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Traditional and Shadow Banks during the Crisis

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Traditional and Shadow Banks During The Crisis

We present a model of the interactions between traditional and shadow banks that explains their coexistence. In the 2007 financial crisis, some of shadow banks' assets and liabilities moved to traditional banks, and assets were sold at fire sale prices. Our model is able to accommodate these stylized facts. The difference between traditional and shadow banks is twofold. First, traditional banks have access to a guarantee fund that enables them to issue claims to households in a crisis. Second, traditional banks have to comply with costly regulation. We show that in a crisis, shadow banks liquidate assets to repay their creditors, while traditional banks purchase these assets at fire-sale prices. This exchange of assets in a crisis generates a complementarity between traditional and shadow banks, where each type of intermediary benefits from the presence of the other. We find two competing effects from a decrease in traditional banks' support in a crisis, which we dub a substitution effect and an income effect. The latter effect dominates the former, so that lower anticipated support to traditional banks in a crisis increases entry in the traditional banking sector *ex-ante*.

Keywords: Traditional banking, Shadow banking, Safe money-like claims, Financial crisis
JEL Codes: E32, E44, E61, G01, G21, G23, G38.

Banques Traditionnelles Et Système Bancaire Parallèle En Temps De Crise

Nous présentons un modèle des interactions entre les banques traditionnelles et le système bancaire parallèle et de leur coexistence. Au cours de la crise financière de 2007, certains actifs et passifs du système bancaire parallèle sont passés aux banques traditionnelles et les actifs ont été vendus à des prix bradés. Notre modèle réplique ces faits stylisés. La différence entre les banques traditionnelles et le système bancaire parallèle est double. Premièrement, les banques traditionnelles ont accès à un fonds de garantie qui leur permet de se financer sans risque en période de crise. Deuxièmement, les banques traditionnelles doivent respecter une réglementation coûteuse. Nous montrons qu'en cas de crise, le système bancaire parallèle liquide ses actifs pour rembourser ses créanciers, alors que les banques traditionnelles achètent ces actifs à des prix bradés. Cet échange d'actifs en temps de crise génère une complémentarité entre les banques traditionnelles et le système bancaire parallèle, où chaque type d'intermédiaire profite de la présence de l'autre. Nous constatons deux effets concurrents d'une diminution du soutien aux banques traditionnelles en période de crise, que nous appelons effet de substitution et effet de revenu. Ce dernier effet domine le premier, de sorte qu'un niveau de soutien anticipé plus faible aux banques traditionnelles en temps de crise induit plus de banquiers à s'orienter vers le secteur traditionnel *ex-ante*.

Mots clés: Banques traditionnelles, Système bancaire parallèle, Actifs sûrs, Crise financière
Codes JEL: E32, E44, E61, G01, G21, G23, G38.

Non-technical summary

Research question

The modern financial system is composed of a wide variety of financial intermediaries, ranging from commercial banks, to investment banks, REITs, Mutual funds or others. In particular, since the 1970's, a growing share of the financial intermediation has been performed outside of the regulated, traditional banking sector, in a sector called *shadow banking sector*. This sector was at the heart of the recent financial crisis and the behavior of the traditional banking sector and the shadow banking sector have strikingly differ during that period.

This paper aims at investigating the causes and consequences of the coexistence of different forms of financial intermediaries, interacting in centralized financial markets, as well as the implications of such an heterogeneity, in the propagation and resolution of financial distress.

Understanding the reason why different forms of intermediation coexist and interact in the modern financial system, and the way they do it, is particularly important to understand how the global financial sector must be regulated.

Contribution and results

This paper is a first attempt to provide a theory of traditional and shadow bank's coexistence in the light of their interaction in times of crises.

In times of crisis, traditional banks buy assets from shadow banks and demand a return to compensate them for the liquidity they provide in the market. This requirement leads to a depreciation of the shadow banks' asset prices. The advantage of traditional banks in providing liquidity to the markets comes from the government guarantee that allows them to attract depositors during this period. This advantage in times of crisis offsets the regulatory overheads that traditional banks normally bear, and justifies the coexistence of these two sectors.

In light of this coexistence, this paper shows that the effect of tightening traditional banks' regulation might be ambiguous concerning the allocation of financial intermediaries between shadow and traditional banking. Indeed, increasing traditional bank's regulation has two opposite effects: on the one hand it reduces the ability of traditional banks to invest, which hinders their development. On the other hand it also prevents traditional banks to purchase shadow banks assets in bad times, hence reducing the backup shadow banks benefit from in bad times, and their ability to invest in normal times. In our setting, this second effect dominates and increased constraints on traditional banks leads to an expansion of traditional banks' activity compared to shadow bank's one.

Résumé non technique

Question de recherche

Le système financier moderne est composé d'une grande variété d'intermédiaires financiers, allant des banques commerciales, aux banques d'investissement, en passant par les FPI, ou les fonds communs de placement. En particulier, depuis les années 1970, une part croissante de l'intermédiation financière a été réalisée en dehors du secteur bancaire réglementé et traditionnel, dans un secteur appelé secteur bancaire parallèle. Ce secteur a été au cœur de la récente crise financière mondiale et le comportement du secteur bancaire traditionnel et du système bancaire parallèle ont considérablement différé pendant cette période.

Cet article vise à étudier les causes et les conséquences de la coexistence de différentes formes d'intermédiation financière, interagissant ensemble sur des marchés financiers centralisés, ainsi que les implications d'une telle hétérogénéité, dans la propagation et la résolution de la détresse financière.

Comprendre la raison pour laquelle les différentes formes d'intermédiation coexistent et interagissent dans le système financier moderne, et leur façon de le faire, est particulièrement important pour comprendre comment le secteur financier global doit être réglementé.

Contribution et résultats

Cet article est une première tentative de proposer une théorie de la coexistence des banques traditionnelles et du secteur bancaire parallèle à l'aune de leur interaction en période de crise.

En période de crise, les banques traditionnelles achètent les actifs du secteur bancaire parallèle et exigent un rendement pour les compenser pour la liquidité qu'elles fournissent sur le marché. Cette exigence induit une dépréciation des prix des actifs du système bancaire parallèle. L'avantage des banques traditionnelles dans la provision de liquidités aux marchés provient de la garantie du gouvernement qui leur permet d'attirer les déposants pendant cette période. Cet avantage en temps de crise compense les surcoûts réglementaires que les banques traditionnelles supportent en temps normal, et justifie la coexistence de ces deux secteurs.

À la lumière de cette coexistence, cet article montre que le renforcement de la réglementation des banques traditionnelles pourrait avoir des effets ambigus sur l'allocation de l'intermédiation financiére entre les deux secteurs. En effet, le renforcement de la réglementation a deux effets opposés: d'une part, il réduit la capacité des banques traditionnelles à investir, ce qui entrave leur développement. D'autre part, cela empêche également les banques traditionnelles d'acheter des actifs du système bancaire parallèle dans les mauvais moments, réduisant ainsi le support apporté au système bancaire parallèle en crise et par conséquent leur capacité à investir en temps normal. Dans notre contexte, ce second effet domine et les contraintes accrues sur les banques traditionnelles entraînent une expansion de l'activité des banques traditionnelles au détriment du secteur bancaire parallèle: une réglementation plus contraignante du secteur traditionnel ne conduit donc pas à un plus grand développement du secteur bancaire parallèle mais affecte toutefois la capacité totale d'intermédiation du secteur financier.

1 Introduction

Recent decades have seen the emergence of financial institutions that perform bank-like activities outside of the regulated (traditional) banking system. This so-called shadow banking system has now reached a size comparable to that of the traditional banking system, representing about one-fourth of total financial intermediation worldwide.[1] The collapse of shadow banking in 2007 to 2008 has arguably played a role in threatening traditional banks' stability and bringing about the financial crisis. The crisis started with a run on shadow banks that endangered the stability of the entire financial system, raising important questions. Why are there two types of banks? How do different types of banks interact in a crisis? Are traditional and shadow banks substitutes or complements? This paper offers the first model of financial intermediation where both a regulated and an unregulated financial sector coexist and interact, while replicating the following facts from the crisis: (i) liabilities transfer from shadow to traditional banks, (ii) assets transfer from shadow to traditional banks, and (iii) fire sales of assets.

Existing theories of traditional and shadow banking emphasize the substitutability between the two. Given that shadow banks are not subject to the regulations that pertain to traditional banks, these regulations might spur financial intermediation into shadow banking to exploit regulatory arbitrage. This view emphasizes the regulatory costs of traditional banks, failing to explain why traditional and shadow banks coexist and omitting the fact that the two bank types behaved differently in the crisis. As shown by He et al. (2010), a striking feature of the US financial crisis is that both assets and liabilities moved from shadow to traditional banks. Some assets such as mortgage-backed securities were sold at fire-sale prices. We document these three facts. First, almost \$600 billion of deposits and borrowings went into the largest traditional banks in 2008q3. This happened in less than a month, concomitantly to a wide run on the shadow banking system. Second, there was a mirror image in terms of asset flows, with approximately \$800 billion assets out of shadow banks and \$550 billion into traditional banks from 2007q4 to 2009q1. Third, some assets were sold at fire sale prices; notably mortgage-backed government-agency securities. These facts suggest some form of complementarity between bank types. We propose a theory of the coexistence of traditional and shadow banks that accommodates the above stylized facts. The theory is based on their interaction in a crisis.

Our model describes the different technologies used by traditional and shadow banks to issue riskless claims against risky collateral. On the one hand, traditional banks have access to a guarantee fund to issue riskless claims in a crisis. This access also enables them to issue riskless claims outside a crisis, because these claims can be rolled-over in a crisis. Access to the guarantee fund comes at the cost of higher regulation for traditional banks. On the other hand, shadow banks rely upon traditional banks' ability to issue riskless claims in a crisis, to absorb their assets and provide them with enough liquidity to reimburse their creditors.

If traditional and shadow banks cannot trade assets in a crisis, traditional banks use their access to the guarantee fund only to roll-over their debt. If traditional banks cannot purchase assets from shadow

[1] This estimate is in terms of credit intermediation (see IMF, 2014). For empirical descriptions of shadow banking, see Pozsar et al. (2013) for the United States, ESRB (2016) for the European Union, IMF (2014) and FSB (2015) for global estimates. Globally, shadow banks' assets were worth \$80 trillion in 2014, up from \$26 trillion more than a decade earlier (FSB (2015)).

banks in a crisis, these latter are unable to issue debt before a crisis. Therefore absent a secondary market for assets traditional banks are levered but shadow banks are not, and the two bank types are substitutes. Instead, if we allow traditional and shadow banks to trade assets in a crisis, both bank types gain from asset trade and traditional banks purchase assets from shadow banks. This interaction in the asset market enables traditional banks to intermediate government insurance to shadow banks, generating a complementarity between the two forms of financial intermediation. This complementarity is the key message of this paper: the more shadow banks in the system, the lower the price traditional banks have to pay for shadow banks' assets in a crisis, and the better off traditional banks. Conversely, the more traditional banks, the higher the (indirect) support from the guarantee fund to the entire financial system in a crisis and the better off the shadow banks. In that sense, traditional and shadow banks form an ecosystem.

Our model yields two sets of results. We endogenize bankers' choice to enter the shadow versus traditional banking sector, and the first result is that coexistence of traditional and shadow banks can arise in equilibrium. It is intrinsically linked to fire sales of assets from shadow to traditional banks in a crisis. In a crisis, traditional banks' ability to issue riskless debt is limited,[2] therefore traditional banks require a discount on asset prices in a crisis to forgo investment opportunities before a crisis, which endogenously determines asset (fire sale) prices in a crisis. Because shadow banks must sell assets in a crisis to repay their creditors, asset prices determine the amount of riskless debt that shadow banks can issue before a crisis. Both banks' expected profits and thereby bankers' choice to enter either type of banking sector is linked to the other banks' decisions through the channel of asset fire sales in a crisis.

Second, we find two competing effects from a reduction in traditional banks' ability to issue deposits in a crisis.[3] On the one hand, this reduces traditional banks' advantage. Traditional banks have access to a lower level of guarantee, which limits their leverage at all times, hence exerting a downward pressure on their profits. This makes traditional banking relatively less profitable than shadow banking, thereby inducing bankers to enter the shadow banking sector. We call this direct effect a substitution effect.[4] On the other hand, note that shadow banks indirectly benefit from traditional banks' access to the guarantee fund through the (secondary) asset market in a crisis. Lowering traditional banks' guarantee in a crisis reduces the support that they provide to shadow banks. This decreases the price at which assets can be sold on the secondary market, hence reducing shadow banks' profits and bankers' incentives to enter the shadow banking sector. We call this effect an income effect. Overall, we find that lower support to traditional banks in a crisis reduces asset prices to such an extent that more bankers choose to enter the traditional banking sector *ex-ante*, i.e. the complementarity effect outweighs the substitution one.

Related literature We argue that traditional banks still compete with but also complement shadow banks, because of their ability to issue deposits in a crisis. Diamond and Dybvig (1983) is the seminal

[2]We think of the guarantee fund as a governmental entity. Therefore this limit captures some form of limited fiscal capacity that prevents the guarantee fund from insuring too large an amount of traditional banks debt.

[3]The reverse reasoning holds true for an increase in traditional banks' ability to issue deposits in a crisis. The reason why We consider small reductions in traditional banks' support in a crisis is that large reductions in traditional banks' support in a crisis wipe out traditional banks from the market, which is an effect already emphasized in the literature.

[4]It is reminiscent of the argument at play in existing models of shadow banking as regulatory arbitrage (see e.g. Plantin, 2015; Ordonez, 2013; Harris et al., 2015).

paper providing a rationale for traditional banks' deposit insurance that is based on the elimination of depositors' incentives to run their bank. Merton (1995) and Rajan (1998a,b) are early discussions questioning the future of traditional banks,[5] which suggest that many of the services provided by traditional banks can be sustained by other types of banks in the modern institutional environment.

In our model, asset fire sales are key to understanding the relationship between traditional and shadow banks. As in Shleifer and Vishny (1992), the price of assets sold during the crisis is the price at which the best users of these assets (traditional banks in our model) can pay, given they are limited in their ability to issue deposits. Shleifer and Vishny (1997) and Gromb and Vayanos (2002) model fire sales during which mispricing occurs due to frictions on arbitrageurs' funding capacity. Acharya et al. (2012) study interbank lending and asset sales when some banks have market power vis-a-vis other banks. Diamond and Rajan (2011) discuss liquidity risks on both sides of banks' balance sheet, and inefficient exposure to fire sales.

A second group of theories relates to traditional banks' regulation and their coexistence with shadow banks.[6] Hanson et al. (2015) are interested in the implications of traditional versus shadow banking businesses in terms of the assets that are held by financial intermediaries. Plantin (2015) studies optimal bank capital regulation in the presence of shadow banking, and finds that the optimal regulation needs not be in line with current regulatory reforms. Ordonez (2013) proposes a model in which reputational concerns are an effective disciplining device in the shadow banking sector. When reputation concerns are weak, banks can only operate using traditional banking. Harris et al. (2015) develop a model where capital requirements reduce banks' risk-taking incentives while lowering their funding capacity, and discuss the cyclicality of optimal bank capital regulation in light of the amount of capital in the economy. Gornicka (2016) and Luck and Schempp (2014) present models where a crisis in the shadow banking sector transmits to the traditional banking sector through guarantees to shadow banks.

