f^L is large that in a recession the new securities become risky in the aggregate. The arrival of $s = \underline{s}$ reveals to investors that – contrary to their initial belief – the new claim is very different from the safe bond it sought to replicate, and drastically reduces their valuation of that claim. This is true even if the news is only marginally informative and investors realize that a recession is still quite unlikely (i.e., π_r is small), so that most of the

times the new claim will in fact repay the promised amount R . The possibility of a recession destroys the very idea that made the new claim appealing to investors at $t = 0$, namely that it was just like a riskless bond. The new claims are not true substitutes for the traditional claims; they are false substitutes, which severely affects financial markets at $t = 1$.

To see this, suppose that at $t = 0$ we are in case 2) of Proposition 1, where the price of all claims perceived to be riskless is $p_N = p_B = \theta \cdot R$. Equation (10) implies that after seeing \underline{s} investors value the new claim at $\theta(y_r/y_d) \cdot R$, which is the present value of that claim's payout in a recession. Since this valuation is lower than the claim's initial price, investors sell the new claim until its price drops to a new equilibrium level $p_{N1} < \theta \cdot R$. To calculate p_{N1} we also need to know the intermediaries' valuation of the new claim. It is immediate to see that after observing \underline{s} , intermediaries value the new claim at:

$$\omega^L \cdot R \quad \text{where} \quad \omega^L \equiv [(y_r / y_d) \Pr^L(y_r | \underline{s}) + \Pr^L(y_g | \underline{s})]. \quad (11)$$

That is, risk neutral intermediaries value the claim at its expected repayment. Parameter $\omega^L < 1$ reflects the drop in the new claim's payout, and plays an important role in our analysis. In particular, it can be interpreted as the local thinker's over-reaction to information; the lower is ω^L , the stronger is such overreaction.

To see this, note that, after observing \underline{s} , a rational agent values the claim at $\omega^{rational} R$, where $\omega^{rational} = (y_r/y_d) \cdot \pi_r(\underline{s}) + [\pi_g(\underline{s}) + \pi_d(\underline{s})]$ is always higher than ω^L . Thus, a rational intermediary values the new claim more than a local thinking one. This is so because, by neglecting y_d , the local thinker under-estimates the probability that the new claim repays in full. To see this, recall that the local thinker believes that the claim repays with probability $\Pr^L(y_g | \underline{s}) = \pi_g(\underline{s}) / [\pi_r(\underline{s}) + \pi_g(\underline{s})]$ which cannot be higher than $\Pr(y_g, y_d | \underline{s}) = \pi_g(\underline{s}) + \pi_d(\underline{s})$, the corresponding probability for a rational thinker. The difference between the local and rational thinker's valuations falls with the prior probability π_d of a downturn (and by A.1 that of a recession π_r). As $\pi_d \rightarrow 0$, it is also the case that conditional probability $\pi_d(\underline{s}) \rightarrow 0$, so that

both $\omega^{rational}$ and ω^L tend to one. If the new claim defaults with only a negligible probability, over-reaction is absent and the local and rationally thinking intermediaries attach the same value to that claim.

Consider now the market outcome at $t = 1$. We can prove:

Proposition 2 After a bad signal $s = \underline{s}$ at $t=1$, the traditional bond trades at the maximum price $p_{B1} = \theta \cdot R$. In contrast, the price p_{N1} of the new claim always drops below its equilibrium level p_B at $t = 1$. There are two cases:

1) If $\omega^L \leq \theta(y_r/y_d)$, which is equivalent to $y_r/y_d \geq \Pr^L(y_g|\underline{s})/[\theta - \Pr^L(y_r|\underline{s})]$, then irrespective of the $t = 0$ equilibrium we have $p_{N1} = \theta \cdot (y_r/y_d) \cdot R$ and the new claim is not traded at $t = 1$;

2) If $\omega^L > \theta(y_r/y_d)$, which is equivalent to $y_r/y_d < \Pr^L(y_g|\underline{s})/[\theta - \Pr^L(y_r|\underline{s})]$, then for a given fraction σ of the $t = 0$ income carried by the intermediary to $t = 1$, we have two sub-cases:

2.1) If $\underline{w} \leq w < \theta \cdot (R+y_d)$, the equilibrium at $t = 0$ falls in case 1) of Proposition 1. In this case, intermediaries' wealth at $t = 1$ is equal to $\sigma \cdot w$ and the equilibrium price of the new claim at $t = 1$ is equal to:

$$p_{N1}(\sigma) = \begin{cases} \omega^L R & \text{for } \sigma \geq \bar{\sigma}_1 \equiv \omega^L \frac{y_d}{w} \\ \sigma \frac{wR}{R+y_d} & \text{for } \sigma \in (\underline{\sigma}_1, \bar{\sigma}_1) \\ \theta(y_r/y_d)R & \text{for } \sigma \leq \underline{\sigma}_1 \equiv \theta(y_r/y_d) \frac{y_d}{w} \end{cases}, \quad (12.1),$$

2.2) If $w > \theta \cdot (R+y_d)$, the equilibrium at $t = 0$ falls in case 2) of Proposition 1. In this case, intermediaries' wealth at $t = 1$ is equal to $\sigma \cdot \theta \cdot (R+y_d)$ and the equilibrium price of the new claim at $t = 1$ is equal to:

$$p_{N1}(\sigma) = \begin{cases} \omega^L R & \text{for } \sigma \geq \bar{\sigma}_2 \equiv \omega^L \frac{y_d}{\theta(R+y_d)} \\ \sigma \cdot R \cdot \frac{\theta(R+y_d)}{y_d} & \text{for } \sigma \in (\underline{\sigma}_2, \bar{\sigma}_2) \\ \theta(y_r/y_d)R & \text{for } \sigma \leq \underline{\sigma}_2 \equiv \theta(y_r/y_d) \frac{y_d}{\theta(R+y_d)} \end{cases} \quad (12.2),$$

In cases 2.1) and 2.2), we have that $p_{N1}(\sigma) \in [\theta \cdot (y_r/y_d) \cdot R, \omega^L R]$ and $p_{N1}(\sigma)$ increases in σ . If $\sigma > 0$, the intermediary buys back at least some of the new claims from investors.

Proposition 2 demonstrates that at $t = 1$ the prices of the old bond and the new claim move in opposite directions. The arrival of bad news segments the market for riskless claims into two separate markets, one for truly riskless bonds and another for new securities. When the volume of new securities is so high that the $t = 0$ price of riskless claims is below θR [i.e. in equilibrium 1) of Proposition 1], then there is a *rise* in the price of the traditional bond, which spikes to its maximum possible level $p_{B1} = \theta R$. There is a close connection between this rise in the price of the traditional bond and the drop in investors' valuation of the new securities. After realizing that the new claims are risky, investors try to sell them in the market, not only to increase current consumption but also to purchase the truly riskless traditional bonds. This boost in the demand for bonds encounters a limited supply because bonds were already owned by investors at $t = 0$. The shortage of bonds, which encouraged the innovation in the first place, naturally leads to a "flight to safety" in our model once investors realize that the new securities are false substitutes for the old ones.

