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BANKS' RISK RACE: A SIGNALING EXPLANATION

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- DR 09007 -

Banks' Risk Race: A Signaling Explanation

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Banks' Risk Race: A Signaling Explanation

ABSTRACT:

Many observers argue that the abnormal accumulation of risk by banks has been one of the major causes of the 2007-2009 financial turmoil. But what could have pushed banks to engage in such a risk race? The answer brought by this paper builds on the classical signaling model by Spence. If banks' returns can be observed while risk cannot, less efficient banks can hide their type by taking more risks and paying the same returns as the efficient banks. The latter can signal themselves by taking even higher risks and delivering bigger returns. The game presents several equilibria that are all characterized by excessive risk taking as compared to the perfect information case.

Key-Words:

- Banking Sector
- Imperfect Information
- Risk Strategy
- Risk/return Tradeoff
- Signaling

RESUME :

L'article explique l'accumulation excessive de risque par les banques avant la crise de 2007-2009 par un mécanisme de signalisation en information imparfaite.

Mots-clés :

- Arbitrage risque/rendement
- Information imparfaite
- Secteur bancaire
- Signalisation
- Stratégie de risque

JEL Classification : G21; G32; D82

BANKS' RISK RACE: A SIGNALING EXPLANATION

Damien Besancenot*, Radu Vranceanu[†]

Abstract

Many observers argue that one of the major causes of the 2007-2009 financial turmoil was the abnormal accumulation of risk by banks. In this paper, we provide an explanation for this "risk race" that builds on the classical signaling approach. If banks' returns can be observed while risk cannot, less efficient banks can hide their type by taking more risks and paying the same returns as the efficient banks. The latter can signal themselves by taking even higher risks and delivering bigger returns. The game presents several equilibria that are all characterized by excessive risk taking as compared to the perfect information case.

Keywords: Banking sector, Risk strategy, Risk/return tradeoff, Signaling, Imperfect information.
JEL Classification : G21; G32; D82.

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1 Introduction

The 2007-2009 crisis has been by all dimensions one of the most severe since the Great Depression (Brunnermeier, 2009). Social costs were huge, both in terms of output loss and rising unemployment. Fiscal positions of many countries were deeply undermined, with lasting consequences on growth prospects. While scholars will debate for many years about the contribution of different factors to this crisis, there is one point on which a majority of experts tend to agree: the financial difficulties that were at the origin of the crisis were brought about mainly by an abnormal accumulation of risk by banks (Borio, 2008; Trichet, 2008; Diamond and Rajan, 2009; Stiglitz, 2010). This observation begs the question on why, in the first place, did banks engage in what can be described as a genuine race for risk?

One key feature of banking activity is their *opacity* in functioning and management. As emphasized by Morgan (2002, p.874) "risks taken into the process of intermediation are hard to observe from outside the banks". Indeed, banks are traditionally very reluctant to disclose any information about their clients on both sides of their balance sheets. Furthermore, the composition of their asset portfolio is both a strategic decision and a key factor of success; no bank will eagerly disclose this information. Over the last twenty years, the complexity (and the opacity) of banks' financial intermediation increased dramatically, being driven essentially by a shift from the traditional "deposit and loan" model to the "originate-to-securitize" model (Diamond and Rajan, 2009; Stiglitz, 2010). In theory, securitization should have allowed banks to transfer most of the credit risk to a myriad of investors; in practice, recent data show that US banks used to hold large amounts of high risk securities on their books; furthermore, during the crisis, they had to cover the risks carried by off-balance sheet entities they had created for securitization purposes. European banks have also aggressively invested in CDOs with a hidden content in US subprime loans, that had a true risk known only to a minority of insiders. Hence, while bank returns are disclosed every quarter, the structural risk taken by a bank is much harder to assess.