Finally, a strand of the literature ties banks' investment choices with asset markets, in line with the mechanism at play in our model. This approach substantially improves the quantitative dynamics of risk premia in crisis episodes where intermediaries' equity capital is scarce. Major contributions in this literature include Adrian and Boyarchenko (2015), Brunnermeier and Sannikov (2014), He and Krishnamurthy (2013) and Viswanathan and Rampini (2010).

The paper proceeds as follows. Section 2 presents stylized facts about traditional and shadow banks during the crisis. Section 3 presents the model, and we analyze the possible coexistence between shadow and traditional banks in Section 4. In Section 5 we discuss the substitution and complementarity effects, and the implications of our model. Section 6 concludes.

[5]Other early discussions of the evolution of the financial landscape are Boyd and Gertler (1994) and James and Houston (1996).

[6]Our model is in line with theories of financial intermediation as issuers of riskfree claims. A seminal paper is Gorton and Pennacchi (1990), and other papers include Stein (2012), DeAngelo and Stulz (2015) and Plantin (2015). As in Gennaioli et al. (2013), Krishnamurthy (2010), Caballero and Krishnamurthy (2008) or Caballero and Farhi (2016), we model households' demand for safety as stemming from households' risk aversion.

2 Motivating evidence

In this section, we document three stylized facts using data from the Financial Accounts of the United States (henceforth FAUS), the Federal Reserve H8 Releases and the quarterly Call Reports. From the FAUS data we define traditional banks as the private depository institutions (L.110). Those institutions are composed of U.S.-chartered depository institutions (L.111), foreign banking offices (L.112), banks in U.S.-affiliated areas (L.113) and credit unions (L.114). Although our stylized facts do not rely on a precise definition of shadow banking using the FAUS, quantitative results depend on which institutions we identify as part of the shadow banking sector. We adopt the view of shadow banking as a chain of market-based transactions among legal institutions which, taken together, perform maturity transformation activities comparable to that of traditional banks. We choose to include money market mutual funds (L.121), mutual funds (L.122), issuers of asset-backed securities (L.127) and security brokers and dealers (L.130), as part of the shadow banking sector.[7] Finally, we use Krishnamurthy and Vissing-Jorgensen (2015)'s definition of short-term debt from the FAUS, 60% of which is composed of small time and savings deposits in the 2007-09 period. We provide details on data construction in Appendix A.1.

2.1 Fact 1: Liabilities flow from shadow to traditional banks

In the early phase of the 2007 financial crisis, investors stopped rolling over shadow banks' short-term funding. Gorton and Metrick (2011) and Copeland et al. (2014) document investors' run on their major yet unstable source of funding: the sale and repurchase market (the "repo" market). Another important fact we emphasize is the deposit inflow on traditional banks' balance-sheets. Table 1 shows the evolution of short-term debt for traditional and shadow banks from 2006q4 to 2011q1. It is apparent from Table 1 that there was a concomitant run on shadow banks and an inflow of short-term debt into traditional banks starting 2008q3. This inflow of deposits in turbulent times is the risk management motive emphasized in Kashyap et al. (2002) to explain why traditional banks combine demand deposits with loan commitments or lines of credit. In a crisis, borrowers draw down on their credit lines while investors seek a safe haven for their wealth, turning to traditional banks because these latter provide insurance due to the government guarantee on their deposits.

Gatev and Strahan (2006) emphasize that it is traditional banks' access to federal deposit insurance that causes economy's savings to move into traditional bank deposits during times of aggregate stress,[8] providing banks with the unique ability to hedge against systematic liquidity shocks. Nevertheless, Acharya and Mora (2015) show and it is apparent from Figure 1 that it was not until the U.S. government's intervention just before the Lehman failure on September 15, 2008 that deposit flew into traditional banks. He et al. (2010) find that core deposits eventually increased by close to $800 billion by early

[7] We build on earlier descriptive work for our definition of the shadow banking system, see e.g. Pozsar et al. (2013), or Adrian and Shin (2010). Shin (2010) and Hanson et al. (2015) provide examples of what shadow banks are in the real world. The simplest example, from Hanson et al. (2015), is the following: a money market fund that invests in assets that are riskless and issues what households perceive as deposits. The seniority and collateralization of sale and repurchase agreements ("repo" transactions), together with equity capital invested along the intermediation chain, renders shadow-banks "deposit-like" claims perfectly safe, and valued as such by households.

[8] This explains why there is no evidence that funds flowed into the banking system when spreads widened during the 1920s, prior to the expansion of the federal safety net with the creation of federal deposit insurance.

Cumulative flows since 2006q4		
	Shadow banks ($Bill)	Traditional banks ($Bill)
2007q2	+437	+106
2007q3	+606	+230
2007q4	+514	+454
2008q1	+378	+591
2008q2	+623	+732
2008q3	+284	+751
2008q4	+505	+1104
2009q1	-277	+1733
2009q2	-670	+1659
2009q3	-966	+ 1428
2009q4	-1132	+1436
2010q1	-1353	+1409
2010q2	-1354	+1431
2010q3	-1412	+1317
2010q4	-1440	+1420
2011q1	-1471	+1596
2011q2	-1398	+2011

Table 1: Traditional and shadow banks: short-term debt inflows (negative values denote outflows) source: Financial Accounts of the United States. We define traditional, shadow banks, and short-term debt in Appendix A.1.

2009. Weekly times series in Figure 1 show a sudden $600 billion deposits and borrowings inflow into the largest US traditional banks in just a few days, from September 10th to October 1st, 2008.

The flow of deposits into traditional banks illustrates the fact that not all entities of the U.S. financial sector deleveraged in the crisis. Ang et al. (2011) show that hedge fund leverage decreases prior to and during the financial crisis from mid-2007 onwards, He et al. (2010) show that leverage of banks and investment banks continues to increase. This helps to put deleveraging into perspective. At the worst periods of the financial crisis in late 2008, hedge fund leverage is at its lowest while the leverage of banks is at its highest. Although traditional banks issued new equity during the crisis, in Appendix A.2 we show the evolution of traditional banks' market and book equity over the crisis.[9] We find that traditional banks did not issue enough new equity during the crisis to compensate for their market losses. As a result, the deposit flow into traditional banks increased their market leverage in the crisis.

2.2 Fact 2: Asset flow from shadow to traditional banks

Figure 2 illustrates that assets were massively reshuffled among financial intermediaries during the financial crisis. In particular, assets flew out of shadow banks and into traditional banks. Although our data does not allow us to identify whether these changes were due to changes in the value of assets or changes in ownership, empirical work by He et al. (2010) and Bigio et al. (2016) provide estimates of the amount of assets that were transferred from shadow to traditional banks during the crisis. From 2007q4 to 2009q1, He et al. (2010) find that shadow banks decreased their holdings of securitized assets by approximately $800 billion while traditional banks increased theirs by approximately $550 billion.

[9] See Baron (2016) for evidence of banks' countercyclical equity issuance.

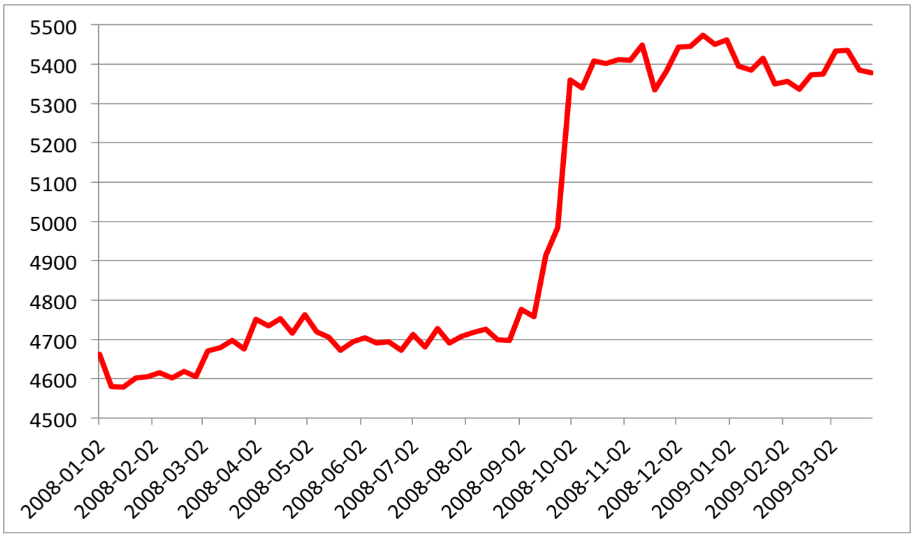


Figure 1: Large traditional banks: deposits and borrowings (stocks in $ bn)
source: Fed H8 Releases

Looking at the wider period from 2007q1 to 2013q1 and considering total asset holdings, Bigio et al. (2016) document a net asset outlfow of $1702 billion out of shadow banks and an asset inflow of $1595 billion into traditional banks.[10]

The main argument that explains why the shadow banking system developed is that traditional banks create off balance-sheets entities, because holding loans on balance sheets is not profitable for them (see e.g. Gorton and Metrick, 2011; Acharya et al., 2013). For instance special conduits are comparable to regular banks in many ways, and they often are managed by traditional banks. Pozsar et al. (2013) dubs shadow banks managed by traditional banks "internal shadow banking". However, the flip side of this off-balance sheet leverage in the shadow banking sector is that liquidity guarantees are provided by traditional banks. Acharya et al. (2013) show that investors in conduits covered by guarantees were repaid in full. This implies a monetary transfer from the traditional to the shadow banking system in the crisis, and the mirror asset transfer from shadow to traditional banks that we see on Figure 2. Although we do not explicitly model the contractual relationship between traditional and shadow banks in terms of liquidity guarantees,[11] our model sheds light on the interaction between the two bank types and the cost/benefit analysis driving traditional banks' choices on whether or not to develop shadow banking.

One main testable prediction of our theory is that traditional banks are able to purchase assets from shadow banks in a crisis, insofar as they benefit from a guarantee on their deposits. This guarantee indeed enables them to attract deposits precisely when shadow banks have to reimburse their creditors. Publicly available data on purchases/sales of assets by traditional and shadow banks during the crisis is not available. Therefore we try to estimate purchases/sales of mortgage-backed securities (henceforth MBS) applying He et al. (2010)'s methodology on traditional banks' regulatory data from the Call Re-

[10] Another important aspect of this asset transfer is the sizable purchase of assets from the Federal Reserve, which balance sheets increased by approximately $1954 billion, as calculated in Bigio et al. (2016).

[11] Luck and Schempp (2014) give an account of how contractual linkages between regulated banking and shadow banking affect financial stability.

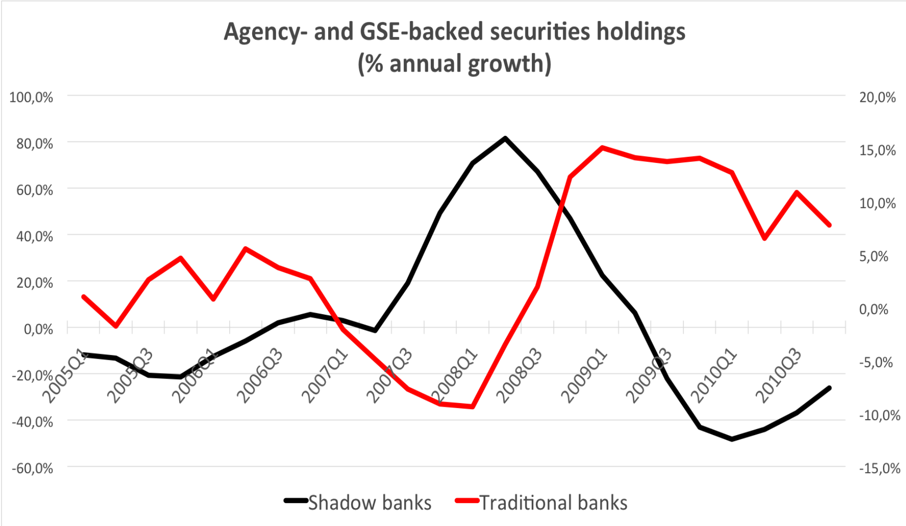


Figure 2: Traditional and shadow banks: asset inflows (negative values denote outflows)
source: Financial Account of the United States

ports. We observe the total value of MBS holdings by each traditional bank before the crisis (denote it $P\_2007q4 * MBS\_2007q4_i$ where P_2007q4 is the fair price of MBS securities in 2007q4 and MBS_2007q4 is the quantity of MBS held by bank i in 2007q4) and after the crisis ($P\_2009q1 * MBS\_2009q1_i$). Besides, denoting f the repayment/maturity rate of MBS net of the new issuance rate during the period from 2007q4 to 2009q1, the International Financial Reporting Standards (IFRS) give us the following accounting identity:

$$P\_2009q1 * MBS\_2009q1_i - P\_2007q4 * MBS\_2007q4_i * (1 - f) = MBSPurchases_i - MBSLosses_i$$

As in He et al. (2010), we test three different scenarii based on (i) the total losses that traditional banks incurred on MBS assets during the 2008 crisis, and (ii) Bloomberg WDCI estimates for the net repayment rate f. Under scenario 1 the repayment rate used to construct the MBS_Purchases variable is 7% and total losses imputed to the financial sector are $500 billion.[12] Under scenario 2, the repayment rate is 12% and total losses are $176 billion. Under the "naive" scenario, we do not correct for the net repayment rate nor total losses.

We analyze the data formally by running the following OLS regression on changes in various items of traditional banks' balance sheets from 2007q4 to 2009q1:

[12]Note that the only available estimate on MBS losses in the crisis is an aggregate over the traditional banking sector from the IMF's Global Financial Stability Report of October 2008 and Bloomberg WDCI (which explains why we test two scenarii thereafter). Denote those estimates for the entire traditional banking sector losses on MBS assets $MBSLosses$. Although we try to estimate MBS purchases/losses by taking into account potential losses on those assets when using the change in MBS holdings from 2007q4 to 2009q1 adjusted for the net repayment/maturity rate, we cannot account for differences in losses across traditional banks. We therefore assume that losses incurred by traditional banks are proportional to the amount of MBS they hold, so that $MBSLosses_i = \frac{MBS\_2007q4_i}{\sum_k MBS\_2007q4_k} * MBSLosses$ and $\sum_k MBSLosses_k = MBSLosses$.

$$
\begin{aligned}
MBSPurchases_i = \quad & \beta_0 + \beta_1.Liquidity_i + \beta_2.Solvency_i + \beta_3.Insured.\_deposits_i \\
& + \beta_4.Non\_insured\_deposits_i + \beta_5.Credit\_granted\_i \\
& + \beta_6.Evolutions\_i + \beta_7.controls\_i + \epsilon_i
\end{aligned}
$$

where $MBSPurchases_i$ is our estimated purchases/sales of mortgage-backed securities by traditional bank i normalized by total assets (banks are aggregated to the top holder level in the Call Reports).