The price of the new securities drops from its initial level p_B to $p_{N1} < p_B$. Case 2) is the most interesting instance of this price drop, because in this case the local thinker's over-reaction is small, and the "false substitutes" effect is the only one responsible for financial fragility. Since $\omega^L < 1$, this case only arises when $\theta(y_r/y_d) < 1$, namely when investors value the new securities at less than their face value. The starkest instance of the false substitute

effect occurs when over-reaction is absent altogether; formally, when $\omega^L \approx 1$. Now investors' valuation of the claim is low not because it is unappealing per se, but because it is not the claim they wanted to hold. Intermediaries, who value the claim more, are willing to buy it back for almost its face value R . In this case, the fraction σ of the $t = 0$ income carried forward by intermediaries becomes critical, for it provides them with the liquidity needed to buy back the new claims. As Proposition 2 illustrates, there are two possible characterizations of the market equilibrium at $t = 1$, each of which is associated, via investors' income, with a different equilibrium at $t = 0$. The important common feature of these cases is that higher intermediaries' wealth σ increases their demand for new claims and thus reduces the price drop ($p_B - p_{N1}$).

To see this in detail, consider the following two examples. If the intermediaries carry little or no wealth to $t = 1$, they will not have the resources to buy all of the new claims, even when the latter are priced at investors' valuation $\theta \cdot (y_r/y_d) \cdot R$. This pattern of segmentation arising in the market for riskless claims at $t = 1$ is graphically represented in Figure 5:

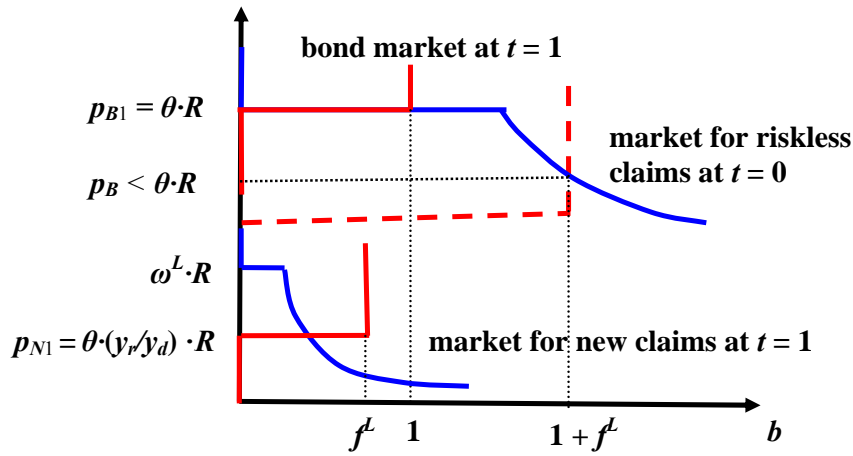


Figure 5

Now the only equilibrium is one where investors are indifferent between selling or not, namely $p_{N1} = \theta \cdot (y_r/y_d) \cdot R$. If we are in case 2.2 of Proposition 2, then the initial price was $p_B = \theta \cdot R$ and the drop in the new claim's price is $\theta R (y_d - y_r) / y_r$. But even if we are in case 2.1,

there is a price drop; the initial price in this case was $p_B = wR / (R + y_d)$, which is always higher than $\theta \cdot (y_r / y_d) \cdot R$ due to the fact – implied by A.2 – that $w > \theta(R + y_r)$.

Consider alternatively the extreme in which intermediaries carry all of their $t = 0$ income to $t = 1$ (i.e., $\sigma = 1$). Proposition 2 says that in this case the new claim's price is equal to the intermediaries' reservation value. Intuitively, when $\sigma = 1$ intermediaries have by assumption enough resources to buy all of the new claims at the *initial* equilibrium price p_B . This is true irrespective of whether we are in case 2.1 or 2.2. But then intermediaries also have enough resources to buy all of the new claims at their own reservation value $\omega^L \cdot R$ because $\omega^L \cdot R < p_B$. Thus, in equilibrium $p_{N1} = \omega^L \cdot R$. If we are in case 2.2 and the initial price for the new claim was $p_B = \theta \cdot R$, this amounts to a price drop of $(\theta - \omega^L)R$. But even if we are in case 2.1, the price of the claim must drop because the initial price p_B is necessarily not lower than R , while $p_{N1} = \omega^L \cdot R < R$.

More generally, in the “false substitute” effect of case 2, p_{N1} increases with σ , suggesting that intermediaries can potentially provide some insurance to investors against excessive drops in the price of new claims. To shed further light on this effect, Section 4 endogenizes intermediaries' wealth at $t = 1$ by adding production to the model.

Consider finally case 1 of Proposition 2. This is the case where $\omega^L \leq \theta \cdot (y_r / y_d)$, so that intermediaries' valuation of the new claim is lower than investors'. The equilibrium price for the new claim settles at $p_{N1} = \theta \cdot (y_r / y_d) \cdot R$. At this price, investors are happy to hold the claims they bought at $t = 0$ and no trading of claims takes place. In contrast to case 2), now the severe drop in the new claim's price does not depend on the lack of liquid wealth of intermediaries, but rather on the fact that the news has induced all market participants to downgrade their valuation of the new claim. This case can also arise when investors' valuation is below the new claim's face value [i.e. when $\theta \cdot (y_r / y_d) < 1$], but only provided

investors over-react (i.e. $\omega^L \ll 1$). Otherwise, we would be back to case 2) above. Over-reaction is a distinct source of financial fragility and of flight to safety in our model.

Although over-reaction is not necessary for the “false substitutes” effect, its presence amplifies the adverse impact of news’ shocks on the price of the new claim. We can show:

Corollary 1 Suppose that at some $t' \in (1,2)$ the state $i = g, d, r$ is becomes known to all and financial markets are open. If $\omega^{rational} \geq \max[\theta \cdot (y_r/y_d), \omega^L]$, the price of the new claim recovers on average at t' .

When the new claim defaults with a sufficiently small probability, namely when $\omega^{rational} \approx 1$, it is easy to see that, provided $\theta \cdot (y_r/y_d) < 1$, $\omega^{rational} \geq \max[\theta \cdot (y_r/y_d), \omega^L]$. In this case, there is a tendency in our model for the new claim to be under-valued at $t = 1$ and thus to experience on average a price recovery at $t' \in (1,2)$. This price recovery does not require over-reaction of investors because it occurs – due to the false substitute effect – even if $\omega^L \ll 1$, provided σ is low. However, investors’ over-reaction amplifies this effect when σ becomes sufficiently large, for the extent of price recovery is bounded below by $\omega^{rational} - \omega^L$.

3.3 Innovation, Local Thinking and Financial Fragility: Discussion

Our model places the demand for new claims at the heart of the link between financial innovation and fragility. Investors’ initial excess demand for safe claims encourages intermediaries to manufacture new claims out of risky cash flows that are perceived to be equally safe. As investors realize that the new claims are a false substitute for the old ones, their reluctance to hold on to these claims triggers a sharp price drop even after marginally bad news. Our model shows that these marked shifts in the demand for the new safe claims are inextricably connected with financial innovation.