In general, given that higher risks command higher returns, banking technology allows the manager to choose the preferred risk/return combination. As the experience of this crisis has

shown, banks are not equally equipped to face adversity. The list of "losers" is as long as the list of "winners".¹ Actually, banks differ in their portfolio of activities, investment and loan opportunities, risk management systems and operating costs. In this paper we focus on the latter, and assume that there are only two types of banks, the highly efficient (or good) ones and the less efficient (or bad) ones. A less efficient bank can deliver the same returns as an efficient bank only if it takes more risks on its balance sheet. We then analyze banks' risk/return strategies within the framework of a classical signaling game (Spence, 1973, 2002; Riley, 1975) that opposes banks' managers to shareholders. In a perfect information world, all investors would flee the less efficient banks to join the most efficient ones, and the former type of bank would be pulled out of the market. However, if returns can be observed by private investors but risk cannot, then less efficient banks would survive if they manage to conceal their type. They can do so by increasing the amount of risk in order to deliver the same returns as the high efficient banks. In equilibrium, bad banks take too much risks.

Another set of equilibria can be obtained if the regulator can set an upper limit on the amount of risk that banks can take, without challenging the assumption of imperfect information. As the experience of this crisis has shown, regulators can get information about the true exposure to dubious assets by performing time-consuming stress tests that measure a bank's resilience to simulated additional shocks. In the US, the Treasury made public the methodology and results of these tests for each large bank subject to these checks; European regulators decided to keep the bank-specific information secret.² Hence the regulator's information is private knowledge, and the public cannot use it in order to make his investment decisions. Some prudential ratios might also be communicated only to the regulator, without being publicly disclosed. If such an upper bound on risk exists, and this limit is known by banks only (and the regulator), good banks can signal themselves by increasing returns (and risk) up to the point where bad banks cannot follow them. If not all good banks undertake the costly "super-signaling" strategy, then bad banks can

¹ The dramatic fall of Lehman Brothers, or the massive support of the respective governments to rescue Citigroup, UBS, Dexia or Northern Rock, etc. should be weighted against rather successful stories of Barclays, Nomura, Santander, Goldman Sachs, JP Morgan Chase, and so on.

² See for instance: "US to push Europe on stress tests", WSJ (02.06.2010), about the conflict between the US Treasury and the European Commission on publicly disclosing results of the tests in Europe.

further survive by taking excessive amounts of risk.

We show that such a game presents several types of equilibria, depending on the on the proportion of good banks and operating costs. The main contribution of the paper is to emphasize that, under imperfect information, in any of these equilibria at least some banks have no other optimal choice than to hold on their balance sheet more risk than in a perfect information set-up. Furthermore, for some parameter values, we get a typical configuration of multiple equilibria; which one of them actually materializes ultimately depends on investors' beliefs. In a multiple equilibria setting, the economic system is prone to extreme instability.

The paper is organized as follows. The next section introduces our main assumptions, Section 3 analyzes the equilibria of the game, Section 4 presents our conclusions.

2 Main assumptions

The model is cast as a game between banks' managers and shareholders under imperfect information of the latter about the structure of the asset portfolio of the bank. The banking sector is made up of publicly listed banks, that take deposits and issue debt in order to grant loans and buy financial assets. If the bank has access to a risk-free asset and to a portfolio of risky assets and loans, the manager can pick any combination of risk/return along the capital market line, a tangent to the efficient frontier (Markowitz, 1952). A higher return can be obtained only if the bank takes more risks (by investing more in the efficient portfolio of risky assets and loans).