Details about the sample construction and the results are in Appendix A.4. We find support for the central mechanisms of our theory: Traditional banks purchased mortgage-backed securities in the crisis, and the more so the more deposits they issued in the crisis. Those assets are precisely the ones shadow banks have sold (see Figure 2). Besides, we find that those banks that purchased assets in the crisis did so at the expense of credit. This is in line with Shleifer and Vishny (2010) and Stein (2013) who discuss how market conditions shape the allocation of scarce bank capital across lending and asset purchases. Using German data, Abbassi et al. (2015) find comparable results.

2.3 Fact 3: Asset fire sales

Many examples in the literature suggest that asset prices have deviated significantly from "fundamental values" and were sold at fire-sale prices during the crisis. Using data on insurance companies, Merrill et al. (2012) show that risk-sensitive capital requirements, together with mark- to-market accounting, can cause financial intermediaries to engage in fire sales of RBMS securities. Krishnamurthy (2008) discusses pricing relationships reflecting similar distortions on agency MBS, and notably the increasing option-adjusted spread of Ginnie Mae MBS versus the US Treasury with the same maturity. Gagnon et al. (2011) also document substantial spreads on MBS rates - well above historical norms. Such evidence of high spreads on a security which has no credit risk points to the scarcity of arbitrage capital in the marketplace and the large effects that this shortage can have on asset prices. Using micro-data on insurers' and mutual funds' bond holdings, Chernenko et al. (2014) finds that in order to meet their liquidity needs during the crisis, investors traded in more liquid securities such as government-guaranteed MBS. This strategy is consistent with theories of fire sales where investors follow optimal liquidation strategies: although spreads on GSE MBS were very high in the fall of 2008, those assets remained the most liquid ones in securitization markets at that time.

Our illustration of asset fire sales comes from Gorton and Metrick (2011). The authors provide a snapshot of fire sales of assets that occurred due to the financial crisis that we reproduce on Figure 3. We see a negative spread between higher- and lower-rate bonds with the same maturity. Aaa-rated corporate bonds would normally trade at higher prices (i.e. lower spreads) than any lower-grade bonds with the same maturity (say, Aa-rated ones), and this negative spread is an evidence of such an important amount of Aaa-rated corporate bonds sales that the spread must rise to attract buyers.

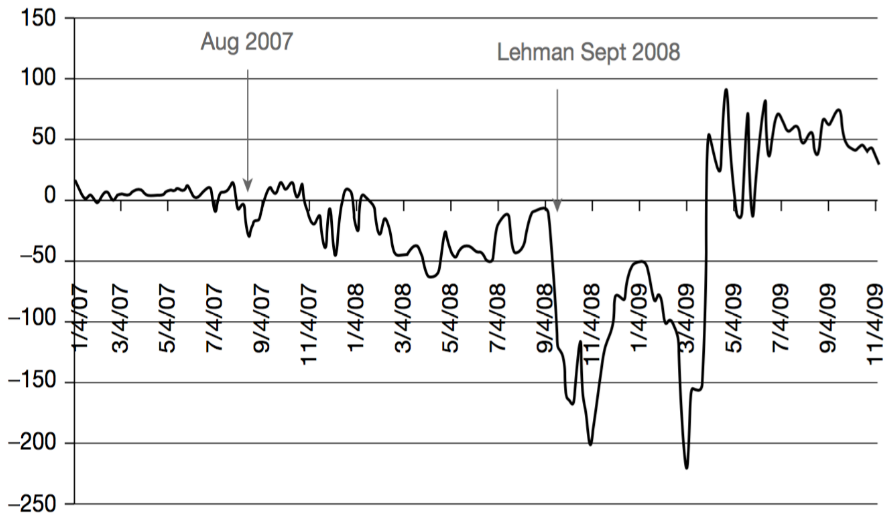


Figure 3: Interest rate spread: 5year AA-AAA Industrials
source: Gorton and Metrick (2009)

3 Model setting

The model features a closed economy, with three dates ($t = 0, 1, 2$), one production technology, two sets of agents (households and bankers) and two types of goods (consumption goods and capital goods).[13] Date 1 includes two states $\{G, B\}$ and date 2 three states $\{GG, BG, BB\}$.

3.1 Households

A unit mass of households is endowed with a large quantity of consumption goods at each date. They can consume at each date and do not discount future consumption. They have linear preferences over consumption at all dates.

At each date $t \in \{0,1\}$, and in each state ω, household's utility function writes as follows:

$$U_{t,\omega} = C_{t,\omega} + \mathbb{E}_{t,\omega}\left[U_{t+1}\right] \quad (1)$$

with

$$U_{2,\omega} = C_{2,\omega} \quad (2)$$

Households are not able to invest directly in physical projects, and can only invest in financial claims issued by banks, which undertake the investment.[14]

[13] The model is broadly inspired by Stein (2012). However, we consider two types of banks: traditional and shadow banks. It is different from the framework of Hanson et al. (2015) in that in our model traditional banks can issue debt in a crisis, and bankers endogenously choose which type of banking sector they enter.

[14] As in Stein (2012) we abstract from any agency problem between the intermediary and the firm manager and assume that the bank has all the bargaining power in the banking-firm relationship, thereby enabling it to extract all the profit from the investment and leaving the firm with no profit in expectation.

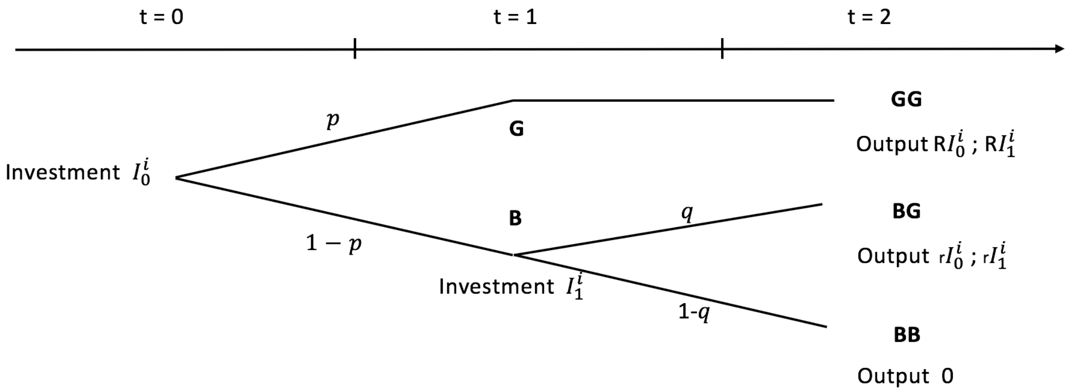


Figure 4: Investments payoffs (states in bold font)

3.2 Bankers

There is a unit mass of identical bankers, who start at $t = 0$ with an endowment n of consumption goods. As households, they are risk neutral and indifferent between consuming at $t = 0, 1, 2$. Each of them chooses the probability at which they are willing to set up a traditional bank (T-bank), $1 - \chi^S$, and a shadow bank (S-bank), χ^S. Once allocated to one sector or the other, they invest a quantity $n^i \in [0, n]$ ($i = \{S, T\}$) into the firm and consume whatever is left from this endowment. The funds invested in the bank constitute the own funds of the bank.

3.2.1 Banks' investment technology

Both T- and S-banks have access to a unique investment technology, whose payoffs are summarized on Figure 4.

Investing one unit of capital good in the investment technology at $t = 0$ yields a risky payoff $z \in \{R, r, 0\}$ in terms of consumption goods at $t = 2$, in each respective state of $\Omega_2 \equiv \{GG, BG, BB\}$. At this date, investment pays off and all capital goods is destroyed. At $t = 1$, information about the occurrence of date 2 states is revealed: when state G (good news) materializes (which occurs with probability p), it is known with certainty that state $\{GG\}$ will take place at $t = 2$ so that investment pays off R, and all uncertainty is resolved. However, when state B (bad news) materializes (which occurs with probability $1 - p$), it is learnt that there is a non-zero probability of 0 output at $t = 2$. The probabilities that each state $\{BG, BB\}$ materializes are $(q, (1 - q))$. In this case, there is an aggregate risk in the economy, that cannot be diversified away through other forms of investments.

3.2.2 Bank's choices

The timeline of the model is detailed in Figure 5.

Time 0 At $t = 0$, both T- and S-banks have the ability to transform consumption goods into capital goods (or physical assets) one-for-one, in order to invest I_0^i ($i = \{S, T\}$) units of capital goods in the long-

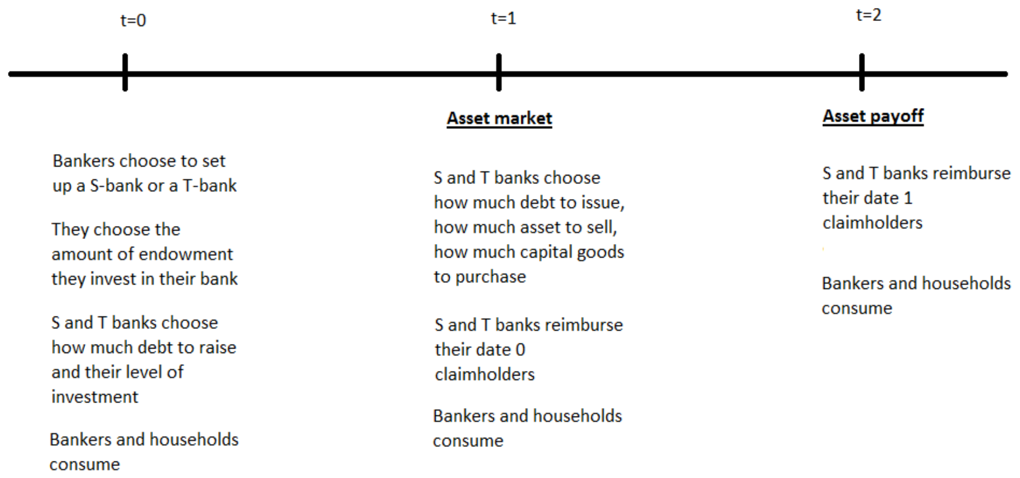


Figure 5: Timeline of the model

term productive investment technology. To fund their investments, they can add to their endowment n^i, D_0^i units of funds raised from the households. Raising funds can be done in the exclusive form of riskless short-term debt, issued on a competitive market.

This assumption captures what we see as one fundamental role of banks: their ability to act as safety and liquidity providers to the households at all times. The key assumption here is that banks have to finance themselves with riskless financial contracts. Our results do not rely on the specific form of these contracts. [15]

Time 1 At $t = 1$, T- and S-banks can't either transform consumption goods into capital goods, or transform capital goods into consumption goods. They can however trade capital goods for consumption goods in a competitive secondary market, where all banks participate. In each state $\omega_1 \in \{B, G\}$, they purchase I^i_{1,ω_1} $(i = \{S, T\})$ units of capital goods at a market price $p_{1,B}qr$ at $t = 1$ in state B and $p_{1,G}R$ at $t = 1$ in state G. These capital goods are then reinvested in the same technology. [16]

Banks can also sell on the market a share $(1 - \alpha^i_{1,\omega_1})$ of their stock of physical assets. We assume liquidation costs for banks such that a share $\varepsilon \in (0, 1]$ of assets sold is destroyed. This cost assumption is meant to capture the forsaken returns from liquidating illiquid projects. [17]

Finally, banks have the ability to raise additional funds from households, D^i_{1,ω_1}, by issuing risk-less short-term debt, either to roll previously issued debt over, or to finance purchases. The debt issued at $t = 0$ must be paid back, such that $r_0 D_0^i$ units of consumption goods must be provided to the debt-holders, where r_0 is the interest rate on the debt issued at $t = 0$, pinned down on the market.

[15] Alternative model specifications closer to the safe asset literature would yield similar results. One could for instance endow the households with an infinite risk-aversion utility function as in Gennaioli et al. (2013) or Epstein-Zin preferences with infinite relative risk aversion and infinite intertemporal elasticity of substitution as in Caballero and Farhi (2016).

[16] We can alternatively think of such trade as a transfer of ownership rights on the payoffs generated by the capital goods

[17] One can also interpret ε as the cost of breaking up a lending relationship, or the loss associated to a loosened monitoring ability induced by a change of ownership. The adjustment cost $(1 - \varepsilon)$ is a form of technological illiquidity, whose importance is emphasized in Brunnermeier and Sannikov (2014).

Time 2 At $t = 2$, the investment pays off in terms of consumption goods, and all capital goods are destroyed. T and S banks reimburse their date 1 debt-holders by providing them with $r_{1,\omega_1} D^i_{1,\omega_1}$ (with $\omega_1 \in \{B, G\}$) units of consumption goods, where r_{1,ω_1} is the interest rate on the debt issued at $t = 1$ in state $\omega_1 \in \{B, G\}$. It is important to note that in each date and state, banks are subject to limited liability constraints.

3.2.3 Differences between shadow and traditional banks

We distinguish traditional from shadow banking by making the following assumptions.

Assumption 1. *Traditional and shadow banks differ in two ways:*

1. *T-banks have access to a guarantee fund at* $t = 1$ *in state* B. *This enables them to issue risk-less claims that promise to pay up to an amount* $k > 0$.
2. *T-banks have to cope with higher operating costs : At* $t = 2$, *T-banks only get a fraction* $\delta \in [0, 1]$ *of the payoff generated by their investments.*

T-banks benefit from an advantage over S-banks in $t = 1$ in state B they have access to a government guarantee which enables them to issue risk-less short-term debt from $t = 1$ in state B to $t = 2$, even if the productive technology is facing a risk of zero output. In our setting, it takes the form of a fairly-priced guarantee fund owned by the state: to get one unit of consumption good at $t = 2$ in state BB, bankers have to provide $\frac{1-q}{q}$ units of consumption goods to the fund at $t = 2$ in state BG such that the government is making no profit in expectation from setting this fund up, and provides no subsidy to the T-banks through this fund. We assume that the maximum guarantee each T-bank can benefit from is set to k, which is a structural parameter of our economy. One interpretation for this is that the government's ability to enforce payments made by T-banks to the fund at $t = 1$ in state G is limited, for instance due to limited fiscal capacity. Another interpretation for this parameter could be a reduced form for informational friction which prevents T-banks from taking too much debt at $t = 1$ in state B[18]. Note that, T-banks being subject to limited liability constraint at all times and states, k is not the only determinant of T-banks debt level, as will be emphasized below.

In return to this advantage, T-banks face regulatory costs, which take the form of a reduced payoff on their investment at $t = 2$ in each state. This cost captures a wide variety of costs associated to higher regulations imposed to the traditional banking sector : taxes to finance the regulating entities, the general functioning costs of the guarantee fund, costs to generate regulatory information, etc. [19]

3.3 Equilibrium definition

In this setting, we formally define an equilibrium as follows.

[18]For such an interpretation, we will see that it is not restrictive not to impose the same constraint on S-bank: the existence of a risk of zero-payoff at $t = 2$ in state BB prevents S-banks to issue any type of risk-less debt at $t = 1$ in state B making such a constraint superfluous

[19]From a positive perspective, it can also be interpreted more broadly as a series of costs associated to the T-banks specificities in terms of business model: they have higher operating costs, employ more workers, provide more services to their customers etc.