The pressure to create new safe claims is strong precisely when investors disregard specific risks such as a possible collapse of home prices in light of favourable recent history. This optimism boosts intermediaries' ability to sell new claims and thus their incentive to innovate. The issuance glut renders the new claim vulnerable to the arrival of bad news that bring to mind previously neglected risks and thus the critical fact that the new claims are not as safe as the assets they sought to replicate. Because of their preferred habitats, investors try to rebalance their portfolios in favour of the truly safe traditional claims, triggering massive sales of the new claims and price drops. Such sales are not driven by leverage or liquidation demands, as in standard fire sales models, but by the fall in demand that arises as investors realize that these new securities are false substitutes for the old ones.

The general message of our model is that when investors have limited representations financial innovation creates a false substitutability between the new and traditional claims. This false substitutability explains both the excessive volume of innovation ex-ante and the ex-post flight to quality occurring as investors come to realize that the new claim exposes them to previously unattended to risks.

Although the motives for financial innovation are the same in our model as in Allen and Gale (1994), the consequences are very different. In our model, innovation benefits intermediaries who earn large profits selling securities at $t = 0$, but hurts investors, who are lured into an inefficient risk allocation and suffer from ex-post price drops. Investors' losses depends on the liquidity of intermediaries and their ability to provide backstop insurance against price drops at $t=1$. As we show in Section 5, investors losses from risk misallocation may be so large as to eliminate the social value of innovation altogether.

4. Innovation and Local Thinking in a Production Economy

Suppose that instead of the intermediaries owning assets, they have exclusive access to production technologies (or activities) B and A . Activity B yields R at $t = 1$ for any unit invested at $t = 0$. The return of activity A is stochastic, equal to y_i with probability π_i , where as before $i = g, d, r$. The riskless activity is in limited supply, so investment I_B in activity B cannot exceed 1. Investment I_A in activity A is in principle unbounded.

The intermediary has initial wealth $w_{int} < 1$ but can raise additional funds from investors by selling claims on A and B . The traditional claim to finance B is a riskless bond priced at p_B at $t = 0$ and yields R at $t = 2$; the traditional claim to finance A has a unit cost p_A and yields y_i at $t = 2$. The difference from the pure exchange economy of Sections 2 and 3 is that now the supply of claims must be consistent with the intermediary's optimal investment decisions. For brevity, we study this production economy only under local thinking, but we later discuss the role of limited representations. In the absence of innovation, the intermediary chooses investment levels I_B and I_A , and issues volumes b and a of traditional claims to solve:

$$\max_{b, a, I_A, I_B, i_A, i_B} \Pi \equiv R(I_B - b) + E^L y (I_A - a) - I_B - I_A + bp_B + ap_A + w_{int} \quad (13)$$

$$\text{s.t.} \quad I_B = bp_B + i_B, \quad (14)$$

$$I_A = ap_A + i_A, \quad (15)$$

$$i_B + i_A \leq w_{int}, \quad (16)$$

$$b \leq I_B \leq 1, \quad a \leq I_A. \quad (17)$$

In Equation (13), the intermediary's payoff is equal to the output generated by A and B net of investors' repayment, minus investment costs, plus the revenue from security sales at $t = 0$. Constraints (14) and (15) say that investment in A or B is equal to the intermediary's own investment in the activity (i_A, i_B) plus the funds raised from investors. Constraint (16) says that the intermediary's own investments cannot exceed his wealth w_{int} ; the constraints in (17) limit total investment and the supply of claims.

By substituting Equations (14) and (15) into the objective function (13) and in the constraints in (17) we can rewrite the intermediary's problem as:

$$\max_{b,a,i_A,i_B} \Pi \equiv R[(p_B - 1)b + i_B] + E^L y [(p_A - 1)a + i_A] - i_A - i_B + w_{int} \quad (18)$$

$$\text{s.t.} \quad i_B + i_A \leq w_{int}, \quad (19)$$

$$-(p_B - 1)b \leq i_B \leq 1 - p_B b, \quad -(p_A - 1)a \leq i_A. \quad (20)$$

The objective function (18) shows that the intermediary is willing to issue a claim only if its price is higher than 1. In this case, the revenue generated by each unit of security issued is higher than the investment cost of creating the promised return. We assume:

$$\mathbf{A.4:} \quad \theta \cdot y_d < 1 \text{ and } w > w^* = \theta \cdot [R + y_d (w_{int} - 1)] / (1 - \theta \cdot y_d)$$

The first part of A.4 says that investors' reservation price for the risky claim is less than one, which implies that in equilibrium $p_A < 1$ and thus the risky claim is not issued ($a = 0$). The second part of A.4 says that the investors' wealth is sufficiently high that, even with innovation, the price of riskless claims is $p_B = \theta \cdot R$. This restriction, which is stronger than the one in A.2, simplifies the equilibrium analysis but can be relaxed. Under A.4 it is immediate to see that the equilibrium at $t = 0$ works as follows:

Lemma 3 In the absence of innovation, no risky claim is issued ($a = 0$) and $p_A < 1$. The bond is issued for an amount $b = 1$ and $p_B = \theta \cdot R$. The intermediary withdraws profits from the sale of b from activity B by setting $i_B = -(\theta \cdot R - 1)$. If $E^L y \geq 1$ the intermediary invests these resources in A by setting $i_A = w_{int} + \theta \cdot R - 1$. If $E^L y < 1$ the intermediary sets $i_A = 0$ and consumes $w_{int} + \theta \cdot R - 1$ before $t = 1$.

The main features of the pure exchange equilibrium of Lemma 1 also obtain in the production economy. There is a shortage of riskless bonds, and their entire supply is sold to investors at their reservation price. No risky claims are issued. The only difference from the

pure exchange economy is that now the risky activity is only operated if its expected return is higher than the cost of investment (i.e., $E^L y \geq 1$).

4.1 Innovation, Equilibrium and Reaction to News

As in Section 3, the intermediary creates new riskless claims by pledging the lowest possible output level generated by A . The maximum quantity of new claims that can be created in this way is equal to:

$$f^{LP} = y_d \cdot I_A / R. \quad (21)$$

The ability to create new claims increases in the amount of investment in activity A . Taking this effect into account, with innovation the intermediary solves:

$$\max_{b, f, i_A, i_B} \Pi \equiv R[(p_B - 1)b + i_B] + (p_B E^L y - R)f + E^L y i_A + w_{int} - i_B - i_A \quad (22)$$

$$\text{s.t.} \quad i_B + i_A \leq w_{int}, \quad (23)$$

$$f \leq f^{LP} = i_A [y_d / (R - p_B y_d)], \quad (24)$$

$$-(p_B - 1)b \leq i_B \leq 1 - p_B b, \quad 0 \leq i_A. \quad (25)$$

Constraint (24) directly follows from substituting into (21) the definition of investment $I_A = fp_B + i_A$. One important implication of (24) is that new claims can only be issued if the intermediary invests some of his wealth in A by setting $i_A > 0$. This is due to assumption A.3, which implies that y_d is sufficiently small that the intermediary must insure investors against the bad state by committing some of its wealth to the project. We also assume:

A.5 $\theta \cdot E^L y > 1$.