Denoting the net return by R and the amount of risk by v , this typical trade-off between risk and return for a bank of type i can be written:

$$R^i(v) = R_0 + \theta v - c^i, \tag{1}$$

where $R_0 > 0$ is the interest rate of the risk-free asset, $\theta > 0$ is the slope of the capital market line and c^i stands for the bank-specific operating cost.³ The inverse function, indicating the risk needed to achieve a given return for a bank with operating cost c^i is also of interest for further

³ Financial literature focuses on return variance (denoted often by σ^2) as a proxy for risk. The risk considered in this text is of the nature of an extreme event. The impact of such event on the firm cannot be directly inferred from the observed return variance.

developments:

$$v^i(R) = \theta^{-1} [R - R_0 + c^i]. \quad (2)$$

We assume that, depending on the quality of their management, banks differ in their operating costs.⁴ To keep the model as simple as possible, we assume that banks can be of two types: good banks (of type g) with a low operating cost c^g that can be normalized to zero without loss of generality and bad banks (of type b) with a high operating cost $c^b = c > 0$. In Figure 1, we represent the capital market lines of such a good and bad bank. It can be noticed that in order to provide shareholders the same net return, bad banks must take riskier bets, that is $v^b(R) > v^g(R)$, $\forall R > R_0$.

Let q be the proportion of good banks in the total population of banks, $1 - q$ being the proportion of bad banks. This distribution of banks is common knowledge.

In a general form, we represent the utility of the representative risk-averse shareholder's by a quasiconcave function $U(R, v)$, with $\partial U(\cdot)/\partial R > 0$, $\partial U(\cdot)/\partial v < 0$. Resulting indifference curves are convex.

Shareholders agree to pay the bank's manager a compensation that is proportional to their perceived utility, or $W = \gamma E[U(R, v)]$, where $E[-]$ is the expectations operator;⁵ the compensation factor γ is not essential, so we normalize it to 1.

Under these assumptions, in a perfect information set-up, a manager running a good bank would simply choose the bundle (R^H, v^H) that maximizes his income given the bank's capital market line, such as indicated at point A in Figure 1.

Notice that the manager of a bad bank would prefer the bundle (R^L, v^L) , at point B in the same figure. Yet, given that shareholders' satisfaction is higher for good banks than for bad banks, no investor would hold the bad bank stocks: therefore less efficient banks cannot survive in this perfect information world.

However, the assumption of perfect information is not very realistic given that a bank's risk

⁴ The structure of the problem and the solution would not change if, instead of different operating costs, we assume that banks differ in their investment opportunities (thus, the Markovitz frontier would be broader for the stronger bank, and the slope of its capital market line would be steeper than for the weaker bank).

⁵ These expectations will be determined over the set of beliefs about the type of bank given the return strategy.