Definition 1 (Equilibrium). *$\{\chi^S, n^S, n^T, \nu^S, \nu^T, p_{1,G}, p_{1,B}, r_0, r_{1,G}, r_{1,B}\}$ with*

$$\nu^i = \{I_0^i, D_0^i, I_{1,G}^i, I_{1,B}^i, D_{1,G}^i, D_{1,B}^i, \alpha_{1,G}^i, \alpha_{1,B}^i\}$$

for $i \in \{S, T\}$ such that

1. *ν^T maximizes traditional bank's date 0 value function $V_0^T\left(p_{1,G}, p_{1,B}, r_0, r_{1,G}, r_{1,B}, n^T\right)$.*
2. *ν^S maximizes shadow bank's date 0 value function $V_0^S\left(p_{1,G}, p_{1,B}, r_0, r_{1,G}, r_{1,B}, n^S\right)$.*
3. *n^i maximizes the expected payoff of a banker's allocated in type i-bank ($i \in \{S, T\}$) $V_0^{i,B}\left(p_{1,G}, p_{1,B}, r_0, r_{1,G}, r_{1,B}\right)$.*
4. *χ^S is a solution to the allocation problem:*

$$\max_{\chi^S \in [0;1]} \chi^S V_0^{S,B}\left(p_{1,G}, p_{1,B}, r_0, r_{1,G}, r_{1,B}\right) + (1-\chi^S) V_0^{T,B}\left(p_{1,G}, p_{1,B}, r_0, r_{1,G}, r_{1,B}\right).$$

5. *Markets for short-term debt clear at time 0, and 1, in states G and B for respective interest rates $\{r_0, r_{1,G}, r_{1,B}\}$.*
6. *Capital goods market clear at time 1 in states G and B at respective prices $\{p_{1,G}qr, p_{1,B}R\}$.*

We now turn to the analysis of this equilibrium, detail the banks and bankers' problems and value functions, as well as the market clearing conditions, and develop the solutions.

4 Model analysis

4.1 Assumptions

Assumptions on expected returns In Assumption 2 we make two restrictions about the investment technology.

Assumption 2. *At $t = 0$, investing is efficient for both T- and S-banks:*

$$\delta\left(pR + (1-p)qr\right) > 1 \tag{3}$$

At $t = 1$ in state B, expected returns are lower than one:

$$qr < 1 \tag{4}$$

Condition (3) ensures that as of $t = 0$, investing is efficient. This implies that each banker invests her full endowment in the bank it sets up, be it a S-bank ($n^S = n$) or a T-bank ($n^T = n$), and each bank invests all her own funds in their time 0 investment technology. Condition (4) reflects the fact that in a crisis, asset returns are lower than in good state.

Assumptions on traditional bank's parameters We make two additional assumptions on the size of the guarantee traditional banks can benefit from, k, as well as its associated cost, δ, which helps us focus on the main cases of interest.

Assumption 3. *The cost associated to traditional banking activity is low enough to prevent asset sales at* $t = 1$ *in state* G*:*

$$\delta > 1 - \varepsilon \tag{5}$$

The guarantee T-banks can benefit from on his time 1, B claims is the binding constraint for time 0, T-banks debt issuance:

$$k < k^* = \frac{\delta q r}{1 - \delta q r} n \tag{6}$$

Condition (5) enables us to rule out asset transfers at $t = 1$ in state G between the two types of intermediaries: it will always be optimal for any type of bank to choose to continue their time 0 investment, at $t = 1$ in state G rather than providing assets on the market for capital goods. This assumption could be relaxed at little cost. It is however convenient in keeping the analysis focused on the interaction between the two types of banks in the bad information state, time 1. Relaxing this assumption generates asset transfers from T-banks to S-banks in the good information state: indeed, if $\delta < 1 - \varepsilon$, it is more valuable for a T-bank to sell capital goods on the market to S-banks who value it more [20], and incur the illiquidity cost ε, than continuing its investment and incur the regulatory cost $1 - \delta$ on its time 2 payoff.

The second assumption (6) will imply that the maximum amount of risk-less debt issued at $t = 0$ that can be rolled-over at $t = 1$ in state B by a T-bank will be constrained by the size of the guarantee fund T-banks have access to at $t = 1$ in state B (hence k), and not the limited liability constraint of time 2, BG the bank has to comply with when financing this guarantee. This ensures that T-banks will be able to issue an amount k of risk-less debt both at $t = 0$ and at $t = 1$ in all states.

Technical assumption Finally, we set the following assumption, in order to ensure coexistence of the two types of institutions.

Assumption 4. *We assume that the cost of regulation is high enough such that both S and T-banks can exist in equilibrium*

$$\delta < \frac{p}{\varepsilon\left(p\left(R-1\right)+\left(1-p\right)qr\right)+p} \tag{7}$$

We discuss later the fact that condition (7) is a necessary condition to find a range of asset prices at $t = 1$ in state B such that both T and S-banks are willing to trade assets, given condition (6).[21]

[20] Each unit of capital good generates a return R for a S-bank in date 2, GG instead of δR for T-banks, and none of them discount future payoffs

[21] It is important to note that the five parametric restrictions generated by these assumptions are not mutually exclusive.

4.2 Equilibrium implications of the assumptions

We now turn to the resolution of the equilibria of the game. In order to reduce the dimensionality of the exercise and ease further exposition we start by detailing some equilibrium conditions implied by our assumptions. We consider equilibrium conditions associated to the debt market, the asset market at $t = 1$ in state G, and discuss their implications.

4.2.1 Debt market clearing conditions

Households are endowed with a large amount of consumption goods at each date, and the ability to generate safe short-term claims in the system being limited,[22] the real rates on short term debt issued by any type of bank is pinned down in equilibrium by the household's utility function. With a linear utility function and no time discounting, this rate is set to 1 in equilibrium.

In equilibrium:

$$r_0 = r_{1,B} = r_{1,G} = 1$$

It is important to note that, the households being endowed with a large amount of consumption goods in each date and state, the limiting factor in banks' ability to expand will always be their ability to generate safe short-term claims. We prevent in this way mispricing of the debt instruments to play any role in the mispricing of assets that could occur when assets flow from one type of bank to the other.

4.2.2 Time 1, G asset market clearing condition

at $t = 1$ in state G, T and S-banks must reimburse their date 0 debt-holders $r_0 D_0^i = D_0^i$ $(i = S, T)$. They can choose to issue short term risk-less debt, sell part of their capital goods to other banks on the asset market, and purchase capital goods sold by others. In this time and state, all uncertainty is resolved, such that both S and T-banks are able to generate short term safe claims $D_{1,G}^i$ $(i = S, T)$ to roll their funding over as long as $D_{1,G}^T \leqslant \delta R I_0^T$ and $D_{1,G}^S \leqslant R I_0^S$ (due to limited liability constraint at $t = 2$ in state GG).

This strategy is a dominating one for S-banks as well as T-banks (due to assumption (5)), as it spares them the destruction of capital goods ε associated to sale of capital goods: if T-banks were to sell their assets on the market, they could get $(1 - \varepsilon) R I_0^T$ as S-banks would be willing to purchase the assets at fair price R, by issuing risk-less short term debt to finance this purchase. This being lower than $\delta R I_0^T$, the value of keeping the assets in place, T-banks will always choose to hold on their time 0 investments, as would S-banks do.

Finally, in equilibrium, no capital goods are supplied on the market, and no trade takes place. Without loss of generality, we simplify S and T-banks programs exposition by presenting and solving them as if no asset market existed at $t = 1$ in state G, and their only option were to roll their funding over, as these two problems are equivalent in equilibrium. We can now turn to the exposition of these modified banks' programs.

[22] It is indeed constrained by the guarantee that can be obtained from the government, which implies that the maximum amount of short term risk-less claims that can be issued at $t = 0$ or $t = 1$ cannot exceed $k(1 - \chi^S)$

4.3 Shadow banks' program

We solve a S-bank's program given it has no access to the asset market at $t = 1$ in state G.

Date 1**, state** G**.** In such a program, at $t = 1$ in state G, S-banks can only roll their funding over. The value function of a S-bank at $t = 1$ in state G, with a date 0 investment level I_0^S, a debt level D_0^S writes, in case of no-default, as follows:

$$V_{1,G}^{S,ND}\left(I_0^S, D_0^S\right) = RI_0^S - D_0^S$$

and the S-bank doesn't default if and only if $RI_0^S - D_0^S \geqslant 0$.

At $t = 1$ in state G, if the S-bank has a higher debt level inherited from $t = 0$, it would have to default on it and would not be able to reimburse its creditors.

As S and T-banks can only issue risk-less short term debt in each date and state, such an event would not occur in equilibrium. We take the convention to set, in these cases, the value function to $-\infty$. S-banks value function at $t = 1$ in state G writes:

$$V_{1,G}^S\left(I_0^S, D_0^S\right) = \begin{cases} RI_0^S - D_0^S \text{ if } D_0^S \leqslant RI_0^S \\ -\infty \text{ otherwise} \end{cases}$$

Date 1**, state** B**.** At $t = 1$, in state B, S-banks choose how much (if any) funding to raise, how much capital goods to sell on the market, and how much capital goods to purchase on the market, for making additional investments in in their technology. They also have to reimburse their date 0 debt-holders.

At $t = 1$ in state B there is a non-zero probability for the investment technology to return a zero payoff at $t = 2$. Therefore, in the absence of any guarantee on the claims they issue, S-banks are not able to issue any risk-less claim at $t = 1$ in state B. The only way for S-banks to reimburse households is to sell capital goods on the market and channel the proceeds of this sale to households so as to meet their obligations. Shadow banks can also choose to interrupt a higher fraction of their date 0 investment, to sell more capital goods on the market, in order either to consume or purchase capital goods from other banks at $t = 1$ in state B.

Remark that S-banks can only invest at $t = 1$ in state B by interrupting previous investments made at $t = 0$. It can never be optimal for a S-bank to interrupt their time 0 investments, which induces an early liquidation cost ε, in order to sell capital goods on the market at a price $p_{1,B}qr$ by unit of capital goods, purchase new capital goods at the same price and reinvest it in the same investment technology. Such a strategy is indeed strictly dominated by the one that consists in keeping the investments without liquidation.

We therefore write the shadow bank's value function at $t = 1$ in state B in the case of no default, as

$$V_{1,B}^{S,ND}\left(I_0^S, D_0^S, p_{1,B}\right) = \max_{\alpha_{1,B}^S \in [0;1]} \alpha_{1,B}^S qrI_0^S + (1-\alpha_{1,B}^S)(1-\varepsilon)p_{1,B}qrI_0^S - D_0^S$$
$$\text{s.t. } (1-\alpha_{1,B}^S)\,(1-\varepsilon)\,p_{1,B}qrI_0^S \geqslant D_0^S$$

where I_0^S is the investment level of the S-bank at $t = 0$, D_0^S the investment level of the S-bank at $t = 0$,

$p_{1,B}qr$ the market price of one unit of capital good, $\alpha^S_{1,B}$ is the share of investment made at $t = 0$ that the S-bank is willing to pursue at $t = 1$ in state B, and the S-bank is subject to a limited liability constraint, as well as positivity and no short-sale constraints.

Keeping the same convention, we set the value function in case of default to $-\infty$.

Lemma 1. *At $t = 1$, in state B, S-banks don't default if and only if $D^S_0 \leqslant (1-\varepsilon)\,p_{1,B}\,qrI^S_0$.*

If $p_{1,B} > 0$, their value function writes

$$V^S_{1,B}\left(I^S_0, D^S_0, p_{1,B}\right) = \begin{cases} \left((1-\varepsilon)p_{1,B}\,qrI^S_0 - D^S_0\right)\max\left(\frac{1}{(1-\varepsilon)p_{1,B}};1\right) \text{ if } D^S_0 \leqslant (1-\varepsilon)\,p_{1,B}\,qrI^S_0 \\ -\infty \text{ otherwise} \end{cases}$$

If $p_{1,B} = 0$, their value function writes

$$V^S_{1,B}\left(I^S_0, D^S_0, p_{1,B}\right) = \begin{cases} qrI^S_0 \text{ if } D^S_0 = 0 \\ -\infty \text{ otherwise} \end{cases}$$

Date 0 At $t = 0$, Shadow banks will always choose levels of debt D^S_0 and investment I^S_0 consistent with an absence of default on their debt at $t = 1$,as they are only able to raise funding in such a way. They also have to face a funding constraint: their time 0 investment is funded with the banker's endowment and the debt raised from households at $t = 0$. [23]

For $p_{1,B} > 0$[24], the date 0 value function of a S-bank, with own funds n^S writes:

$$\begin{aligned} V^S_0\left(p_{1,B}, n^S\right) = \max_{D^S_0, I^S_0 \geqslant 0} & [(1-p)\left((1-\varepsilon)p_{1,B}\,qrI^S_0 - D^S_0\right)\max\left(\frac{1}{(1-\varepsilon)p_{1,B}};1\right) \\ & + p\left(RI^S_0 - D^S_0\right) + (D^S_0 + n^S - I^S_0)] \\ \text{s.t. } & D^S_0 + n^S \geqslant I^S_0 \\ & D^S_0 \leqslant (1-\varepsilon)\,p_{1,B}\,qrI^S_0 \\ & D^S_0 \leqslant RI^S_0 \end{aligned}$$

Denoting $\overline{p}^S_1 \equiv \frac{1}{(1-\varepsilon)(qr + \frac{p(R-1)}{1-p})} < \frac{1}{1-\varepsilon}$, we obtain the following proposition.

Proposition 1 (S-bank program). *At $t = 0$, S-banks take the following decisions.*

1. *If $0 \leqslant p_{1,B} < \overline{p}^S_1$, $D^S_0 = 0$, $I^S_0 = n^S$. Shadow banks do not issue short-term claims at $t = 0$, i.e. they do not lever themselves. In this case, $V^S_0\left(p_{1,B}, n^S\right) = (1-p)qrn^S + pRn^S$*
2. *If $p_{1,B} = \overline{p}^S_1$, any $D^S_0 \in \left[0; \frac{(1-\varepsilon)\overline{p}^S_1 qr}{1-(1-\varepsilon)\overline{p}^S_1 qr} n^S\right]$ is an equilibrium solution, and $I^S_0 = n^S + D^S_0$. Shadow*

[23] Thanks to condition (3), we know that bankers will always choose to invest all their endowment into the bank they set up.

[24] If $p_{1,B} = 0$ this reduces to

$$\begin{aligned} V^S_0\left(0, n^S\right) = \max_{I^S_0} & (1-p)\left(qrI^S_0\right) + p\left(RI^S_0\right) \\ \text{s.t. } & n^S \geqslant I^S_0 \\ & I^S_0 \geqslant 0 \end{aligned}$$

banks sell a fraction $\frac{D_0^S}{(1-\varepsilon)p_{1,B}qr(D_0^S+n^S)}$ *of their capital goods at* $t = 1, B$, *so as to repay their date-0 creditors. In this case,* $V_0^S\left(p_{1,B}, n^S\right) = (1-p)qrn^S + pRn^S$

3. *If* $\overline{p}_1^S < p_{1,B} < \frac{1}{(1-\varepsilon)qr}$, $D_0^S = \frac{(1-\varepsilon)p_{1,B}qr}{1-(1-\varepsilon)p_{1,B}qr}n^S$, $I_0^S = n^S + D_0^S$. *Shadow banks sell all their capital goods at* $t = 1$ *in state* B, *so as to repay their date-0 creditors. In this case,* $V_0^S\left(p_{1,B}, n^S\right) = p\left(\frac{R-(1-\varepsilon)p_{1,B}qr}{1-(1-\varepsilon)p_{1,B}qr}\right)n^S$

4. *If* $p_{1,B} \geqslant \frac{1}{(1-\varepsilon)qr}$, $D_0^S = +\infty$, $I_0^S = +\infty$ *and* $V_0^S\left(p_{1,B}, n^S\right) = +\infty$

Proof. See appendix. □

Although S-banks do not have access to the guarantee fund, they can issue riskless debt at $t = 0$ insofar as they are backed by the liquidation value of the fraction $(1 - \alpha_{1,B}^S)$ of their existing investment they sell at $t = 1$ in state B. It is S-banks' ability to pull the plug in the crisis that enables them to issue safe short-term debt at $t = 0$. When liquidating at $t = 1$ in state B, proceeds from selling capital goods are $(1 - \alpha_{1,B}^S)(1 - \varepsilon)p_{1,B}qrI_0^S$ where $p_{1,B}qr$ is the price of a unit of capital good in the secondary market at $t = 1$ in state B. The proceeds of this sale depend on T-banks' ability to purchase capital goods in the crisis, which itself relies on the guarantee fund these latter can access.