A.5 implies that, in order to maximize objective (22) at $p_B = \theta \cdot R$, the intermediary always wants to issue the maximum possible volume of new bonds f^{LP} because the price the intermediary obtains for the bond issued on A is higher than the ratio between the promised return R and A 's average return $E^L y$. We then have:

Proposition 3 Under A.4 and A.5, there are two possible equilibrium configurations:

1) If $E^L y + (\theta - 1) \cdot y_d < 1$, innovation does not occur and the equilibrium described in Lemma 3 arises.

2) If $E^L y + (\theta - 1) \cdot y_d > 1$, innovation occurs. The price of riskless claims is $p_B = \theta \cdot R$, the intermediary sets $I_B = b = 1$ and $i_B = -(\theta \cdot R - 1)$. This allows the intermediary to set $i_A = w_{\text{int}} + \theta \cdot R - 1$, and to sell the new security in volume $f^{LP} = [w_{\text{int}} + \theta \cdot R - 1] [y_d / R (1 - \theta \cdot y_d)]$.

Compared to Proposition 1, here a cost of financial innovation arises endogenously when the physical return to capital in A is lower than the investment cost, i.e. $E^L y < 1$. In this case, creating new securities requires the intermediary to invest in the risky technology, which entails a private cost. If however the unit profit $(\theta - 1) \cdot y_d$ obtained by the intermediary from each new “riskless” claim is large enough to more than compensate for the cost [formally if $E^L y + (\theta - 1) \cdot y_d > 1$], then innovation takes place. As we shall see, through this effect financial innovation can be a source of investment inefficiencies because at $t = 0$ the intermediary may decide to invest in A and sell new claims even if without the possibility of financial innovation he would not invest.

The second message of Proposition 3 is that when the creation of new claims requires investment, an intermediary’s desire to create new claims introduces a strong force for it to commit all of his initial wealth and income to investment so as to expand the volume of innovation. As a consequence, when at $t = 1$ bad news arrives, the intermediary does not have spare wealth to buy any of the new claims back. The result below formally shows the consequences of this logic:

Proposition 4 In the equilibrium with innovation of Proposition 3, after the arrival of a bad signal $s = \underline{s}$ at $t = 1$, the price of the traditional bond stays constant at $p_{B1} = \theta \cdot R$, while the price of the new claim drops to $p_{N1} = \theta \cdot (y_r / y_d) \cdot R$ and new claims are not traded at $t = 1$.

The key difference from the result obtained in the pure exchange economy is that now the equilibrium price of the new claim drops to investors' valuation regardless of whether the intermediary's reservation price $\omega^L \cdot R$ for the same claim is higher than $\theta(y_r/y_d) \cdot R$. The intuition is that now intermediaries have no spare wealth to buy back the new claims at $t = 1$, as they have optimally invested the totality of their $t = 0$ resources to boost the volume of innovation. As a result, the local thinker's neglect of the possibility of a recession leads to substantial price drops even when intermediaries barely react to news. The idea that intermediaries tie up their capital in innovation, and have no spare liquidity in a crisis, is also present in Shleifer and Vishny (2010). In that model, intermediaries had to co-invest with outsiders to keep some "skin in the game." Here the mechanism is different: profit maximizing intermediaries need to commit their capital at $t = 0$ to provide insurance to investors, but doing so deprives them of liquidity in a crisis.

This analysis reinforces the message of the exchange model with respect to the role played by the shifting demand for new securities in generating financial fragility. The issuance "glut" fostered by investors' demand for riskless claims creates the room for severe price drops not only by inducing investors to recognize the claim as risky upon the arrival of bad news, but also by reducing the liquidity of intermediaries and thus their ability to support the new claim's price. The initial boost in the issuance of the new securities, and their ex-post price decline, are just two sides of the same coin.

5. Welfare Analysis

Section 2 showed that under rational expectations financial innovation is socially beneficial: it boosts intermediaries' profits while leaving investors' welfare unchanged.⁵ With

⁵ In the model of Section 2 intermediaries obtain the full benefit of innovation because assumption A.2 ensures that investors buy the new claim at their reservation price. If A.2 does not hold, the price of the new claim drops below $\theta \cdot R$, investors also benefit from innovation, and the creation of the new claim makes everybody better off.

local thinking, the welfare analysis is more complex. From the viewpoint of agents' beliefs at $t=0$, financial innovation is beneficial, just as under rational expectations. However, since agents' initial beliefs are incorrect, this welfare level is illusory because it does not account for the price drop occurring after bad news hit. Behavioural economists have long stressed that this tension between reality and incorrect beliefs raises important conceptual issues for defining a normative welfare metric. We do not aim to resolve these issues in this section.

Instead we consider how the “false substitute” effect created by financial innovation affects the average payoff realized by market participants, computed objectively as of $t=0$. To isolate the “false substitute” effect, we average payoffs by using the correct $t = 0$ distribution of the signal and by assuming that after observing s the beliefs of agents are correct. This implies that the market outcome at $t=1$ is computed by replacing ω^L with $\omega^{rational}$ in Proposition 2. This metric captures the average welfare that local thinkers realize if, after committing to investment, trading and consumption at $t = 0$, they are immediately told the realization of s and the true distribution of states. Little changes in the analysis if agents are local thinkers at $t=1$ as well. Given our interest in false substitutability, in welfare analysis we focus on the case of $\omega^{rational} > \theta \cdot (y_r / y_d)$. We also assume that in the exchange economy the new claim receives its maximal price $p_B = \theta \cdot R$ at $t = 0$, which facilitates the comparison between exchange and production, as in the latter case it is also true that $p_B = \theta \cdot R$.

5.1 Welfare in the Pure Exchange Model

Without financial innovation, the average welfare of investors at $t = 0$ is trivially equal to $E(U) = w$, while that of intermediaries to $E(\Pi) = \theta \cdot R + E(y)$, where U and Π denote the utility of the investor and intermediary, respectively. With financial innovation, investors obtain $E(U_{inn} | \bar{s}) = w$ upon observing \bar{s} and $E(U_{inn} | \underline{s}) = w - \theta \cdot R \cdot (1 + f^L) + \theta \cdot R \cdot [1 + (y_r / y_d) \cdot f^L]$ upon observing \underline{s} . In the latter case, the local thinker's valuation for the new claims drops to

$\theta \cdot (y_r/y_d) \cdot R$. Thus, the average welfare of investors from an ex-ante standpoint (i.e. across realizations of s) is equal to:

$$E_s(U_{\text{inn}}|s) = w - \Pr(\underline{s}) \cdot \theta \cdot [1 - (y_r/y_d)] R \cdot f^L, \quad (26)$$

where the subscript in the expectation operator indicates averaging with respect to signal values s . Equation (26) assumes that there is no re-trading of the new claims at $t = 1$. If the intermediary carries his wealth to $t = 1$, investors sell the new claims at $p_{N1} = \omega^{\text{rational}} \cdot R$, so that investors now obtain $w - \Pr(\underline{s}) \cdot (\theta - \omega^{\text{rational}}) R \cdot f^L$.