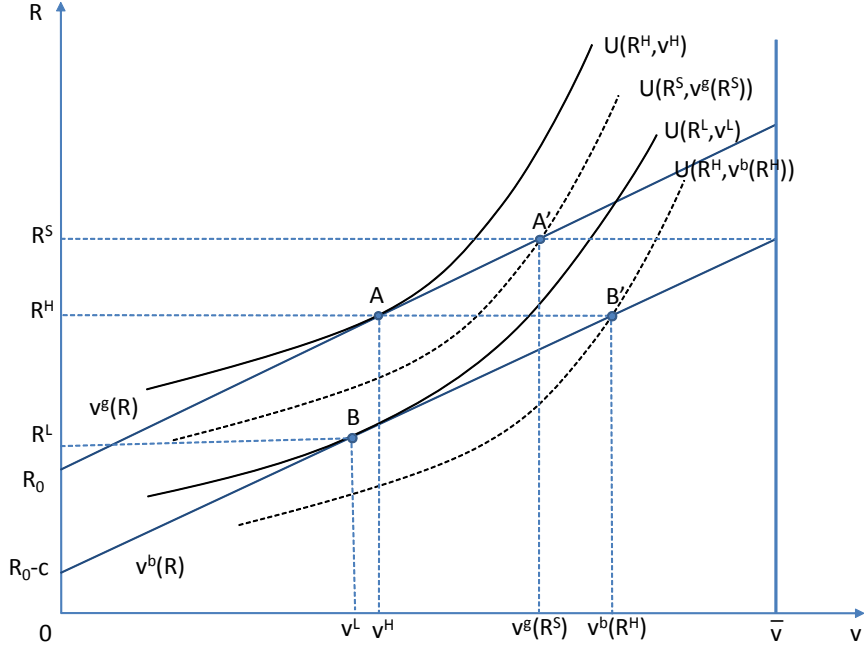


Figure 1: Return strategies, risk and utilities

exposure is a very complex commodity. As noticed in the Introduction, it is very difficult for outsiders, even for expert ones, to evaluate the full amount of risk taken by a bank. Building on these basic fact, we further assume that the level of risk exposure of a given bank is private information to its manager, while the stock return is public information. In this context the set of strategies of the banks is more sophisticated:

- For bad banks, like in the perfect information set-up, the strategy of playing R^L is never optimal since it reveals the type of the bank and all the shareholders would leave it. At difference with the perfect information case, in the imperfect information environment a bad bank can survive if it manages to conceal its type. It can reach this outcome by increasing the riskiness of its portfolio such as to deliver the return R^H , i.e. the perfect information return of the good bank (at point B' in Figure 1).
- Good banks can play their perfect information optimal strategy R^H as well. However, if good banks want to make sure that no bad bank has an incentive to imitate them, they should pay a sufficiently high return that a bad bank cannot deliver it. In order to analyze the broadest set of equilibria, let us assume that regulators can set an upper limit on the

total risk allowed to be taken by any bank, denoted by \bar{v} (the vertical line on Figure 1). Shareholders do not have the same ability to measure risk as the regulator. This situation is characteristic for instance of the European banking landscape where results to stress tests carried out in 2009 were not made public. Then, for sure, if a bank pays a return slightly above R^S , defined by:

$$R^S = R_0 + \theta\bar{v} - c, \quad (3)$$

then it signals itself as a good bank, given that bad banks cannot further increase risk such as to copy them.⁶ R^S is thus the second return strategy of the good bank.

Turning now to the manager's payoff, we argued that if investors perceive that a bank is of the bad type, this bank leaves the market and the compensation of the manager becomes zero. So, a positive compensation for the manager can be defined only for banks that stay on the market (those that are not been perceived as being bad banks). Denoting by $\Pr[i|R^j]$ the probability shareholders assign to the event that a bank is of the type i , with $i \in \{b, g\}$, if the return strategy is R^j , with $j \in \{L, H, S\}$, the manager's payoff can be written:

$$W(R^j) = \begin{cases} 0, & \text{if } \Pr[b|R^j] = 1 \\ \Pr[g|R^j]U(R^j, v^g(R^j)) + \Pr[b|R^j]U(R^j, v^b(R^j)), & \text{if } \Pr[b|R^j] \in [0, 1[\end{cases} \quad (4)$$

Notice that return strategies R^S and R^L reveal perfectly a bank's type. Thus $W(R^S) = U(R^S, v^g(R^S))$ and $W(R^L) = 0$.

Figure 2 presents the decision tree.

The typical *sequence of decisions* goes like this:

- At step 0, Nature picks the type of bank, either b or g .
- At step 1, depending on their type, banks chose their return strategy.
- At step 2, shareholders make their opinion about the type of bank given the observed returns and pay the manager a compensation proportional to their own expected utility; the game ends.

⁶ In principle, the government policy is common knowledge, thus shareholders should know what is this upper limit. However, this is *not* a necessary assumption in our model. What is important, is that banks know the upper risk limit.