Indirectly, S-banks therefore rely on the guarantee fund via T-banks, thereby granting T-banks the ability to play the role of government support intermediary. They are able to purchase guarantee from the government at fair price and sell it to S-banks at a potential premium.

4.4 Traditional banks' program

We now turn to T-banks' program, which we expose and solve again by backward induction.

As for S-banks, and for the clarity of exposition, we expose and solve, without loss of generality, the modified problem, of a T-bank with no access to capital goods market at $t = 1$ in state G, and whose only option is to roll its funding over.

Date 1, state G. As for S-banks, at $t = 1$ in state G, T-banks roll their funding over. With the same convention on value function in case of default, T-banks value function at $t = 1$ in state G writes:

$$V_{1,G}^T\left(I_0^T, D_0^T\right) = \begin{cases} \delta RI_0^T - D_0^T \text{ if } D_0^T \leqslant \delta RI_0^T \\ -\infty \text{ otherwise} \end{cases}$$

Date 1, state B In contrast to S-banks, T-banks are able to issue safe claims at $t = 1$ in state B because they can access a guarantee fund that makes these claims safe despite a non-zero probability of a zero output at $t = 2$. The possibility of a zero output at $t = 2$ therefore does not deter T-banks from issuing claims to households at $t = 1$ in state B, but T-banks are subject to two constraints in this respect. They have (i) to fairly pay for the guarantee on their short-term debt, while complying with their time 2 limited liability conditions and (ii) to comply with their debt constraint k.

Constraint (i) puts an upper bound on the amount of risk-less debt that can be reimbursed at $t = 2$ in states BB and BG (or similarly issued at $t = 1$ in state B): this amount cannot exceed the expected payoff of the productive investment at $t = 2$.

Indeed, the guarantee fund does not provide any subsidy to the T-bank: the T-bank must reimburse its date 1, B debt $D^T_{1,B}$ at $t = 2$, either by reimbursing the debt $D^T_{1,B}$ directly (at $t = 2$ in state BG), or by fairly financing its time 2, BB guarantee at $t = 2$ in state BG, hence providing the guarantee fund with $\frac{1-q}{q} D^T_{1,B}$ at $t = 2$ in state BG, such that the expected net payment made to the fund, from a time 1, B perspective is:

$$q \frac{1-q}{q} D^T_{1,B} + (1-q)(-D^T_{1,B}) = 0$$

For a T-bank, with a date 0 investment level I^T_0, who chooses to keep a share $\alpha^T_{1,B}$ on its balance sheet, and purchases $I^T_{1,B}$ units of capital goods at $t = 1$ in state B, the limited liability constraint at $t = 2$ in state BG rewrites (with $D^T_{1,B}$ the amount of riskless short term debt issued at $t = 1$ in state B) :

$$\frac{1-q}{q} D^T_{1,B} + D^T_{1,B} \leqslant \delta r \left(I^T_{1,B} + \alpha^T_{1,B} I^T_0 \right)$$

Or equivalently

$$D^T_{1,B} \leqslant \delta q r \left(I^T_{1,B} + \alpha^T_{1,B} I^T_0 \right)$$

Constraint (ii) writes as follows

$$D^T_{1,B} \leqslant k$$

In addition to these constraints, the bank is facing a limited liability constraint at $t = 1$ in state B and must reimburse its date 0 debt-holders and finance its date 1, T purchase either by raising new debt, or by selling part of its capital goods on the market. It also faces the same no short-sale constraint, and positivity constraints as the S-banks

In the no-default case, the value function of a T-bank at $t = 1$ in state B, writes

$$V^{T,ND}_{1,B} \left(I^T_0, D^T_0, p_{1,B} \right) = \max_{(\alpha^T_{1,B}, D^T_{1,B}, I^T_{1,B}) \in [0;1] \times [0;k] \times \mathbb{R}_+} \left(\delta - p_{1,B} \right) q r I^T_{1,B} + \alpha^T_{1,B} \delta q r I^T_0 + (1-\alpha^T_{1,B}) p_{1,B} q r I^T_0 \left(1-\varepsilon\right) - D^T_0$$
$$\text{s.t. } (1-\alpha^T_{1,B}) p_{1,B} q r I^T_0 \left(1-\varepsilon\right) + D_{1,B} \geqslant D^T_0 + p_{1,B} q r I^T_{1,B}$$
$$D_{1,B} \leqslant q\delta \left(r \alpha^T_{1,B} I^T_0 + r I^T_{1,B} \right)$$

We keep the convention of setting $V^T_{1,B} \left(I^T_0, D^T_0, p_{1,B} \right) = -\infty$ if the bank defaults on its time 0 debt-holders.

As shown in the appendix, the T-bank does not default on its debt if and only if $D^T_0 \leqslant \overline{D}^T_0 \left(I^T_0, p_{1,B} \right)$, where $\overline{D}^T_0 \left(I^T_0, p_{1,B} \right)$ is given in the appendix. The value function of a T-bank at $t = 1$ in state B is given in Proposition 2.

Proposition 2. *For any* $I^T_0 \geqslant 0$, $D^T_0 \geqslant 0$ *and* $p_{1,B} > 0$,

$$V^T_{1,B} \left(I^T_0, D^T_0, p_{1,B} \right) = \begin{cases} V^{T,ND}_{1,B} \left(I^T_0, D^T_0, p_{1,B} \right) \text{ if } D^T_0 \leqslant \overline{D}^T_0 \left(I^T_0, p_{1,B} \right) \\ -\infty \text{ otherwise} \end{cases}$$

with

$$V_{1,B}^{T,ND}\left(I_0^T, D_0^T, p_{1,B}\right) = \left(\frac{(\delta - p_{1,B})_+}{p_{1,B}}\left(k - D_0^T\right)_+ + \left(k - D_0^T\right)_- \frac{(\delta - p_{1,B}(1-\varepsilon))_+}{p_{1,B}(1-\varepsilon)}\right)$$

$$+ (p_{1,B}(1-\varepsilon) - \delta)_+ qrI_0^T + \delta qrI_0^T - D_0^T$$

Moreover, if $p_{1,B} = 0$, $V_{1,B}^{T,ND}\left(I_0^T, D_0^T, p_{1,B}\right) = +\infty$

Proof. See appendix □

The intuition goes as follows. If the debt raised at $t = 0$ is higher than the maximum guarantee traditional banks can benefit on the time 1, B claims they issue $D_0^T > k$, the T-bank is not able to roll over all its funding. According to the price level, it will either choose to roll over as much of its previous debt as possible, hence k, (when the price is low), and sell just a high enough share of its assets, to cover for the remaining debt that must be reimbursed, or might choose not to roll over any debt, and sell capital goods on the market if the price gets high enough.

However, if the debt raised at $t = 0$ can be fully reimbursed by raising short term debt $t = 1$ in state B, the T-bank shall choose to roll all its funding over for low level of prices. Moreover, if prices are low enough, T-banks will choose to bind their k-constraint (set $D_{1,B}^T \leqslant k$) by raising additional debt such as to purchase under-priced capital goods. For higher level of prices, T-banks would choose not to invest, and only raise additional debt in order to reimburse its date 0 claim-holders, as well as potentially increase its time 1 consumption. Finally, if the price is high enough, T-banks might also be willing to sell all its capital goods on the market.

If the date 0 debt level is higher than the payoff that can be obtained with these strategies, the T-bank would not be able to reimburse all its date 0 debt-holders, while still complying with the different constraints it has to face. It would then only be able to reimburse less than the debt face value, which would lead to a default. In this case, the convention we chose is to put the value function to $-\infty$.

From a date 0 perspective, as T-banks can only finance themselves through risk-less short term debt, such a high level of debt cannot be chosen in equilibrium.

Date $t = 0$. At $t = 0$, T-banks choose how much funds to raise, and how much consumption goods to transform into capital goods. As for S-banks, T-banks have to choose a debt level such that no-default occurs. Moreover, the same funding constraint applies.

T-banks value function at $t = 0$ writes:

$$V_0^T\left(p_{1,B}, n^T\right) = \max_{\substack{(D_0^T, I_0^T) \in \mathbb{R}_+^2 \\ D_0^T \leqslant \overline{D}_{0,B}\left(I_0^T, p_{1,B}\right) \\ D_0^T \leqslant \delta R I_0^T \\ D_0^T + n^T \geqslant I_0^T}} p\left(\delta R I_0^T - D_0^T\right) + (1-p)V_{1,B}^{T,ND}(D_0^T, I_0^T, p_{1,B}) + (D_0^T + n^T - I_0^T)$$

Denoting $p_{1,L}^T \equiv \frac{\delta}{\delta qr + \frac{p(\delta R-1)}{1-p}} < \delta$, and $p_{1,H}^T = \frac{p_{1,L}^T}{1-\varepsilon} < \frac{\delta}{1-\varepsilon}$, T-banks' program yields the following proposition.

Proposition 3. *(T-bank program) Under condition (6), T-bank's program solves as follows*

1. *If* $0 < p_{1,B} < p_{1,L}^T$, $D_0^T = 0, I_0^T = n$, $V_0^T = p(\delta Rn) + (1-p)\left(\delta qrn - k + \frac{\delta}{p_{1,B}}k\right)$
2. *If* $p_{1,B} = p_{1,L}^T$,*any* $D_0^T \in [0;k]$, $I_0^T = n + D_0^T$ *is an equilibrium solution and* $V_0^T = p(\delta R(n+k) - k) + (1-p)(\delta qr(n+k) - k)$
3. *If* $p_{1,L}^T < p_{1,B} < p_{1,H}^T$, $D_0^T = k, I_0^T = k + n$ *and* $V_0^T = p(\delta R(n+k) - k) + (1-p)(\delta qr(n+k) - k)$
4. *If* $p_{1,B} = p_{1,H}^T$, *any* $D_0^T \in [k; \frac{k\left(1-\frac{p_{1,B}(1-\varepsilon)}{\delta}\right) + (1-\varepsilon)p_{1,B}qrn}{1-p_{1,B}(1-\varepsilon)qr}]$ *is an equilibrium solution,* $I_0^T = n + D_0^T$ *and* $V_0^T = p(\delta R(n+k) - k) + (1-p)(\delta qr(n+k) - k)$
5. *If* $p_{1,H}^T < p_{1,B} \leqslant \frac{\delta}{1-\varepsilon}$, $D_0^T = \frac{k\left(1-\frac{p_{1,B}(1-\varepsilon)}{\delta}\right) + (1-\varepsilon)p_{1,B}qrn}{1-p_{1,B}(1-\varepsilon)qr}$, $I_0^T = n + D_0^T$ *and* $V_0^T = p(\delta R(D_0 + n) - D_0)$
6. *If* $\frac{\delta}{1-\varepsilon} \leqslant p_{1,B} < \frac{1}{(1-\varepsilon)qr}$, $D_0^T = \frac{p_{1,B}(1-\varepsilon)qrn}{(1-p_{1,B}(1-\varepsilon)qr)}$, $I_0^T = D_0^T + n$, *and* $V_0^T = p(\delta R(D_0 + n) - D_0)$
7. *If* $p_{1,B} \geqslant \frac{1}{(1-\varepsilon)qr}$, $D_0^T = +\infty$, $I_0^T = +\infty$ *and* $V_0^T = +\infty$

Moreover, if $p_{1,B} = 0$, $V_0^T = +\infty$

Depending on the price of capital goods on the secondary market at $t = 1$ in state B, T-banks choose how much short-term debt to issue at $t = 0$ to invest in positive NPV projects, versus how much buffer to keep to purchase capital goods from S-banks at $t = 1$ in state B. Although the guarantee fund enables T-banks to issue short-term debt at $t = 1$ in state B, they have to trade-off between those two investment opportunities because their issuance of short-term debt is limited by the size of the support.

For low level of prices, the return T-banks get on purchasing capital goods on the market overcomes the one of investing in the positive NPV projects they are faced with at $t = 0$. They prefer not issuing short term debt at $t = 0$, to keep slack in order to purchase goods at $t = 1$ in state B. When prices get higher, they are better off investing even more at $t = 0$, and selling part of his capital goods in the market when a crisis hits. As shall be seen shortly, this would not occur in equilibrium.

One implication which is worth emphasizing is that the size of the support the T-bank can benefit from the government at $t = 1$ in state B has an impact on its time 0 maximum debt level. Indeed, thanks to the guarantee fund, T-banks get the ability to raise risk-free debt at $t = 0$ up to an amount k under condition (6), without the need to delever at $t = 1$ in state B.[25] The T-bank is then able to issue up to k short term risk-less deposits whatever price prevails on the market at $t = 1$ in state B, generating a positive spillover from guarantee at $t = 1$ in state B to $t = 0$.

[25]The bank has always the choice to roll its time 0 debt over in this case

4.5 Banker's endowment allocation

Finally, given $V_0^i(p_{1,B}, n^i)$, bankers who choose to set up a i-bank ($i \in \{S;T\}$), allocate their initial endowment n between a part n^i they invest as bank's own funds, and the remaining part $(n - n^i)$ they consume.

When investing $n^i \in [0;n]$ units of their endowment into a i-bank, they obtain the residual payoffs of the bank. This provides them with an expected utility $V_0^i(p_{1,B}, n^i)$ from a date 0 perspective. Their problem writes as follows

$$V_0^{i,B}(p_{1,B}) = \max_{n^i \in [0;n]} (n - n^i) + V_0^i\left(p_{1,B}, n^i\right)$$

Then

1. If $p_{1,B} < \frac{1}{(1-\varepsilon)qr}$, they choose $n^i = n$. Indeed, each unit of funds a banker allocates to the i-bank can at least be transformed into capital goods and invested into the investment technology the bank has access to. The expected payoff generated by such a strategy is at least $\delta(pR + (1-p)qr)$, which provides more utility to the banker than immediate consumption of the funds (assumption 3)
2. If $p_{1,B} \geqslant \frac{1}{(1-\varepsilon)qr}$ the banker is indifferent between the different levels of endowment allocation.

