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### *Securitization, Transparency and Liquidity*

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# *Securitization, Transparency and Liquidity*

Marco Pagano<sup>♦</sup> and Paolo Volpin<sup>♥</sup>

### **Abstract**

We present a model in which issuers of asset backed securities choose to release coarse information to enhance the liquidity of their primary market, at the cost of reducing secondary market liquidity. The degree of transparency is inefficiently low if the social value of secondary market liquidity exceeds its private value. We show that various types of public intervention – mandatory transparency standards, provision of liquidity to distressed banks or secondary market price support – have quite different welfare implications. Finally, we extend the model by endogenizing the private and social value of liquidity and the proportion of sophisticated investors.

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# 1 Introduction

It is widely agreed that the securitization of mortgage loans has played a key role in the 2007-08 subprime lending crisis (Adrian and Shin, 2008; Brunnermeier, 2009; Gorton, 2008; and Kashyap, Rajan and Stein, 2008, among others). In particular, it is commonplace to lay a good part of the blame for the crisis on the poor transparency that accompanied the massive issues of asset backed securities (ABS), such as mortgage backed securities (MBS) and collateralized debt obligations (CDO): see for instance Financial Stability Forum (2008) and IMF (2008).

Both securities issuers and rating agencies are responsible for the lack of transparency of the securitization process. The prospectus of MBS only provided summary statistics about the typical claim in the underlying pool. Even though detailed information on the underlying mortgage loans was available from data providers, subscription to these data sets is expensive and considerable skills are required to analyze them. As a result, most investors ended up relying on ratings, which simply assess the default probability of the corresponding security (S&P and Fitch) or its expected default loss (Moody's). These statistics capture only one dimension of default risk, and fail to convey an assessment of the systematic risk of CDOs, as pointed out by Coval, Jurek and Stafford (2009) and Brennan, Hein and Poon (2009), and of the sensitivity of such systematic risk to macroeconomic conditions, as noted by Benmelech and Dlugosz (2009). Moreover, in their models, rating agencies assumed correlations of defaults in CDO portfolios to be stable over time, rather than dependent on economic activity, house prices and interest rates.<sup>1</sup>

The implied information loss is seen by many not only as the source of the pre-crisis

mispricing of ABS but also as the reason for the subsequent market illiquidity: after June 2007, the market for ABS shut down, because most market participants did not have enough information to price and trade these securities. This market freeze created an enormous overhang of illiquid assets on banks' balance sheets, which in turn resulted in a credit crunch (Brunnermeier and Pedersen, 2009).

However, the links between securitization, transparency and market liquidity are less than obvious. If the opaqueness of the securitization process affects the liquidity of ABS, why should ABS issuers choose opaqueness over transparency? After all, if the secondary market is expected to be illiquid, the issue price should be lower.<sup>2</sup> But the pre-crisis behavior of issuers and investors alike suggests that they both saw considerable benefits in securitization based on relatively coarse information. The fact that this is now highlighted as a major inefficiency suggests that there is a discrepancy between the private and the social benefits of transparency in securitization. What is the source of the discrepancy, and when should it be greatest? How do different forms of public intervention compare in dealing with the problem? These questions are crucial in view of the current plans of reforming financial regulation in both the United States and Europe.

In this paper, we propose a model of the impact of transparency on the market for structured debt products that addresses these issues. Issuers may wish to provide coarse information about such products in order to improve the liquidity of their primary market. This is because few potential buyers are sophisticated enough to understand the pricing implications of complex information, such as that required to assess the systematic risk of ABS. Releasing such information would create a "winner's curse" problem for unsophisticated investors in the issue market.<sup>3</sup>

This point does not apply only to ABS: it extends to any security, insofar as it is



complex and therefore difficult to value. For instance, accurate valuation of the equity issued by a multidivisional firm would require detailed accounting information about the performance of each division: yet, few investors would be equipped to process such detailed information, so that disclosing it may put many potential market participants at a disadvantage. Similarly, rating the bonds of a large financial institution such as Citigroup is at least as complex as rating an ABS, since the details of the bank's portfolio are largely unobservable. Hence, such a firm may prefer to limit disclosure of its division-level data in order to widen its shareholder base to less sophisticated investors.<sup>4</sup> Another example is that of "block booking", i.e. the practice of selling securities or goods exclusively in bundles, rather than separately (Kenney and Klein, 1983): asset managers are shown to lower trading costs by 48% via "blind auctions" of stocks, whereby they auction a set of trades as a package to potential liquidity providers, without revealing the identities of the securities in the package to the bidders (Kavajecz and Keim, 2005).<sup>5</sup> In general, when some investors have limited ability to process information, releasing more public information may increase adverse selection and thus reduce market liquidity. Incidentally, this highlights that the standard view that transparency enhances liquidity hinges on all market participants being equally skilled at information processing and asset pricing.