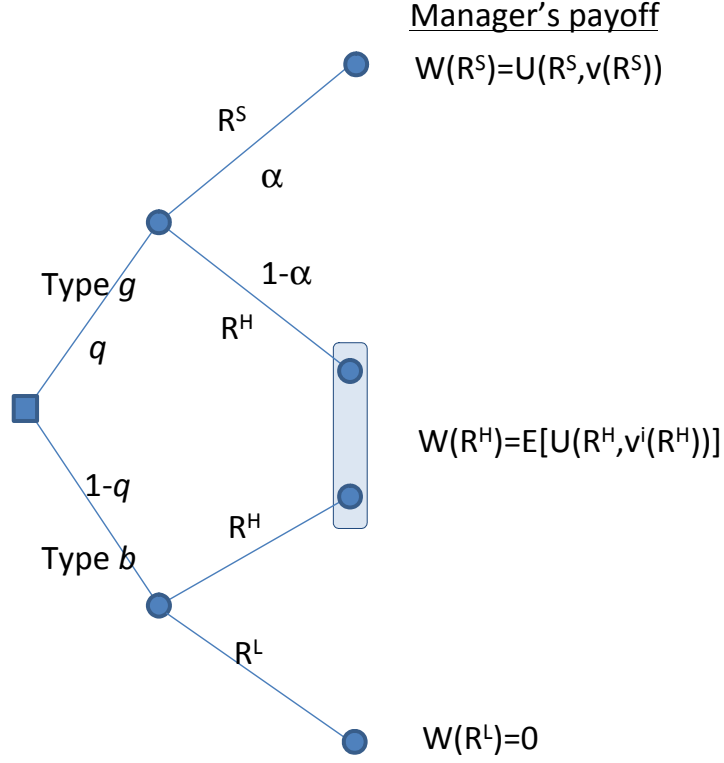


Figure 2: Decision Tree

Finally, we notice that the gap between $U(R^S, v^g(R^S))$ and $U(R^H, v^b(R^H))$ depends on the operating cost c . Figure 3 shows that there is a critical \tilde{c} such that $U(R^S, v^g(R^S)) = U(R^H, v^b(R^H))$.

Taking R^H as given and using Eq. (2), we can show that the utility of the manipulating bad bank is decreasing in c :

$$\frac{dU(R^H, v^b(R^H, c))}{dc} = \frac{\partial U(R^H, v^b(R^H, c))}{\partial v^b(R^H, c)} \frac{dv^b(R^H, c)}{dc} = \theta^{-1} U_v < 0. \quad (5)$$

On the other hand, using Eq (3) to determine $dR^S/dc = -1$ and Eq. (2), to get $dv^g(R^S)/dR^S = \theta^{-1}$ we can show that the utility of the good bank that implements the signaling strategy is increasing in c :

$$\begin{aligned} \frac{dU(R^S(c), v^g(R^S(c)))}{dc} &= \frac{\partial U}{\partial R^S} \left(\frac{dR^S}{dc} \right) + \frac{\partial U}{\partial v^g} \frac{dv^g(R^S(c))}{dR^S(c)} \left(\frac{dR^S}{dc} \right) = \\ &= -U_R - U_v \theta^{-1} = -\theta^{-1} U_R [\theta - MRS(R^S, v(R^S))]. \end{aligned} \quad (6)$$

But outside the optimum of the good bank, for $R^S > R^H$, the marginal rate of substitution $MRS = -U_v/U_R > \theta$, thus the derivative has a positive sign.