In any case,

$$V_0^{i,B}(p_{1,B}) = V_0^i(p_{1,B}, n)$$

4.6 Capital goods market clearing

In this section, we derive the market-clearing conditions for the capital goods market at $t = 1$ in state B, taking the shares χ^S ($(1-\chi^S)$) of S-banks (T-banks) as given. Let us define an equilibrium on the secondary market for capital goods at $t = 1$ in state B.

Definition 2. *A market equilibrium at $t = 1$ in state B is defined by*

1. *A quantity $S(p_{1,B})$ of capital goods supplied*
2. *A quantity $D(p_{1,B})$ of capital goods demanded*
3. *A price $p_{1,B}$ such that $D(p_{1,B}) = S(p_{1,B})$*

We have the following proposition

Proposition 4 (Supply and demand)**.** *In date 1, B, with $\chi^S \in [0;1]$ denoting the share of S-banks and $(1-\chi^S)$*

that of T-banks, the aggregate demand for capital goods writes:

$$D(p_{1,B}) = \begin{cases} +\infty & \textit{if } p_{1,B} = 0 \\ \frac{k}{p_{1,B}qr}(1-\chi^S) & \textit{if } 0 < p_{1,B} < \overline{p}^T_{1,L} \\ \in \left[0; \frac{k}{p_{1,B}qr}(1-\chi^S)\right] & \textit{if } p_{1,B} = \overline{p}^T_{1,L} \\ 0 & \textit{if } p_{1,B} > \overline{p}^T_{1,L} \end{cases}$$

and the aggregate supply of capital goods writes:

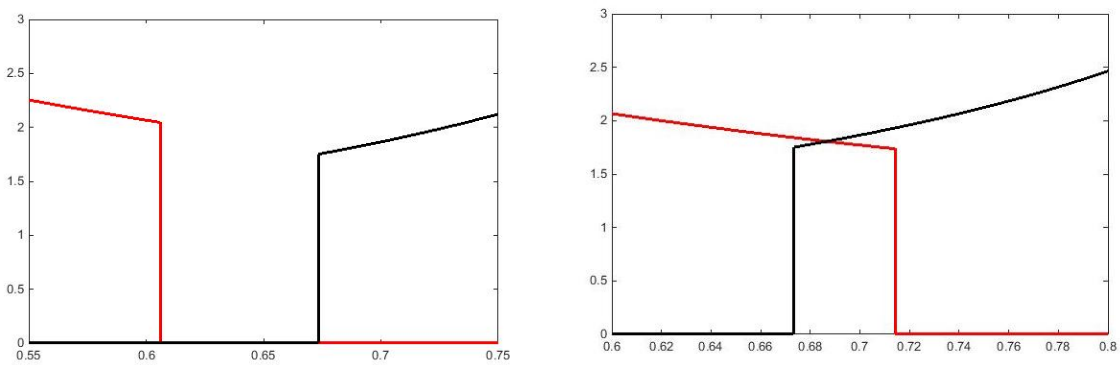
$$S(p_{1,B}) = \begin{cases} 0 & \textit{if } 0 \leqslant p_{1,B} < \overline{p}^S_1 \\ \in \left[0; \frac{n(1-\varepsilon)}{1-(1-\varepsilon)p_{1,B}qr}\chi^S\right] & \textit{if } p_{1,B} = \overline{p}^S_1 \\ \frac{n(1-\varepsilon)}{1-(1-\varepsilon)p_{1,B}qr}\chi^S & \textit{if } \overline{p}^S_1 < p_{1,B} < \overline{p}^T_{1,H} \\ \in \left[\frac{n(1-\varepsilon)}{1-(1-\varepsilon)p_{1,B}qr}\chi^S; \frac{n(1-\varepsilon)}{1-(1-\varepsilon)p_{1,B}qr}\chi^S + \frac{(1-\varepsilon)}{qr}\frac{(-\frac{k}{\delta})+qr(n+k)}{1-p_{1,B}(1-\varepsilon)qr}(1-\chi^S)\right] & \textit{if } p_{1,B} = \overline{p}^T_{1,H} \end{cases}$$

If $p_{1,B} > \overline{p}^T_{1,H}$*, the aggregate supply of capital goods is strictly larger than the aggregate demand such that the market cannot clear.*

Proof. See appendix □

The supply and demand for capital goods are illustrated in Figure 6 and follow from our previous analysis: when the price is low, there is a high demand for capital goods by T-banks. They prefer keeping slack at $t = 1$, to take the chance of buying underpriced assets at $t = 1$ in state B. When prices increase, they are better off issuing debt and investing at $t = 0$.

When the price is low shadow banks are not willing to lever themselves at $t = 0$, because the price they would get by selling assets on the capital goods market is too low, which makes the cost of time 0 debt too high for them, the intermediation price of government guarantee being too high. When prices increase, this reduces the cost of making their short-term debt safe, hence the cost of levering. This tradeoff is akin to the one emphasized in Stein (2012).



(a) Case $\delta = 1$
No asset trade

(b) Case $\delta < 1$ ($\delta = 0.8$)
Asset trade

Figure 6: Numerical illustration of the capital goods market at $t = 1$ in state B
(T-banks' demand in red, S-banks' supply in black)

One notices that $S(p_{1,B}) > 0$ when $p_{1,B} > \overline{p}^T_{1,H}$. Indeed, for such prices, both S and T-banks are willing to sell capital goods, which induces a positive supply whatever the allocation of intermediaries between the two types of banks. This restricts the set of prices that can prevail in equilibrium to $[0; \overline{p}^T_{1,H}]$.

Our technical assumption (7) ensures that $\overline{p}^S_1 < \overline{p}^T_{1,L} < \overline{p}^T_{1,H}$. According to the share of S-banks, different equilibria on the capital goods market can prevail.

Proposition 5. *(Market equilibrium) In equilibrium, we have*

1. *Either* $\chi^S = 0$, $D = S = 0$, *and* $\overline{p}^T_{1,L} \leqslant p_{1,B} \leqslant \overline{p}^T_{1,H}$. *No assets are traded.*

2. *Or* $\chi^S \in (0;1)$, $D = S$, *and*

   (a) *Either* $\dfrac{\frac{k}{\overline{p}^S_1 qr}}{\frac{n(1-\varepsilon)}{1-(1-\varepsilon)\overline{p}^S_1 qr} + \frac{k}{\overline{p}^S_1 qr}} \leqslant \chi^S$ *and* $D = S = \frac{k}{\overline{p}^S_1 qr}(1-\chi^S)$, *and* $p_{1,B} = \overline{p}^S_1$

   (b) *Or* $\chi^S \in \left[\dfrac{\frac{k}{\overline{p}^T_{1,L} qr}}{\frac{k}{\overline{p}^T_{1,L} qr} + \frac{n(1-\varepsilon)}{1-(1-\varepsilon)\overline{p}^T_{1,L} qr}}; \dfrac{\frac{k}{\overline{p}^S_1 qr}}{\frac{n(1-\varepsilon)}{1-(1-\varepsilon)\overline{p}^S_1 qr} + \frac{k}{\overline{p}^S_1 qr}}\right]$ *and* $p_{1,B} = \dfrac{1}{\frac{\chi^S n}{k(1-\chi^S)}+1}\dfrac{1}{qr(1-\varepsilon)} \in [\overline{p}^S_1; \overline{p}^T_{1,L}]$, $D = S = \frac{k}{p_{1,B} qr}(1-\chi^S) = \frac{n(1-\varepsilon)}{1-(1-\varepsilon)p_{1,B} qr}\chi^S$

   (c) *Or* $\dfrac{\frac{k}{\overline{p}^T_{1,L} qr}}{\frac{k}{\overline{p}^T_{1,L} qr} + \frac{n(1-\varepsilon)}{1-(1-\varepsilon)\overline{p}^T_{1,L} qr}} \geqslant \chi^S$ *and* $D = S = \frac{n(1-\varepsilon)}{1-(1-\varepsilon)\overline{p}^T_{1,L} qr}\chi^S$, $p_{1,B} = \overline{p}^T_{1,L}$

3. *Or* $\chi^S = 1$, $D = S = 0$, *and* $0 \leqslant p_{1,B} \leqslant \overline{p}^S_1$. *No assets are traded*

4.7 The allocation program

We now endogenize bankers' choice to enter the T-or a S-banking sector by observing that bankers will choose whatever banking business is more profitable. They compare *ex ante* value functions as of $t = 0$, and choose an allocation χ^S such as to solve

$$\max_{\chi^S \in [0;1]} \chi^S V_0^{S,B}(p_{1,B}) + (1-\chi^S) V_0^{T,B}(p_{1,B})$$

where $p_{1,B}$ is a market price for capital goods at $t = 1$ in state B.

Let's define

$$\Delta : p_{1,B} \to V_0^{T,B}(p_{1,B}) - V_0^{S,B}(p_{1,B})$$

Recalling that equilibrium market prices for capital goods at $t = 1$ in state B are to be found in $[0; \overline{p}^T_{1,H}]$, it is sufficient to study Δ on this interval. On $[0; \overline{p}^T_{1,H}]$, Δ is a continuous, strictly decreasing function.

As, $\Delta(0) = +\infty$, it can cancel at most once on this interval. We end up with the following proposition

Proposition 6 (Allocation program)**.** *Defining* $S = \Delta^{-1}(0) \cap [0; \overline{p}^T_{1,H}]$, *the allocation program solves as follows*

1. *If* $S = \emptyset$, $\chi^S = 0$

2. *Otherwise, denoting* $p_1^* = \Delta^{-1}(0) \cap [0; \overline{p}_{1,H}^T]$*, we have*

$$\chi^S = \begin{cases} 0 & \textit{if } p_{1,B} \in [0; p_1^*) \\ \in [0;1] & \textit{if } p_{1,B} = p_1^* \\ 1 & \textit{if } p_{1,B} \in (p_1^*; \overline{p}_{1,H}^T] \end{cases}$$

4.8 The game equilibria

Having detailed the different parts of our equilibrium, we can now focus on the equilibrium determination of our game. We have the following result, which follows from the above propositions.

Proposition 7 (Equilibria description)**.** *In all equilibria, bankers invest all their initial endowment in the bank they set up. The bank invests all the funds obtained from the bankers in the productive investment technology.At* $t = 1$ *in state* G *no assets are traded on the capital goods market, and banks roll over their time 0 short-term risk-free debt (*$p_{1,G} \in [1; \frac{\delta}{1-\varepsilon}]$*). In each date and state, risk-less short term debt (if any) is sold at par to the households, and the households purchase all the short term debt sold to them by the bankers.*

And:

1. *Either* $\Delta(\overline{p}_1^S) < 0$*. In this case, there is a unique* $p_{1,B}^* \in (0; \overline{p}_1^S)$ *such that* $\Delta\left(p_{1,B}^*\right) = 0$*. Then* $\chi^S = 1$ *is the unique equilibrium allocation, and any* $p_{1,B} \in [p_{1,B}^*; \overline{p}_1^S]$ *is an equilibrium market price at* $t = 1$ *in state* B*. No assets are traded in these equilibria, and only S banks exist. They don't issue any form of riskless debt.*

2. *Or* $\Delta(\overline{p}_1^S) = 0$*. In this case, any* χ^S *such that* $\frac{\frac{k}{\overline{p}_1^S qr}}{\frac{n(1-\varepsilon)}{1-(1-\varepsilon)\overline{p}_1^S qr} + \frac{k}{\overline{p}_1^S qr}} \leqslant \chi^S$ *is an equilibrium allocation, and* $p_{1,B} = \overline{p}_1^S$*. Either only S-banks exist, and they don't issue any type of riskless debt, and invest all their endowment in the productive investment, or shadow and traditional banks coexist, and interact on the asset market: T-banks raise funds at* $t = 0$ *to invest in the productive investment technology, and at* $t = 1$ *in state* B*, to purchase capital goods on the market.*

3. *Or* $\Delta(\overline{p}_1^S) > 0$ *and* $\Delta(\overline{p}_1^T) < 0$*. Then, there is a unique* $p_{1,B}^* \in (\overline{p}_1^S; \overline{p}_1^T)$ *such that* $\Delta\left(p_{1,B}^*\right) = 0$*. In this case* $\chi^S = \frac{1}{1 + \frac{p_{1,B}^* qr}{1-(1-\varepsilon)p_{1,B}^* qr} \frac{n(1-\varepsilon)}{k}}$ *is the unique equilibrium allocation, and* $p_{1,B} = p_{1,B}^*$ *is the unique equilibrium market price at* $t = 1$ *in state* B*. Shadow and traditional banks coexist, and interact on the asset market at* $t = 1$ *in state* B*: T-banks don't issue short-term debt at* $t = 0$*, but issue short term debt at* $t = 1$ *in state* B *in order to purchase underpriced capital goods from S-banks. S-banks lever at* $t = 0$*, and sell capital goods on the market at* $t = 1$ *in state* B*.*

4. *Or* $\Delta(\overline{p}_1^T) = 0$*. In this case, any* χ^S *such that* $\frac{\frac{k}{\overline{p}_1^T qr}}{\frac{n(1-\varepsilon)}{1-(1-\varepsilon)\overline{p}_1^T qr} + \frac{k}{\overline{p}_1^T qr}} \geqslant \chi^S$ *is an equilibrium allocation, and* $p_{1,B} = \overline{p}_1^T$*. Either only T-banks exist, and they issue* k *units of riskless debt at* $t = 0$*, or both S and T-banks exist, and T-banks issue less claims at* $t = 0$*, to keep slack to purchase capital goods at* $t = 1$ *in state* B *from S-banks. Shadow and traditional banks can coexist in this case, in which case assets are traded between the two types of intermediaries.*

5. *Or* $\Delta(\overline{p}_1^T) > 0$. *In this case* $\chi^S = 0$ *and any* $p_{1,B} \in \left[\overline{p}_{1,L}^T; \overline{p}_{1,H}^T\right]$ *such that* $\Delta(p_{1,B}) \geqslant 0$ *is an equilibrium market price. No assets are traded in these equilibria. Only T banks exist, and they issue* k *units of riskless debt at* $t = 0$*, which they roll over at* $t = 1$ *in state* B *and in state* G.

The conclusion we draw from Proposition 7 is that both types of intermediaries can coexist and interact on capital goods market. When they do, S-banks lever themselves thanks to T-banks' ability to purchase capital goods sold by shadow banks in a crisis (i.e. at $t = 1$ in state B). In such a situation, fire-sales always occur.

Indeed, T-banks' have a limited ability to issue short-term debt, and thereby the total quantity of investment they can make at $t = 0$ and $t = 1$ in state B is limited. In order to purchase capital goods from S-banks in the crisis, T-banks need to be compensated for foregoing investment opportunities at $t = 0$. T-banks face a trade-off between issuing short-term debt at $t = 0$ and keeping some buffer in order to issue short-term debt at $t = 1$ in state B so as to purchase S-banks' capital goods. Interestingly this makes the fire sale prices always lower than the price at which the traditional banks value the asset (i.e. δ): the fire sale is not entirely driven by the need for T-banks to be compensated for higher functioning costs. However, the fire-sale price cannot be too low either: S-banks have to be be better off paying such a cost at $t = 1$ in state B to benefit from the intermediated government guarantee, in order to benefit from increased leverage in good times, rather than not levering up at all.

These trade-offs are key to understand the occurrence of fire-sales in a crisis and the interaction between traditional and shadow banks.