Consider now an intermediary. By selling riskless securities promising to repay R out of the risky claim, it obtains $E_s(\Pi_{\text{inn}}|s) = \theta \cdot R (1 + f^L) + E(y) - [\Pr(\underline{s})\omega^L + \Pr(\bar{s})]R \cdot f^L$. The third term in this formula accounts for the fact that repayment of the new claim drops when the signal is bad. The payoff of the intermediary does not change if the latter carries all of its wealth to $t = 1$ because, in this case, the intermediary buys the new claims back at its reservation price $\omega^L R$. It is immediate to show that:

Lemma 4 With financial innovation, the intermediary gains $[\theta - \Pr(\underline{s})\omega^{\text{rational}} - \Pr(\bar{s})]R \cdot f^L$ relative to the no innovation case. If the intermediary does not carry any wealth to $t = 1$, investors lose $\Pr(\underline{s}) \cdot \theta \cdot [1 - (y_r/y_d)] R \cdot f^L$ relative to the no innovation case; if instead the intermediary carries all of its wealth to $t = 1$ investors lose $\Pr(\underline{s}) \cdot (\theta - \omega^{\text{rational}}) R \cdot f^L$.

Innovation benefits the intermediary by allowing it to sell more claims while it hurts investors by enabling them to buy a claim that is more risky than they think. If intermediaries do not carry wealth to $t = 1$ then, after observing \underline{s} , the loss to investors is larger than intermediaries' gain because investors inefficiently bear risk in equilibrium. As a consequence, the intermediaries' average gain may be smaller than the investors' loss even if innovation increases the level of social welfare experienced after a good signal. If in contrast

intermediaries carry wealth to $t = 1$, then there is no “net loss” from innovation after \underline{s} : by buying back the new claims, intermediaries allow investors to increase current consumption, preventing them from bearing any future risk. Now total welfare rises with innovation.

This analysis illustrates that, besides creating market fragility, false substitutability adds a countervailing cost to the standard “market completing” benefit of financial innovation. When the ex-post drop in the prices the new securities is large, the cost may dominate and innovation may reduce overall welfare.

5.2 Welfare in the Model with Production

Investors’ welfare does not change much with production. Without innovation, $E(U) = w$ as in the pure exchange model. With innovation, since $p_B = \theta \cdot R$, we have that $E(U_{\text{inn}} | \bar{s}) = w$ and $E(U_{\text{inn}} | \underline{s}) = w - \theta \cdot R \cdot (1 + f^{L,P}) + \theta \cdot R \cdot [1 + (y_r/y_d) \cdot f^{L,P}]$, where $f^{L,P} = [w_{\text{int}} + \theta \cdot R - 1] [y_d / R (1 - \theta \cdot y_d)]$ is the volume of innovation occurring with production. Since the intermediary invests all of its wealth in A , it carries no wealth to $t = 1$. As a result, in the spirit of Lemma 3, investors lose $\Pr(\underline{s}) \cdot f^{L,P} \cdot \theta \cdot R [1 - (y_r/y_d)]$ from innovation.

Consider now the intermediary’s welfare. Lemma 4 says that without innovation the intermediary obtains $E(\Pi) = w_{\text{int}} + \theta \cdot R - 1$ if $E^L y < 1$ and $E(\Pi) = E(y) \cdot [w_{\text{int}} + \theta \cdot R - 1]$ if $E^L y \geq 1$. The only difference between the two cases is that when the intermediary perceives the average return from activity A to be higher than 1, he invests all of his wealth in it; otherwise he consumes his wealth immediately.

If the intermediary can instead innovate then, in light of Proposition 3, it does so when $E^L y + (\theta - 1) \cdot y_d > 1$. Otherwise, the intermediary behaves as in the case with no innovation. In the allocation of Proposition 3, the payoff obtained by the intermediary with innovation is on average equal to:

$$E(\Pi_{\text{inn}}) = \{E(y) - [\Pr(\underline{s})\omega^L + \Pr(\bar{s})]y_d\} \frac{w_{\text{int}} + \theta \cdot R - 1}{1 - \theta y_d}. \quad (27)$$

By exploiting equation (27) we then establish:

Proposition 5 When $E^L y + (\theta - 1)y_d > 1$, the intermediary innovates and two cases arise:

1) If $E^L y < 1$, the intermediary gains in the case of innovation when:

$$E(y) + \{\theta - [\Pr(\underline{s})\omega^L + \Pr(\bar{s})]\} \cdot y_d > 1, \quad (28)$$

and loses otherwise.

2) If $E^L y \geq 1$, the intermediary gains in the case of innovation when:

$$\theta E(y) > \Pr(\underline{s})\omega^L + \Pr(\bar{s}), \quad (29)$$

and loses otherwise.

In the model with production, not only investors, but also intermediaries might lose from financial innovation. As Equations (28) and (29) illustrate, intermediaries may lose from innovation when the true expected return from activity A is sufficiently low that manufacturing new claims is not profitable to begin with (not even by taking into account the fact that these claims do not repay in full in a recession). Formally, this means that $E(y)$ must be sufficiently smaller than 1. In this case, optimism about the profitability of the new claim at $t = 0$ encourages the intermediary to over-invest in an unproductive activity, eventually triggering a loss. The most interesting case in this respect occurs when $E^L y < 1$. Now the return to A is perceived to be sufficiently low that investment in A occurs only if new securities can be engineered, so financial innovation bears sole responsibility for unproductive investment. It can be argued that the expansion in the supply of housing in the last decade was an example of such inefficient investment needed to meet the growing demand for securitization of mortgages.

In sum, while under rational expectations financial innovation improves social welfare by reducing the shortage of riskless claims, under local thinking it can reduce both investors' and even intermediaries' welfare by distorting the allocation of risk and investment in the economy.

6. Extensions

6.1 Rational Intermediaries

We have assumed so far that intermediaries and investors share the same incorrect beliefs. We now show that the “false substitutes” effect holds even if the intermediaries hold rational expectations. Rationality of the intermediaries introduces two changes into our previous setting. First, the intermediaries evaluate returns at their true values, which influences their investment and issuance decisions. Second, intermediaries may try to profit from the possible drop in prices of the new securities by carrying some liquid wealth to $t = 1$. This second effect (emphasized by Diamond and Rajan 2010) is crucial because it may offset an intermediary's incentive to commit its wealth to the risky project so as to expand the supply of new claims.

When deciding at $t = 0$ what volume f of new securities to issue, what amount of own wealth i_A to invest in A and what amount of own wealth l to leave liquid for $t = 1$, a forward looking intermediary solves:

$$\begin{aligned} \max_{b, a, i_A, i_B} \quad \Pi \equiv & R[(p_B - 1)b + i_B] + [p_B E y - (1 - \pi_r)R - \pi_r(y_r/y_d)R]f + E y i_A + \\ & + w_{int} - i_B - i_A + l [\Pr(\underline{s})(\omega^{rational} \cdot R - p_{N1})/p_{N1} - 1] \end{aligned} \quad (30)$$

$$\text{s.t.} \quad i_B + i_A + l \leq w_{int}, \quad (31)$$

$$f \leq i_A [y_d / (R - p_B y_d)], \quad (32)$$

$$-(p_B - 1)b \leq i_B \leq 1 - p_B b, \quad 0 \leq i_A, \quad 0 \leq l \quad (33)$$

The rational intermediary anticipates, in the second term of the objective function in (30), the possibility that in a recession the new claim pays only $(y_r/y_d)R$. Additionally, the last term in Equation (30) illustrates that the intermediary expects to obtain a capital gain of $(\omega^{rational} \cdot R - p_{N1})/p_{N1}$ by leaving some liquid wealth l for the event that the signal turns out to be low, which occurs with ex ante probability $\Pr(\underline{s})$,⁶

As in Section 4, under A.5 the intermediary issues – for a given amount of capital i_A committed to A – the maximum possible amount of new claims at $t = 0$, implying that constraint (32) is binding. In addition, since the equilibrium price of riskless claims at $t = 0$ is still equal to $p_B = \theta \cdot R$, the intermediary invests up to capacity in B and sets $i_B = -(\theta \cdot R - 1)$. The new choice that the rational intermediary must make now is whether to invest his wealth $w_{int} + \theta \cdot R - 1$ into A so as to expand the supply of new claims at $t = 0$ or to store liquidity until $t = 1$ by setting $l > 0$.