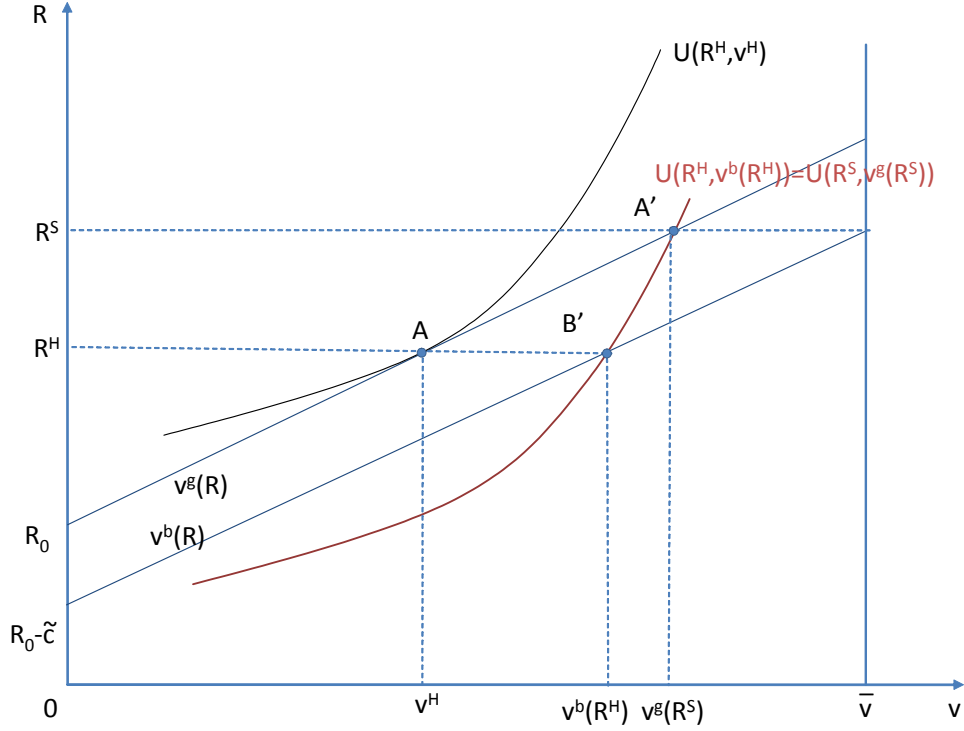


Figure 3: The critical operating cost \tilde{c}

Thus, for any $c < \tilde{c}$ we have $U(R^S, v^g(R^S)) < U(R^H, v^b(R^H))$ and for $c > \tilde{c}$, $U(R^S, v^g(R^S(c))) > U(R^H, v^b(R^H, c))$. This is the case depicted in Figure 1.

3 Equilibria

An equilibrium of this game is defined as a situation where banks' strategies are optimal (i.e., allow to their CEO to earn the highest compensation) given shareholders' beliefs about the type of bank, and shareholders' beliefs are correct given banks' optimal strategies. We may distinguish between a separating equilibrium (where the return strategy of the banks perfectly reveals their type), a pooling equilibrium (where all banks implement the same strategy and thus no information about the type of bank can be inferred from the observed return strategy), and a hybrid equilibrium (wherein banks play Nash mixed strategies and their strategy carry some but not full information about their type).

In order to rule out a trivial situation, we admit that, by increasing risk enough, bad banks can deliver the perfect information optimal return of the good bank, or, in an equivalent way, that

$R^S > R^H$.⁷ If bad banks cannot copy the strategy of the good banks, only the latter do survive and implement the perfect information strategy R^H .

3.1 Signaling equilibrium: good banks do R^S

We can show that an elementary separating equilibrium where all good banks deliver their signaling return R^S and bad banks have left the market is always possible.

In such an equilibrium, good banks' strategy is $s(g) = R^S$. The equilibrium beliefs are: $\Pr[g|R^S] = 1$, and, given that any bank that pays less than R^S should be a bad bank, $\Pr[g|R^L] = 0$ and $\Pr[g|R^H] = 0$.

Bad banks can play either R^L or R^H , but given the system of beliefs, the manager's payoff is: $W(R^L) = W(R^H) = 0$. There is no incentive for a bad bank to stay in the market. Furthermore, R^S is the optimal strategy for the good bank: indeed, the condition $W(R^S) > W(R^H) = 0$ is always true.

In this equilibrium, the risk exposure of good banks exceeds the perfect information level, $v^g(R^S) > v^g(R^H)$. Good banks resort to excessive risk taking as a barrier to entry.

3.2 Pooling equilibrium: all banks do R^H

We can now put forward the existence of a pooling equilibrium where all banks play R^H : bad banks play the perfect information optimal strategy of good banks, and good banks decide not to signal themselves by doing R^S . Banks' single strategy is $s(i) = R^H, \forall i \in \{b, g\}$.