5 Discussion

5.1 The effects of assets transfer

Complementarity between T-banks and S-banks In the model, S-banks can issue riskless claims by relying upon T-banks' asset purchases in a crisis. T-banks are better off when there are more shadow banks because they have to pay a lower price for shadow banks' assets in a crisis. In that sense, our model exhibits a form of complementarity between T-banks and S-banks that goes through the asset market at $t = 1$ in state B (henceforth "in a crisis").

One implication of this complementarity is T-banks channel the support from the guarantee fund to the rest of the financial system. Indeed, T-banks have the possibility to intermediate this support by providing back-up to S-banks in times of troubles. In our setting, the more T-banks, the higher the (indirect) support from the guarantee fund to the financial system in a crisis. The higher this support, the better off the S-banks. Conversely, the more S-banks, the higher the amount of capital goods that needs to be absorbed by T-banks when S-banks need to delever. This induces a decrease in prices, as T-banks are limited in their ability to issue riskless debt in a crisis. This also increases T-bank's profit from asset purchases. T-banks are therefore better off when there are more S-banks.

The complementarity induced by the secondary asset market has consequences in terms of bankers' allocation between the two types of banks, and the aggregate level of investment in the economy (hence welfare).

Sectoral allocation effect and welfare impact To clarify this point, let us conduct the following thought experiment. Take our model and assume that there is no secondary asset market in a crisis. In such a case, there cannot be asset trade in a crisis, which means that neither T- nor S-banks can use the proceeds of asset sales to reimburse their creditors. A notable difference between T- and S-banks is that T-banks have access to the guarantee fund making their debt safe in a crisis, while shadow banks do not. As a result, it is impossible for shadow banks to issue debt at $t = 1$ in state B and - backwardly - neither at $t = 0$, because there is a nonzero probability that S-banks' output goes to zero at future date $t = 2$. In contrast, because they can access the guarantee fund, T-banks can issue risk-less debt in a crisis. From the viewpoint of $t = 0$, T-banks are able to issue risk-less debt insofar as they are able to refinance this debt at future dates, whatever state materializes at $t = 1$.

When there is no secondary asset market in a crisis, bankers' choice to enter the T- or S-banking sector becomes the following. One the one hand, T-banks enjoy deposit insurance in a crisis. Even though they do not benefit from fire-sales of S-banks' assets, this enables them to issue debt at $t = 0$. Again this comes at the cost of being regulated, which is captured by the parameter $\delta < 1$ in the model. On the other hand, S-banks do not have to comply with regulatory costs, and they do not enjoy deposit insurance in a crisis. Even without a secondary asset market, the absence of deposit insurance is detrimental to S-banks because they cannot issue debt at $t = 0$, thus no debt at all. Bankers therefore choose either to enter a levered though regulated T-banking sector, or an unregulated though unlevered S-banking sector.

Keeping the same notations as in the model, the time-0 value function of a banker entering the S-banking sector in an environment where there is no asset market in a crisis writes:

$$V_0^{SB,NM} = [pR + (1-p)qr]n \tag{8}$$

where we denote "NM" for "no market". Meanwhile, time-0 value function of a banker entering the T-banking sector when there is no asset market in a crisis writes:

$$V_0^{TB,NM} = \delta[R(n+k) - k] + (1-p)(\delta qr(n+k) - k) \tag{9}$$

This has two implications. First, it should be noted that theses value functions are a lower bound for the value function of bankers entering the T- and S-banking sectors in the model with an asset market. This implies that opening up the asset market can only generate gains from trade, hence can only positively impact the welfare of the economy. One example of such a welfare improvement associated to the existence of this market is detailed in Figure 7.

Moreover, in a general way, the existence of such an asset market impacts the allocation of bankers in one type of bank or the other. In Figure 7, we provide an example where T-banking is dominated when markets are closed ($V_0^{TB,NM} < V_0^{SB,NM}$). Once we open up the asset market, bankers start allocating themselves in the T-bank sector. We interpret this as a potential rationale for why T-banks continue existing, even though their business model is dominated absent the opportunity to earn a profit from fire sales, the latter stemming from their ability to benefit from crises by issuing deposits when other intermediaries cannot.[26] The shaded area represents the welfare gains from trade on the asset market at $t = 1$ in state B.

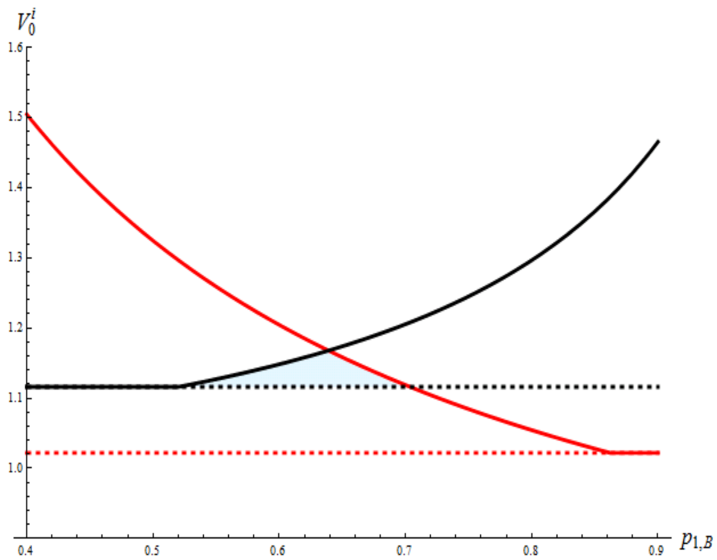


Figure 7: Value functions against asset price in a crisis
(V_0^T in red, V_0^S in black, NM dashed)

5.2 Impact of changes in the level of deposit insurance on the relative size of the traditional and shadow banking sectors

We now turn to the analysis of comparative statics of the model. In so doing, we focus on equilibria of type 3, as described in point 3 of proposition 7.

In an equilibrium of type 3, recall that bankers allocate themselves between T-banks and S-banks such that the value function at $t = 0$ of entering the T- or S-banking sector is the same (the solution is interior). We have $V_0^T = V_0^S$ with

$$V_0^T = \left[p\,(\delta R) + (1-p)\left(\delta q r + \frac{\delta - p_{1,B}^*}{p_{1,B}^*} \frac{k}{n} \right) \right] n$$

$$V_0^S = \left[\frac{p(R - (1-\varepsilon) p_{1,B}^* q r)}{1 - (1-\varepsilon) p_{1,B}^* q r} \right] n$$

where $p_{1,B}^*$ is the market equilibrium price for capital goods at $t = 1$ in state B.

Denoting $\chi_*^S \in [0, 1]$ the equilibrium share of S-banks, market clearing condition in a crisis yields:

$$p_{1,B}^* = \frac{\frac{k}{n}}{(1-\varepsilon)\, q r \left(\frac{\chi_*^S}{(1-\chi_*^S)} + \frac{k}{n} \right)}$$

[26]The allocation of bankers between the two forms of intermediation technology is illustrated in Figure 8, both with and without asset market, for different values of k.

Recall that for parameter values such that this equilibrium exists, it is uniquely defined. Combining these three conditions we obtain

$$V_0^S = n\frac{p(R-1)}{\frac{\chi_*^S}{(1-\chi_*^S)}}\left(\frac{\chi_*^S}{(1-\chi_*^S)}+\frac{k}{n}\right)+np \tag{10}$$

$$V_0^T = np\delta R + (1-p)\left(\delta qrn + (\delta(1-\varepsilon)qr-1)\frac{k}{n} + \delta(1-\varepsilon)qr\frac{\chi_*^S}{(1-\chi_*^S)}n\right) \tag{11}$$

which enables us to link the equilibrium sectoral allocation to the value function of T-banks and S-banks.

We use expressions (10) and (11) to discuss how the relative size of the two banking sectors is modified when allowing for a slight change in the size of the government guarantee.

Change in the amount of deposit insurance k For clarity we discuss the effects of lowering k. We first focus on a change in k low enough to ensure that the considered modified equilibrium stays of type 3. Two competing effects are at stake.

1. On the one hand, keeping all parameters constant, a lower k reduces the size of the advantage of being a T-bank: T-banks have access to a lower government guarantee, which limits their leverage at all times, hence exerting a downward pressure on T-bank's profits. This makes T-banking relatively less profitable than S-banking, thereby inducing bankers to enter the S-banking sector. We call this direct effect a substitution effect.[27]

2. On the other hand, S-banks indirectly benefit from T-banks' guarantee fund through the (secondary) asset market in a crisis: this is at the root of the complementarity effect we pointed out in the previous subsection. Lowering k reduces the support that can be provided to S-banks through T-banks, reducing the price at which capital goods can be sold on the secondary market, hence reducing S-banks' profits and the incentive of entering the S-banking sector. We call this effect an income effect.

In our setting, the asset price adjustment associated to a lower asset demand by T-banks in a crisis outweighs the direct effect of lowering k on T-banks' profits: the net effect of lowering k on T-banks' expected profits is positive taking bankers' allocation as given.[28] We find that lower support to T-banks in a crisis reduces asset prices to such an extent that more bankers choose to enter the T-banking sector *ex-ante*, i.e. the income effect outweighs the substitution one. Bankers therefore react by allocating themselves with a higher probability in the traditional banking sector.

However, this does not hold true for high changes in k: holding δ fixed, when k gets low enough, T-banking becomes too inefficient for T-banks to continue existing. Indeed, for low levels of k, the T-banks would require too high a compensation for purchasing the asset at $t = 1$ in state B that S-banks would be better off not issuing short term debt. Moreover, in this range, entering the unlevered shadow banking sector is more valuable than entering the traditional banking sector where banks issue k units

[27]It is reminiscent of the argument at play in existing models of shadow banking as regulatory arbitrage (see e.g. Plantin, 2015; Ordonez, 2013; Harris et al., 2015).

[28]This is evidenced by the fact that, in equation (10), the coefficient of k, $(1-p)(\delta(1-\varepsilon)qr-1)\frac{1}{n}$ is negative.

of risk-less claims at $t = 0$ to invest in the productive technology. Finally, bankers allocate themselves only in S-banking, and no short-term debt is issued.

Figure 8 illustrates the allocation of bankers into the shadow banking system when the parameters are such that S-banking is dominating absent a market for assets in a crisis (i.e., at $t = 1$ in state B). We take $n = 1, p = 0.9, r = 1, q = 0.99, R = 1.13, \varepsilon = 0.11, \delta = 0.9$, for $0 < k < k^*$. The dashed red line illustrates the fact that all bankers allocate to the S-banking sector if T-banks cannot purchase capital goods from S-banks in the secondary market. The plain black line illustrates the two effects at play for different values of $0 < k < k^*$.[29] When k is low, T-banks' advantage of issuing debt in a crisis do not compensate for their costs, and all bankers allocate to the S-banking sector ($\chi^S = 1$). Once T-banks' advantage enables them to purchase assets from S-banks at fire-sale prices, not all bankers allocate to the S-banking sector and T- and S-banks coexist. By the same reasoning as previously, increases in the amount of deposits guaranteed in a crisis pushes more bankers to allocate to the S-banking sector.

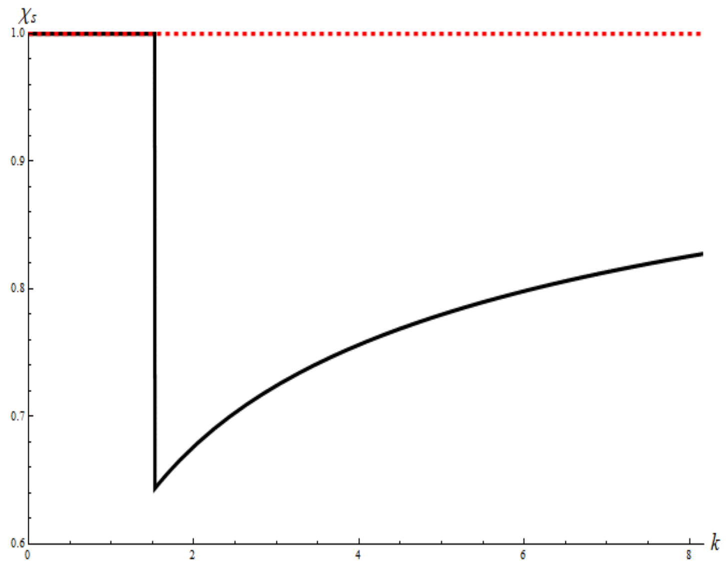


Figure 8: Share of shadow banks according to the level of guarantee (plain with asset market, dashed without asset market)

Analogy with capital requirements A positive analogy that can be developed is to consider a model where the structural limit on the size of T-banks' support in a crisis (k) comes at the cost of complying with capital requirements, that are imposed to T-banks for reasons outside of the model.

We assume that at $t = 1$ in state B, T-banks face a capital requirement of the form:

$$D^T_{1,B} \leqslant (1 - c) \left[\alpha I^T_0 + p_{1,B}\, q r I^T_1 \right] \tag{12}$$

where $D^T_{1,B}$ denotes the amount of funds borrowed from households and $p_{1,B}$ the price of capital goods.[30] Such a model would yield similar results, where our k counterpart would be found in $\frac{(1-c)n}{c}$.

[29]Notice that, for these values of the parameters, coexistence of the different forms of intermediation is ensured only when asset markets are open.

[30]At $t = 1$ in state B, we would set the following constraint, for the capital constraint to be stringent enough (rhs) while not

As is the case in our model, imposing such a capital requirement on desposits issued in a crisis spills over to date 0, as T-banks needs to roll all their debt over at $t = 1$ in state B, when no other intermediary is able to purchase assets.

The same argument as in our model can then be adapted to this case, where increased capital requirement in a crisis (thereby at all dates and states) would reduce T-bank's ability to purchase assets in a crisis, making T-banks better off and reducing bankers' incentives to set up a S-bank *ex-ante*. Conversely, lower capital requirement in a crisis would reduce the impact of fire sales: In that way, policies such as countercyclical capital buffers could have the potentially unwanted consequences of increasing the support to the shadow banking system at the time when shadow banks need it the most, hence driving more intermediaries into setting up unregulated entities.

Post-crisis banking reforms There have been several policy initiatives to impose restrictions on banks' trading activities since the crisis. Prohibiting regulatory arbitrage is the paradigm in Section 619 of the Dodd-Frank Act in the U.S. (known as the "Volcker Rule"), in the Financial Services Act of 2013 in the U.K. (based on the Report of the Vickers Commission), as well as the 2012 Report of the European Commission's High-level Expert Group on Bank Structural Reform in the E.U. (known as the Liikanen Report). Those regulation proposals include a prohibition of proprietary trading by commercial banks ("Volcker Rule"), a separation between different risky activities (Liikanen Report), and ring-fencing of depository institutions and systemic activities (Report of the Vickers Commission, enacted in 2013 in the Financial Services Act).