From objective (30) and constraint (32), it is easy to check that at the equilibrium price $p_B = \theta \cdot R$ the return the intermediary obtains from increasing i_A is higher than that from increasing l , so that it is optimal for the intermediary to set $l = 0$ provided:

$$[\theta E y - (1 - \pi_r) - \pi_r(y_r/y_d)] \frac{y_d}{1 - \theta y_d} + E y > \Pr(\underline{s}) \left(\frac{\omega^{rational} \cdot R - p_{N1}}{p_{N1}} \right). \quad (34)$$

Equation (34) can be rewritten as:

$$\frac{\pi_g(y_g - y_d)}{1 - \theta y_d} > \Pr(\underline{s}) \cdot \left(\frac{\omega^{rational} \cdot R - p_{N1}}{p_{N1}} \right). \quad (35)$$

Even a rational intermediary invests all of its wealth in A when each unit invested in risky project generates a sufficiently large upside (which the intermediary keeps for himself). The return from investing \$1 in A is multiplied by factor $1/(1 - \theta y_d)$. This “multiplier”

⁶ One implicit restriction in the above problem is that the intermediary cannot issue deposits to investors to finance its liquidity at $t = 1$. This restriction is weak as these deposits must pay a return of 1 to the local thinking investor who is therefore indifferent between lending or not. Furthermore, under a broad set of conditions the rational intermediary does not want to carry liquid wealth, which reduces his demand for liquid deposits to zero.

captures the intermediary's ability to profit by creating new claims from such investment, realize a profit on them, to reinvest such profit in A to create more new claims and so on.

Condition (35) is easiest to satisfy when the probability that the new claim defaults is negligible [in the extreme when $\omega^{rational} = 1$] and the price of the new claim at $t = 1$ is lowest, namely when $p_{N1} = \theta \cdot (y_r / y_d) \cdot R$. As a result, the rational intermediary invests all of its wealth in A at $t = 0$ provided:

$$\frac{\pi_g (y_g - y_d)}{1 - \theta y_d} > \Pr(\underline{s}) \cdot \left(\frac{y_d - \theta y_r}{\theta y_r} \right), \quad (36)$$

which is satisfied for a broad range of parameter values. If Condition (36) does not hold, then the intermediary restricts the supply of new claims up to the point where the capital gain on the new claims is sufficiently small to use some but not all of his wealth to innovate, and to transfer the rest to $t = 1$.

6.2 Finite Risk Aversion

To study the case of finite risk aversion, we assume that investors' have Epstein-Zin (199X) preferences. These preferences take the general functional form:

$$U = \left\{ C_0^\rho + C_1^\rho + \theta \cdot \left[\pi_g \cdot C_g^\alpha + \pi_d \cdot C_d^\alpha + \pi_r \cdot C_r^\alpha \right]^\frac{\rho}{\alpha} \right\}^\frac{1}{\rho}, \quad (37)$$

where $\rho < 1$ captures the agent's intertemporal smoothing desire, $\alpha < 1$ risk aversion (which falls in α). If $\alpha = \rho$ the agent has standard CRRA preferences. Because we focus on risk aversion rather than on intertemporal smoothing, we set $\rho = 1$. In this case, Equation (37) tends to the infinite risk aversion formulation of Section 2 as $\alpha \rightarrow -\infty$.

We restrict the analysis to pure exchange. Without innovation, the intermediary sells bonds and shares to investors when $p_B \geq R$ and $p_A \geq E^L y$. Investors' wealth is large, so at $t = 0$ local thinking investors buy a shares and b bonds until:

$$\begin{aligned}
p_A &= \theta \cdot \left[\pi_g^L + \pi_d^L (C_d / C_g)^\alpha \right]^{\frac{1-\alpha}{\alpha}} \cdot \left[\pi_g^L y_g + \pi_d^L y_d (C_d / C_g)^{\alpha-1} \right], \\
p_B &= \theta \cdot R \cdot \left[\pi_g^L + \pi_d^L (C_d / C_g)^\alpha \right]^{\frac{1-\alpha}{\alpha}} \cdot \left[\pi_g^L + \pi_d^L (C_d / C_g)^{\alpha-1} \right],
\end{aligned} \tag{38}$$

where $C_g = ay_g + bR$ and $C_d = ay_d + bR$ (so that $C_g \geq C_d$). By simple differentiation, it is easy to verify the following key property: the bond price p_B decreases in C_d/C_g , the reverse is true for the share price p_A . Intuitively, as consumption in the two states becomes more similar, the investor needs less insurance so that the demand for bonds falls while that for shares rises.

As in Section 2, we focus on an equilibrium in which investors buy all the bonds ($b = 1$). With finite risk aversion, the investor optimally bears some risk by holding at least a few shares. If risk aversion is sufficiently high that investors do not absorb all the shares, then $p_A = E^L y$, so that intermediaries are willing to supply the equilibrium level of shares $a^* < 1$ [determined by the first Equation in (38)], and $p_B > R$ is determined by the second Equation in (38). We can show that the allocation and prices just described are equilibrium provided :

$$\mathbf{A.5} \quad E^L y > \theta \cdot \left[\pi_g^L + \pi_d^L (y_d + R / y_g + R)^\alpha \right]^{\frac{1-\alpha}{\alpha}} \cdot \left[\pi_g^L y_g + \pi_d^L y_d (y_d + R / y_g + R)^{\alpha-1} \right].$$

That is, for investors to buy all shares, price p_A must be so low that intermediaries are not willing to supply any share. A5 also ensures that $p_B > R$.

Consider now the case of financial innovation. One complication is that now after buying the new claim investors will also demand some shares because it is again optimal for them to bear some risk. As a result, the intermediary cannot supply more than $f = y_d(1 - a)/R$ new claims, where a is the amount of shares issued. By selling part of asset A in the form of risky shares, the intermediary reduces the cash flows available to create new claims. This implies that now the intermediary only supplies shares if the price of the latter satisfies:

$$p_A \geq E^L y + y_d \left(\frac{p_B}{R} - 1 \right). \tag{39}$$

The price of a share must compensate the intermediary not only for A 's expected return but also for the profits ensured by the creation of another new claim. If Equation (32) holds with inequality, the intermediary only supplies shares and does not innovate.