Shareholders' equilibrium beliefs can be written: $\Pr[g|R^S] = 1, \Pr[g|R^H] = q$ and $\Pr[g|R^L] = 0$.

Necessary conditions for this equilibrium are: (1) $W(R^H) > W(R^S)$ for the good bank and (2) $W(R^H) > W(R^L) = 0$ for the bad bank. Since $W(R^S) > 0$, the equilibrium exists under the single condition $W(R^H) > W(R^S)$. Given the definition of the manager's payoff (Eq. 4), this condition becomes:

$$qU(R^H, v^g(R^H)) + (1 - q)U(R^H, v^b(R^H)) > U(R^S, v^g(R^S)) \quad (7)$$

⁷ In turn, this condition is met only if the operating cost is not too big, i.e. if $c < R_0 + \theta\bar{v} - R^H$.

or:

$$q > q_1 \equiv \frac{U(R^S, v^g(R^S)) - U(R^H, v^b(R^H))}{U(R^H, v^g(R^H)) - U(R^H, v^b(R^H))}. \quad (8)$$

In the small operating cost case ($c < \tilde{c}$), we have $U(R^S, v^g(R^S)) < U(R^H, v^b(R^H))$ that implies $q_1 < 0$: the previous condition is always true. The pooling equilibrium always exists if the loss of utility of shareholders who support a bad bank is not too large; this can happen if the operating cost gap c is small.

In the large operating cost case ($c > \tilde{c}$), we have $U(R^S, v^g(R^S)) > U(R^H, v^b(R^H))$, thus $q_1 > 0$. Furthermore, $q_1 < 1$ as $U(R^S, v^g(R^S)) < U(R^H, v^g(R^H))$. We can conclude that in the large cost case, the pooling equilibrium exists only if the frequency of good banks is large enough. If there are not too many bad banks who imitate the good banks, the manager of the latter has not too much to lose, and it does not worth for him to implement an expensive signaling strategy.

In the pooling equilibrium, bad banks take too much risks as compared to the perfect information set-up, but they all survive in this environment.

3.3 Hybrid equilibrium: some good banks signal themselves, all others play R^H

In this equilibrium, a proportion α of the good banks decide to signal themselves by playing R^S , and $(1 - \alpha)$ play their perfect information strategy R^H . All bad banks copy the latter and play R^H .

The mixed equilibrium strategy of the good banks is $s(g) = \{\alpha R^S + (1 - \alpha)R^H \mid \alpha \in [0, 1]\}$ and the bad banks' strategy is $s(b) = R^H$. Using Bayes rule, and denoting by $\Pr[R^j|i]$ the probability that a bank of type i plays strategy R^j , equilibrium beliefs can be written: $\Pr[g|R^L] = 0$, $\Pr[g|R^S] = 1$ and:

$$\Pr[g|R^H] = \frac{\Pr[R^H|g] \Pr[g]}{\Pr[R^H]} = \frac{(1 - \alpha)q}{(1 - \alpha)q + (1 - q)}. \quad (9)$$

In equilibrium, a good bank must be indifferent between strategies R^H and R^S :

$$W(R^S) = W(R^H) \Leftrightarrow U(R^S, v^g(R^S)) = \Pr[g|R^H]U(R^H, v^g(R^H)) + \Pr[b|R^H]U(R^H, v^b(R^H)). \quad (10)$$

This equation allows us to determine $(1 - \alpha)$ with respect to predetermined variables:

$$(1 - \alpha) = \frac{(1 - q) [U(R^S, v^g(R^S)) - U(R^H, v^b(R^H))]}{q [U(R^H, v^g(R^H)) - U(R^S, v^g(R^S))]} \quad (11)$$

We first notice that $U(R^H, v^g(R^H)) - U(R^S, v^g(R^S)) > 0$. Hence, in the small cost case ($c < \tilde{c}$), since $U(R^S, v^g(R^S)) < U(R^H, v^b(R^H))$ we have $(1 - \alpha) < 0$: the hybrid equilibrium is impossible.