The aim of these reforms is to prevent regulatory arbitrage by traditional banks through off-balance sheet (unregulated) activities, which Pozsar et al. (2013) refer to as "internal shadow banking". Through the lens of our model, we indeed acknowledge the fact that contractual relationships on liquidity guarantees from traditional to shadow banks tend to favor shadow banking by increasing asset prices in a crisis. However, our key finding is that, even absent contractual relationships between traditional and shadow banks, the two types of banks coexist because they are not only substitutes but also complements. The complementarity between the two bank types comes from shadow banks' asset (fire) sales to traditional banks in a crisis. One implication of this complementarity is that traditional banks channel the support from the guarantee fund to shadow banks, even absent a contractual relationship between the two. Although it might then seem like a good idea to prevent traditional banks from trading assets in a crisis, this paper argues that traditional banks' profits from shadow banks' fire-sold assets in a crisis outweigh the (regulatory) costs that traditional banks have to comply with. This explains why traditional banks still exist even though shadow banks perform comparable activities while not having to comply with regulations. When designing banking reforms one needs to think hard about the implications of reforms such as a shutdown of the (interbank) asset market, in light of the reasons why regulated and unregulated banks coexist in the first place. This paper provides a framework to do so.

incitating T-banks to delever at $t = 1$ in state B (lhs):

$$\delta(1-\varepsilon)qr \leqslant (1-c) \leqslant \delta qr \tag{13}$$

5.3 Robustness of the analysis

We discuss in this section the robustness of the analysis to the relaxation of some of our assumptions.

Level of regulatory cost Relaxing the constraint on the level of regulatory costs - captured by the term δ - does not bring much changes to the analysis. The same types of equilibria prevail.

If condition (5) in assumption 3 does not hold, then $\delta < 1 - \varepsilon$ and asset transfers can occur between the two types of intermediaries. In a crisis, S-banks purchase all assets sold by T-banks. An interesting point is that asset are now transferred both ways: In good times (i.e. at $t = 0$) the shadow banking sector expands and levers up, purchasing assets from the relatively more costly traditional banking sector. In bad times (i.e. in a crisis), S-banks delever, benefiting from T-banks' access to government guarantee.

Level of deposit guarantee Let us now consider relaxing equation (6), in assumption 3. One key implication of this is that multiple equilibria can now arise in the asset market: as detailed in the appendix, for a given sectoral allocation between T-banks and S-banks χ^S, different prices can clear the market, and sunspot equilibria arise. To avoid the occurrence of sunspot equilibra, we tilt the game timeline and assume that bankers simultaneously choose a level of initial investment I_0^T, I_0^S and an allocation into one or the other sector. In this setup, only one equilibrium of the game can survive.

In such a case, for high levels of k, another form of complementarity can occur and thereby a new type of coexistence equilibrium. The intuition goes as follows. For high levels of k, T-banks cannot issue an amount k of short term-debt at $t = 0$, as they would not be able to refinance such a high amount of debt at $t = 1$ in state B, while satisfying its time 2, BG limited liability constraint.

However, although unable to finance up to k, T-banks would be able to finance more investment at $t = 0$ than would be possible absent S-banks. Indeed, by purchasing assets at fire sale price in times of crisis, they can rely on profits made on such trades at $t = 2$ in state BG, thereby relaxing their time 2, BG limited liability constraint. Then, they could use this additionnal profit to collateralize more riskless debt at $t = 0$ (and increase their investment at $t = 0$). The complementarity effect goes as follows. The more S-banks, the more profit T-banks can make on asset purchases in a crisis, and the higher the overall level of debt they can secure, backed by the profit made in times of crises.

In summary, relaxing equation (6) generates additionnal forms of complementarity between T-banks and S-banks. In that case, T-banks' ability to make profits on asset purchases in a crisis enables them to secure a higher level of debt overall (i.e. at $t = 0$ in our model), than they could absent this ability.

Coexistence assumption Relaxing the technical assumption which ensures coexistence (condition (7) in assumption 4) - while keeping condition (6) in assumption 3 binding - makes coexistence equilibria disappear. All equilibria then consist either of a unit mass of unlevered S-banks, or a unit mass of T-banks raising k units of riskless debt at date 0.

However, if we were to relax these two constraints simultaneously, coexistence equilibria of the type described above become possible again.

6 Conclusion

We document and integrate stylized facts from the 2007 financial crisis into a simple model that rationalizes the coexistence of traditional and shadow banks. This paper offers the first model of financial intermediation where both a regulated and an unregulated sector coexist and interact, while replicating the following facts from the crisis: (i) liabilities transfer from shadow to traditional banks, (ii) assets transfer from shadow to traditional banks, and (iii) fire sales of assets.

The model describes the different technologies used by traditional and shadow banks in order to issue safe claims against risky collateral. On the one hand, traditional banks rely on a guarantee fund to be able to issue riskless claims in a crisis. Therefore this guarantee also enables them to issue riskless claims outside a crisis. This access to a guarantee fund comes at a cost of higher regulation. On the other hand, shadow banks rely upon traditional banks' ability to issue riskless claims in a crisis, to absorb their assets and provide them with enough liquidity to reimburse their debt holders. This interaction in the asset market enables traditional banks to intermediate government insurance to the rest of the financial system, generating a complementarity between the two forms of financial intermediation. This complementarity is the key message of this paper: the more shadow banks in the system, the lower the price traditional banks have to pay for shadow banks assets in a crisis, and the better off the traditional banks. We see this form of complementarity as a main driver of the coexistence of these two banking sectors in the financial system.

We find that when shadow and traditional banks coexist in an economy, a small reduction in traditional banks' ability to issue deposits in a crisis induces a shift of intermediation towards the traditional banking sector. Indeed, two opposite effects are at play. One is the direct effect of hindered traditional banks' ability to raise funds in a crisis, which is to reduce their ability to lever up and thereby their expected profits. This substitution effect induces bankers to shift to the shadow banking sector, as this latter is not directly impacted by such a reduction in traditional banks ability to issue risk-less debt. The other one is indirect and akin to an income effect: a reduction in traditional banks' ability to issue riskless claims induces a lower asset demand in the crisis, creating a downward pressure on the equilibrium price of assets transferred from the shadow to the traditional banking sector. This lowers shadow banks' expected profits and increases traditional banks' expected profit, thereby pushing more bankers into the regulated sector. We show that this latter effect is sizeable and outweigh the former. All in all, a reduction in traditional banks' ability to lever up in a crisis, if not too strong, leads to an increase in the relative size of the traditional banking sector.

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A The data

A.1 Stylized balance sheets of US financial intermediaries

Once we aggregate those financial intermediaries that we include in our definition of the shadow banking sector[31], we define short-term debt using the FAUS by using the same terminology as Krishnamurthy and Vissing-Jorgensen (2015). We build stylized balance-sheets by consolidation of the financial balance sheets of the legal institutions for which we have data in the Financial Accounts of the United States (FAUS).

The list of items included in shadow banks' short-term debt is: Security repurchase agreements (net), Depository institution loans n.e.c., Trade payables, Security credit (Customer credit balances), Security credit (U.S.-chartered institutions), Security credit (foreign banking offices in U.S.), Taxes payable, Commercial paper, Open market paper.

A.2 Book versus market value of equity

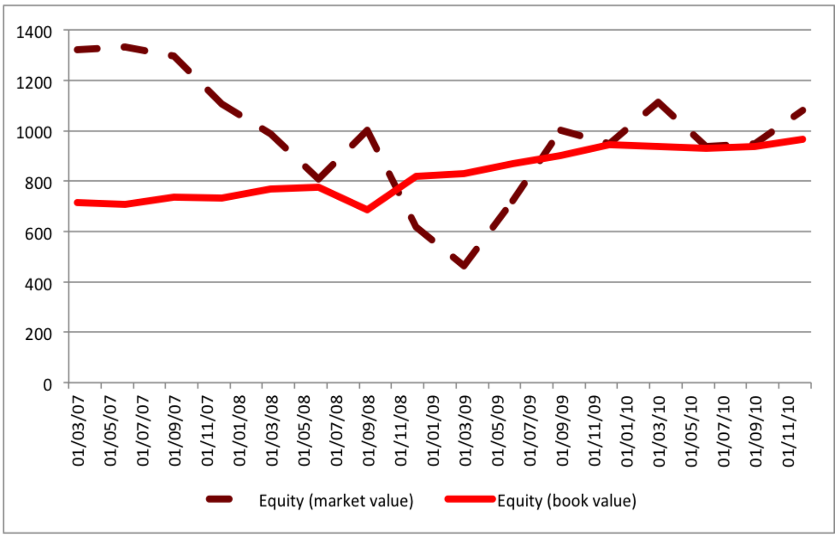

Figure 9: Traditional banks: Book versus market value of equity

He et al. (2010) and Bigio et al. (2016) also find that traditional banks' book equity increased by around US $250 billion during the crisis. Figure 9 provides evidence of this increase in the stock of book equity of the US traditional banking sector through the crisis. This Figure is based on reported book value of equity, which is the leverage measure most used for regulatory purposes. However, there are reasons to believe that the true level of capital for the traditional banking sector was lower. We use data from CRSP to measure the market value of traditional banks' equity and we see that most of the increase in book value of equity disappears when one looks at market value of equity.

[31] Recall we define shadow banks as .

A.3 Deposit inflows into traditional banks

We take the definition of the largest US bank-holding companies on Figure 1 from the Federal Reserve's website (https://www.ffiec.gov/nicpubweb/nicweb/HCSGreaterThan10B.aspx/).

A.4 Regression: Traditional banks' MBS purchases in the crisis

The data come from the quarterly Call Reports and He et al. (2010)'s estimates. We use the procedure described in Acharya and Mora (2015) to construct our sample. Variables ending in 2007q4 represent variable levels as of 2007q4. Variables starting with "Change" are growth rates from 2007q4 to 2009q1, normalized by total assets as of 2007q4. The dependent variable MBS_Purchases represents purchases of mortgage-backed securities by traditional banks between 2007q4 and 2009q1, normalized by total assets as of 2007q4. As in He et al. (2010) we test many scenarios in terms of MBS repayment rate and total losses on assets, to make sure that what our dependent variables capture are actual purchases of MBS by traditional banks. We report three of these scenarios, including the "naive" one. Under scenario 1 the repayment rate used to construct the MBS_Purchases variable is 7% and total losses imputed to the financial sector are $500 billion. Under scenario 2, the repayment rate is 12% and total losses are $176 billion. Under the "naive" scenario, we do not correct for the net repayment rate nor total losses. The White robust standard error estimator is used. Table 10 below details the construction of variables (mainly following Acharya and Mora, 2015).

Variable	Variable Name	Call Report Items
Insured deposits	insured_deposits	rconf049 +rconf045
Brokered deposits	brokered_deposits	rcon2365
Interest rate on large deposits	ir_large_deposits	rconf049 + rconf045
Unused commitment		rcfd3814+rcfd3816+rcfd3817+rcfd3818+rcfd6550+rcfd3411
Credit	Credit	rcfd1400 + Unused_commitments
Unused commitments ratio	Unused_commitments_ratio	unused commitments/(unused commitments+rcfd1400)
Cash		rcfd0010
Federal Funds Sold		rcfd1350+rconb987 (rconb987+rcfdb989 if after 2002/03/30)
MBS		rcfd1699+rcfd1705+rcfd1710+rcfd1715+rcfd1719+rcfd1734 +rcfd1702+rcfd1707+rcfd1713+rcfd1717+rcfd1732+rcfd1736
Securities (MBS excluded)		rcfd1754+rcfd1773-(rcfd8500+rcfd8504+rcfdc026+rcfd8503+rcfd8507+rcfdc027)
Liquid assets		Securities (MBS excluded)+ Federal Funds Sold+Cash
Liquidity ratio	Liquidity_ratio	Liquid Assets/rcfd2170
Wholesale funding		rcon2604+rcfn2200+rcfd3200+rconb993+rcfdb995+rcfd3190
Wholesale funding ratio		Wholesale funding/rcfd2170
Net Wholesale fund ratio	Net_Wholesale_fund	Wholesale funding -(Securities (MBS excluded)+Federal Funds Sold+Cash)
Non performing loan		rcfd1407+rcfd1403
Non performing loan ratio	NPL_ratio	Non performing loan/rcfd1400
Capital ratio	Capital_ratio	(rcfd3210+rcfd3838)/rcfd2170
Real Estate Loan Share	Real_Estate	rcfd1410/rcfd1400
Residential Mortgages		(rcfdf070+rcfdf071)/rcfd2170
Financial Assets		rcfd0081+rcfd0071+rcfda570+rcfda571+rcona564+rcona565 +rcfd1350+rcfda549+rcfda550+rcfda556+rcfda248
Short Term Liabilities		rcon2210+rcona579+rcona580+rcona584+rcona585+rcfd2800+rcfd2651+rcfdb571
Maturity Gap	Mat_Gap	(Financial Assets- Short Term Liabilities) / rcfd2170
Tag deposits	Tag_deposits	rcong167

Figure 10: Variables definitions

Note: All missing observations are considered equal to zero. Banks are aggregated to top holder level (RSSD9348). We follow the same procedure as Acharya and Mora (2015).

Table 2: Traditional banks: Determinants of MBS purchases during the crisis

	(1) Scenario 1	(2) Scenario 2	(3)
Change_insured_deposits	0.231***	0.227***	0.223***
	(0.049)	(0.044)	(0.039)
Change_brokered_deposits	0.016	0.031	0.046
	(0.046)	(0.042)	(0.038)
Change_ir_large_deposits	−0.777***	−0.465**	−0.160
	(0.233)	(0.188)	(0.162)
Change_Credit	−0.112***	−0.102***	−0.092***
	(0.032)	(0.028)	(0.024)
Change_Capital_ratio	−0.695***	−0.583***	−0.474***
	(0.117)	(0.109)	(0.105)
Change_Net_Wholesale_fund	0.119***	0.116***	0.113***
	(0.037)	(0.034)	(0.032)
Change_Real_estate	−0.016	−0.034	−0.052
	(0.049)	(0.041)	(0.037)
Change_NPL_Ratio	−0.363***	−0.287***	−0.213***
	(0.078)	(0.066)	(0.059)
Change_Liquidity	−0.374***	−0.332***	−0.292***
	(0.044)	(0.037)	(0.032)
Liquidity_ratio_2007q4	−0.019	−0.001	0.017
	(0.027)	(0.023)	(0.020)
NPL_ratio_2007q4	−0.303***	−0.290***	−0.277***
	(0.114)	(0.093)	(0.080)
Mat_Gap_2007q4	−0.119***	−0.079***	−0.040***
	(0.014)	(0.012)	(0.011)
ir_large_deposits_2007q4	−0.979***	−0.613***	−0.255
	(0.226)	(0.181)	(0.156)
Net_Wholesale_fund_ratio_2007q4	0.025	0.016	0.008
	(0.021)	(0.017)	(0.015)
Unused_commitments_ratio_2007q4	−0.004	−0.024	−0.043*
	(0.033)	(0.028)	(0.024)
Real_Estate_2007q4	−0.055***	−0.045***	−0.034***
	(0.016)	(0.013)	(0.011)
Capital_ratio_2007q4	−0.058	−0.046	−0.035
	(0.059)	(0.051)	(0.048)
Tag_deposits	0.198***	0.153***	0.109***
	(0.048)	(0.042)	(0.039)
log_assets	0.007***	0.004***	0.000
	(0.002)	(0.001)	(0.001)
Constant	0.081***	0.074***	0.068***
	(0.031)	(0.025)	(0.021)
Observations	3954	3954	3954
adjusted R^2	0.1989	0.2229	0.2374

Source: Call Reports

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B The model

See online technical appendix.

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