But while opaqueness enhances liquidity in the primary market, it may reduce it, even drastically, in the secondary market, and cause ABS prices to decline more sharply when the underlying loans default. This is because the information not disclosed at the issue stage may still be uncovered by sophisticated investors later on, especially if it enables them to earn large rents in secondary market trading.<sup>6</sup> So limiting transparency at the issue stage induces more subsequent information acquisition by sophisticated investors and shifts the adverse selection problem to the secondary market, reducing its liquidity

or even inducing it to become inactive.<sup>7</sup> Conversely, disclosing information at the issue stage eliminates the sophisticated investors' incentive to seek it before secondary market trading (being a form of "substitute" disclosure in Boot and Thakor's (2001) terminology), even though it generates adverse selection in the primary market. Thus, in choosing the degree of transparency, issuers effectively face a trade-off between primary and secondary market liquidity.

We show that issuers never choose to release detailed information, even though they anticipate that this may reduce secondary market liquidity. The reason is that under transparency, adverse selection arises in the primary market, and therefore is invariably borne by the issuer in the form of a discounted issue price; conversely, under opaqueness the adverse selection cost arises in the secondary market only insofar as investors are hit by a liquidity shock, and therefore with probability less than one.

In general, however, the degree of transparency chosen by issuers will fall short of the socially optimal whenever secondary market liquidity has a social value in excess of its private one. This will be the case if the illiquidity of the secondary market triggers a cumulative process of defaults and premature liquidation of assets in the economy, for instance because of inefficient fire sales by banks (Acharya and Yorulmazer, 2008). In this case, the socially efficient degree of transparency is higher than that chosen by the issuers of structured bonds, thus creating a rationale for regulation. In practice, regulation can raise the transparency of the securitization process either by requiring issuers of structured debt to release more detailed data about underlying loan pools or rating agencies to provide more sophisticated ratings: for instance, multidimensional ratings that not only estimate the probability of default, but also the correlation of default risk with aggregate risk.

We find that mandatory transparency is likely to be socially efficient when secondary market liquidity is very valuable and the adverse selection problem in the secondary market is very severe – indeed so severe that in the absence of transparency the secondary market would be inactive. In our setting, this occurs only if the variance of the signal that only sophisticated investors can process is sufficiently large, that is, for securities that are sufficiently exposed to aggregate risk. Instead, mandating transparency would be inefficient for safer securities, since it would damage their primary market liquidity with no offsetting advantage in the secondary market. This result neatly applies to the ABS market: the crisis saw the freeze of the market for privately issued MBS, which were uninsured against default risk, while the market for agency MBS, which carried a public credit guarantee, remained very liquid throughout 2008-09.<sup>8</sup> This is in spite of the fact that agency MBS are extremely opaque when placed via the TBA (“to-be-announced”) market, where MBS sellers specify only a few basic characteristics of the security to be delivered (Vickery and Wright, 2010). At the normative level, our model suggests that mandating greater information disclosure would have been warranted for privately issued MBS, but not for agency MBS, where greater disclosure would likely damage the liquidity of the TBA market.

We also analyze the effects of two forms of *ex-post* public liquidity provision: one targeted to distressed bondholders when the ABS market is inactive, and the other aimed at supporting the ABS secondary market price. Both policies eliminate the negative externality arising from secondary market illiquidity, yet they are not equally desirable for society. Liquidity provision to distressed bondholders is optimal whenever the secondary market is inactive, provided that the benefits (in terms of larger proceeds from the ABS sale and no liquidity externality) exceed the costs due to distortionary taxes. Price

support to the ABS market by the government is instead warranted under more restrictive conditions, as it does not increase the ABS issue price (which is socially beneficial) and instead raises sophisticated investors' informational rents, thus prompting them to seek more information (which entails no social gain or even a social loss).