In the large cost case ($c > \tilde{c}$), we have $U(R^S, v^g(R^S)) > U(R^H, v^b(R^H))$, so $1 - \alpha > 0$. The equilibrium exists if $1 - \alpha < 1$, which is equivalent to:

$$q > q_1 \equiv \frac{U(R^S, v^g(R^S)) - U(R^H, v^b(R^H))}{U(R^H, v^g(R^H)) - U(R^H, v^b(R^H))} \quad (12)$$

This is the same existence condition as that of the pooling equilibrium in the same large cost case (Eq 8).

In the hybrid equilibrium, both bad banks and a fraction α of the good banks are taking an excessive risk. The maximum amount of risk in the economy appears for $\alpha \rightarrow 1$; we infer that if the hybrid equilibrium is in place, the amount of risk in this economy reaches its highest level for $c \searrow \tilde{c}$.

3.4 A summary of possible equilibria

Table 1 presents a summary of the possible equilibria. Except for the case of large costs and a small proportion of bad banks ($q < q_1$), the game features a typical configuration of multiple equilibria, where the equilibrium that will actually materialize depends on investors' beliefs.

	"Small" cost ($c < \tilde{c}$)	"Large" cost ($c > \tilde{c}$)
"A few" bad banks: $q < q_1$	separating, pooling	separating
"Many" bad banks: $q > q_1$	separating, pooling	separating, pooling, hybrid

Table 1. Summary of possible equilibria

This analysis was performed using general forms for shareholder utility functions. There is no need to argue much about the modelling benefit of general forms as compared with specific forms. The reverse side of the coin is that in absence of explicit thresholds (q_1 and \tilde{c}) it is not

easy identify what type of equilibrium would describe the best the banking sector situation in the eve of the last crisis. If we consider the overall number of banks in the US and Europe (more than 8000 in the US and about 7500 in Europe), the proportion of "bad" banks can be seen as being small. However, if we limit our analysis to the "exclusive" segment of large, multi-product banks with a global reach, then the proportion of banks that were deeply affected by the crisis turned out to be substantial. In general, differences between these large banks in terms of investment opportunities and operating costs are small. Our analysis does not allow to say "how small is small" as compared to the critical cost \tilde{c} (for which we provide only the implicit definition). Thus, on a pure theoretical ground it is impossible to rule out the hybrid equilibrium case.

In any case, the most important result from our general analysis is that in any equilibrium except the separating one, banks take too much risks as compared to the perfect information case. In addition, in all configurations of multiple equilibria, the financial system is prone to substantial instability, since shifts from one equilibrium to another are essentially driven by "sandy" expectations.

4 Conclusion

There is widespread consensus that the origin of the 2007-2009 financial crisis was an abnormal accumulation of risk by banks throughout the world. The analysis in this paper connects this race for risk to imperfect information in the banking sector. In a world where returns can be observed but risk cannot, banks running with high operating costs would take more risk only to deliver higher returns and be perceived as highly efficient banks. The latter can signal themselves by further increasing risks well above their perfect information optimal level.

The game presents several equilibria, all being characterized by excessive accumulation of risk by banks compared to the ideal, perfect information case. Depending on the proportion of bad banks and the differential in operating costs, the model presents several multiple equilibria configurations.

The policy implications are straightforward. Any reform able to reduce the asymmetry of information between banks' managers and outsiders should eliminate the key reason for the risk

race. Yet there should be no miracle solution able to achieve this result. If banks' true exposure to risk is hard to assess by outsiders and at least some good banks implement their high-risk signaling strategy, then stronger regulation is needed to cap the maximum amount of risk banks can take. In the light of this model, the recommendation of the G20 leaders in September 2009 to impose tighter capital requirements on banks and a new leverage limit should go in the right direction.

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