It is easy to check that A5 implies that Equation (39) cannot hold with inequality. Thus, investors purchase an amount of shares $a^{**} < 1$ and the volume of innovation is positive. In this equilibrium, p_A is pinned down by Equation (39) – which holds with equality – and investors buy all the riskless claims available. The latter's price is pinned down by the second Equation in (38) evaluated at the new consumption levels $C_g = a^{**}(y_g - y_d) + R + y_d$ and $C_d = R + y_d$ prevailing under innovation. Since innovation expands insurance opportunities, it increases C_d/C_g . As we have seen, such an increase in C_d/C_g reduces the price of riskless bonds, so that – as in Section 2 – innovation reduces p_B below the no-innovation level. A new effect arising under finite risk aversion is that, with innovation, share prices rise.

When bad news hit, agents substitute a downturn y_d with a recession y_r in their representations. This affects investors' valuation of their original portfolio because the news: i) changes investors' perception of the return streams of different assets, and ii) induces investors to revise downward their lowest consumption level to $C_r = R + y_r$.

Because bonds, new claims, and shares are all held by investors, and intermediaries have no wealth to buy them back, prices must adjust so that investors are happy to hold on to their original portfolios. As a result, prices at $t=1$ are equal to:

$$\begin{aligned}
p_{A,1} &= \theta \cdot \left[\pi_r^L + \pi_r^L (C_r / C_g)^\alpha \right]^{\frac{1-\alpha}{\alpha}} \cdot \left[\pi_g^L y_g + \pi_r^L y_r (C_r / C_g)^{\alpha-1} \right] \\
p_{N,1} &= \theta \cdot R \cdot \left[\pi_g^L + \pi_r^L (C_r / C_g)^\alpha \right]^{\frac{1-\alpha}{\alpha}} \cdot \left[\pi_g^L + (y_r / y_d) \pi_r^L (C_r / C_g)^{\alpha-1} \right] \\
p_{B,1} &= \theta \cdot R \cdot \left[\pi_g^L + \pi_r^L (C_r / C_g)^\alpha \right]^{\frac{1-\alpha}{\alpha}} \cdot \left[\pi_r^L + \pi_r^L (C_r / C_g)^{\alpha-1} \right]
\end{aligned} \tag{40}$$

The above expressions show that as the possibility of a recession comes to the agents' minds, the following three patterns obtain. First, $p_{A1} < p_A$ because investors realize that consumption is too unequal across states and the payout of shares is low: both of these facts reduce the

demand for shares and thus their price. Second, $p_{B1} > p_B$ as the demand for the truly safe claim increases with the agent's desire to smooth consumption across states.⁷

What about the price of the new claim? Given that, as we assume, the signal is not very informative (formally, even for a local thinker $\pi_r^L \approx \pi_d^L$), we have that $p_{N1} < p_B$ provided the following sufficient condition holds⁸:

$$\frac{y_r}{y_d} \leq \frac{R}{R + y_g - y_d}. \quad (41)$$

Condition (34) says that the drop in the new claim's repayment in recession must be sufficiently large that this claim is effectively perceived as risky at $t = 1$. Condition (34) holds for any value of risk aversion $\alpha < 1$, implying that the main qualitative properties of the infinite risk aversion setting (drop in the price of new claims and increase in the price of old claims relative to $t = 0$) also hold when risk aversion is finite.

7. Discussion

Our paper offers a different perspective on the recent financial crisis and policy reforms that have emerged among economists. Several economists, including Gorton and Metrick (2010) and Stein (2010) recognize the creation of safe securities as an important function of the banking and shadow banking systems. In their view, the creation of such “private money” is in itself desirable, but exposes the financial system to the risks of financial meltdown due to socially excessive leverage. Desirable policies would thus seek to preserve the creation of liquidity by the banking system, but control leverage or improve mechanisms of reducing leverage and unwinding security holdings in distress. Recent proposals for

⁷ One can check that at the above prices the intermediary would like to buy back shares and sell new claims to investors. However, since the intermediary neither has wealth nor new claims (or bonds) to exchange, he is at a “corner” where he cannot trade with the investor.

⁸ The logic to find condition (34) is the following. Start from the $t = 0$ price of riskless assets p_B . If only the return of the new asset is revised according to the new expectations then, provided $\pi_r^L \approx \pi_d^L$, the price must fall. Condition (34) ensures that, starting from this revised price level the price of the new claim drops further once the change in the consumption patterns is also taken into account.

financial reform, such as those of the Squam Lake Group (2010), Duffie (2010), or the Dodd bill in the US senate largely adopt this point of view.

Our model, in contrast, questions the idea that all creation of private money by the banking system is necessarily desirable. We recognize the benefits of private supply of safe securities, but also note that, at least in some cases, such securities proved to be false substitutes for the traditional ones. False substitutes by themselves lead to financial instability, and may reduce welfare, even without the effects of excessive leverage.

The financial fragility discussed in our model would interact, perhaps dangerously, with leverage. When investors or intermediaries perceive some securities to be safe, they would borrow using them as collateral, often with very low haircuts (Shleifer and Vishny 2010, Stein 2010). The realization that these securities are actually risky would lead to their sales by both investors and intermediaries trying to meet their collateral requirements, leading to additional fragility from fire sales. The stronger is the ex ante belief that securities are safe, the higher is the borrowing against them, and the more extreme the fire sales. Sales from unwinding levered positions and sales from disappointed expectations thus go in the same direction. As discussed by Shleifer and Vishny (2010) and Stein (2010), depressed security prices can have especially adverse welfare consequences ex post because they cut off lending to new investment. A financial crisis leads to an economic crisis. We do not discuss these welfare issues here because they have been analyzed elsewhere, but only emphasize the reinforcing influence of leverage and misunderstood risks on fragility.

If this perspective is correct, it suggests that recent policy proposals, while desirable in terms of their intent to control leverage and fire sales, do not go nearly far enough. It is not just the leverage, but the scale of financial innovation and of creation of new claims itself, that might require regulatory attention. Whether such strategies can mitigate fragility without shutting off financial innovation is a crucial question for further study.

8. Proofs

Proof of Lemma 1. The proof is straightforward but illustrates the basic logic behind several of our results. Given that $Ey > \theta \cdot y_d$, there exists no price $p_A \geq Ey$ at which intermediaries are willing to sell that also induces investors to buy. As a result, $p_A = Ey$ and each intermediary is happy to hold its endowment of shares, i.e. $a = 0$. If $p_B < \theta \cdot R$, investors demand more than 1 unit of bonds [because by A2 $w/\theta R > 1$] and – provided $p_B \geq R$ – intermediaries are willing to sell the full supply $b=1$. As a result, in equilibrium it must be that $p_B = \theta \cdot R$ so that is optimal for investors to buy exactly $b = 1$.

Proof of Lemma 2. The result directly follows from the proof of lemma 1, with only two changes. First, the supply of bonds is now equal to $b = 1 + y_r/R$, but A2 implies that investors can absorb all of it at their reservation price, so in equilibrium $p_B = \theta \cdot R$. Second, $p_A = Ey - y_d$ and none of the risky claims is sold to investors (who value them zero).

Proof of Proposition 1. The result directly follows from the proof of lemma 1, with the only changes of replacing y_r with y_d . Then, since the supply of bonds is now $b = 1 + y_d/R$, if investors can absorb it at their reservation price, namely if $w/\theta \cdot R \geq 1 + y_d/R$, in equilibrium $p_B = \theta \cdot R$. If instead this is not the case, i.e. if $w < \theta \cdot (R + y_d)$, then investors spend all of their wealth to purchase the bonds and $p_B = wR/(R+y_d) > R$.

Proof of Proposition 2. Consider the market's reaction to a bad signal \underline{g} . In the first place, note that the $t = 1$ equilibrium must have $p_{B,1} = \theta \cdot R$. To see why, suppose that $p_{B,1} < \theta \cdot R$ (as we have seen, $p_{B,1} > \theta \cdot R$ is not an equilibrium because at this price investors sell their bonds but intermediaries are not willing to buy them). At this price, investors want to purchase as many bonds as possible provided $p_{N,1} > (y_r / y_d) p_{B,1}$ for in this case the price-return ratio is lower for bonds than for the new claim. This cannot of course be an equilibrium because investors' demand for bonds does not encounter any supply. Consider instead the case where $p_{N,1} \leq (y_r / y_d) p_{B,1}$. Now the new claim is priced below investors' valuation $p_{N,1} < (y_r / y_d) \theta \cdot R$. This cannot however be an equilibrium because all investors demand the new claim (or some of the bond as well) but nobody supplies it. As a result, it must be that $p_{B,1} = \theta \cdot R$.

Consider now the market for the new claim. Given that $p_{B,1} = \theta \cdot R$, if $p_{N,1} < (y_r / y_d) \theta \cdot R$ all investors would demand the new claim at $t = 1$, which cannot be an equilibrium because investors hold the total supply of it. As a result, in equilibrium it must be that $p_{N,1} \geq (y_r / y_d) \theta \cdot R$. If $p_{N,1} = (y_r / y_d) \theta \cdot R$ investors are indifferent between holding and selling the claim, if $p_{N,1} > (y_r / y_d) \theta \cdot R$ investors supply their total holdings f^L . If $\omega^L < (y_r / y_d) \theta$, the intermediary's valuation of the new claim is lower than investors' valuation. As a result, the equilibrium price is equal to $p_{N,1} = (y_r / y_d) \theta \cdot R$. If instead $\omega^L > (y_r / y_d) \theta$, intermediaries are willing to buy at least some of the claims from investors and the equilibrium price $p_{N,1}$ depends on the share σ of $t = 0$ income carried by the intermediary to $t = 1$.

The intermediary's $t = 0$ income can take two values depending on whether the $t=0$ equilibrium falls in case 1) or 2) of proposition 1. If we are in case 1), namely $\theta \cdot (R + y_r) < w < \theta \cdot (R + y_d)$, the intermediary's $t = 0$ income is equal to w . As a result, the intermediary's wealth at $t = 1$ is equal to $\sigma \cdot w$. By equalizing supply and demand for the new claim one can easily find that the equilibrium price is equal to:

$$p_{N,1}(\sigma) = \begin{cases} \omega^L R & \text{for } \sigma \geq \bar{\sigma}_1 \equiv \omega^L \frac{y_d}{w} \\ \sigma \frac{wR}{R + y_d} & \text{for } \sigma \in (\underline{\sigma}_1, \bar{\sigma}_1) \\ \theta(y_r / y_d) & \text{for } \sigma \leq \underline{\sigma}_1 \equiv \theta(y_r / y_d) \frac{y_d}{w} \end{cases},$$

Which implies, together with A2 that $p_{N,1}(\sigma) < p_B = wR / (R + y_d)$.

Suppose instead that we are in case 2), namely $w > \theta \cdot (R + y_d)$, the intermediary's $t = 0$ income is equal to $\theta(R + y_d)$. In this case, the intermediary's wealth at $t = 1$ is equal to $\sigma \cdot \theta(R + y_d)$. By equalizing supply and demand for the new claim one can easily find that the equilibrium price is now equal to:

$$p_{N,1}(\sigma) = \begin{cases} \omega^L R & \text{for } \sigma \geq \bar{\sigma}_2 \equiv \omega^L \frac{y_d}{\theta(R + y_d)} \\ \sigma \cdot R \cdot \frac{\theta(R + y_d)}{y_d} & \text{for } \sigma \in (\underline{\sigma}_2, \bar{\sigma}_2) \\ \theta(y_r / y_d) & \text{for } \sigma \leq \underline{\sigma}_2 \equiv \theta(y_r / y_d) \frac{y_d}{\theta(R + y_d)} \end{cases},$$

It is obvious that $p_{N,1}(\sigma) < p_B = \theta R$.

Proof of Corollary 1. This result immediately follows from the fact that the price of the new claim at t' is on average equal to $\omega^{rational}R$. As a result, when $\omega^{rational} \geq \max[(y_r/y_d)\theta, \omega^L]$, the claim is under-valued at $t = 1$ and its price on average recovers at t' .

Proof of Lemma 3. For investors to buy shares it must be that $p_A \leq \theta \cdot y_d$; by A3 this implies that investors only buy shares if $p_A < 1$. However, in objective (18) the intermediary issues shares only if $p_A \geq 1$. As a result, in equilibrium the intermediary does not issue any shares and $p_A = 1$. Since in equilibrium $p_B = \theta R \geq R$, the intermediary issues the maximal amount $b = 1$ bonds because these yield at least as much as the intermediary's own investment i_B in B at the same unit investment cost. Thus, the intermediary withdraws from B the profits from bond sales by setting $i_B = -(\theta R - 1)$. The intermediary then invests these resources along with his own wealth w_{int} in A if and only if $E^L y > 1$.

Proof of Proposition 3. Assume for now that $p_B = \theta R$, we later show that in equilibrium it must be so. This has two consequences; first, together with A4 implies in objective (22) that the intermediary issues the maximum volume of new claims so that (23) is binding. Second, as in the proof of lemma 3, the intermediary issues $b = 1$ bonds and sets $i_B = -(\theta R - 1)$. By substituting $p_B = \theta R$ and constraint (24) in the intermediary's objective (22), we see that up to an additive constant such objective becomes equal to:

$$\left[\frac{E^L y + (\theta - 1)y_d - 1}{1 - \theta y_d} \right] i_A.$$

As a result, when $E^L y + (\theta - 1)y_d < 1$ the intermediary sets $i_A = 0$ and does not create any new claims. When instead $E^L y + (\theta - 1)y_d \geq 1$ the intermediary sets i_A at its maximum $w_{int} + (\theta R - 1)$ and issues new claims for the volume implied by Equation (24). It is easy to check that given A4 this volume is sufficiently low (relative to investors' wealth w) that the equilibrium price for riskless bonds is effectively equal to $p_B = \theta R$.

Proof of Proposition 4. The logic of the proof is identical to the one used in the Proof of Proposition 2. The only difference is that now the production structure pins down the intermediary's wealth at $t = 1$ which is $\sigma = 0$.

Proof of Proposition 5. The proof is by inspection.

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