Finally, we endogenize the private and social value of liquidity, and the proportion of sophisticated investors. First, we show how the liquidity externality assumed in the model can arise: in the presence of severe adverse selection in the ABS secondary market, a liquidity shock may induce investors to engage in fire sales of real assets used in production, and thereby hurt suppliers of complementary inputs (e.g., workers), inflicting a deadweight cost to society. Second, we endogenize the proportion of sophisticated investors faced by an issuer, by assuming that these investors can become sophisticated by undertaking a costly investment before they know the details of the issue. This extension allows us to study how the fraction of sophisticated investors depends on the parameters of the model: for instance, we show that financial sophistication is increasing in the probability of default and in the magnitude of informational rents.

While our adverse selection setting provides a reason why issuers may prefer ratings to be coarse and uninformative, another explanation for this outcome has been proposed by cheap talk models of rating agencies, building upon Lizzeri's (1999) model of certification intermediaries: Doherty, Kartasheva and Phillips (2009) and Goel and Thakor (2010) show that rating agencies themselves have an incentive to produce coarse ratings, by pooling together several types of borrowers within the same rating class in order to increase the total rating fees that they can charge. Like ours, these models imply that ratings will be coarse but not inflated. In this respect, they differ from recent papers where ratings are inflated because issuers can engage in "rating shopping" (Skreta and

Veldkamp, 2009, and Spatt, Sangiorgi and Sokobin, 2009), and possibly collude with rating agencies (Bolton, Freixas and Shapiro, 2009). In contrast, in our setting rating agencies report information faithfully: in the opaque regime, they simply do not disclose security characteristics that many investors would be unable to price.<sup>9</sup> In practice, both the coarseness of ratings and their inflation induced by rating shopping and collusion are likely to have played a role in the crisis, and indeed may have amplified each other's effects.

The paper is organized as follows. Section 2 lays out the structure of the model. Section 3 solves for the equilibrium secondary market prices, while Section 4 characterizes the issuer's choice between opaqueness and transparency. In Section 5 we determine the cases in which the socially efficient level of transparency may be higher than the privately optimal level, and consider various forms of public intervention, some ex-ante such as mandatory transparency, and other ex-post, such as liquidity provision in the secondary market for ABS. Section 6 presents two extensions that endogenize magnitudes taken as exogenous parameters in the baseline model. Section 7 concludes.

## 2 The Model

An issuer owns a continuum of measure 1 of financial claims, such as mortgage loans or corporate bonds, and wants to sell them because the proceeds can be invested elsewhere at a high enough net rate of return  $r$ . For brevity, we shall refer to these financial claims simply as “loans”.

There are three future states of nature: a good state ( $G$ ), which occurs with probability  $p$ , and two bad states ( $B_1$  and  $B_2$ ), occurring with probability  $(1 - p)/2$  each.<sup>10</sup> The

good state corresponds to an economic expansion, while of two bad states,  $B_1$  corresponds to a mild slowdown and  $B_2$  to a sharp contraction of aggregate consumption. Therefore, the marginal utility of future consumption is highest in state  $B_2$ , intermediate in state  $B_1$  and lowest in state  $G$ , that is,  $q_{B_2} > q_{B_1} > q_G$ , where  $q_s$  denotes the stochastic discount factor of state- $s$  consumption. These stochastic discount factors are common knowledge. For simplicity, the risk-free interest rate is set at zero, that is, the price of a certain unit of future consumption is one:  $pq_G + [(1 - p)/2](q_{B_1} + q_{B_2}) = 1$ .

The issuer's pool is formed by two types of loans, 1 and 2, in proportions  $\lambda$  and  $1 - \lambda$  respectively. As shown in Table 1, both type-1 and type-2 loans pay 1 unit of consumption in state  $G$ , but have different payoffs in bad states: type-1 loans yield  $x < 1$  units of consumption in state  $B_1$  and 0 in state  $B_2$ , while the opposite is true of type-2 loans. Therefore, type-1 loans are more sensitive to aggregate risk than type-2 loans, and accordingly less valuable by an amount equal to the difference between their state prices,  $[(1 - p)/2](q_{B_2} - q_{B_1})x > 0$ .<sup>11</sup>

**Table 1. Loan Payoffs**

State	Probability	Payoff of type-1 claim	Payoff of type-2 claim	State price	Payoff of claim pool
$G$	$p$	1	1	$pq_G$	1
$B_1$	$(1 - p)/2$	$x$	0	$\frac{1-p}{2}q_{B_1}$	$\lambda x$
$B_2$	$(1 - p)/2$	0	$x$	$\frac{1-p}{2}q_{B_2}$	$(1 - \lambda)x$

## 2.1 Securitization

We assume that the issuer must sell these claims as a portfolio because selling them one-by-one would be prohibitively costly.<sup>12</sup> The portfolio's payoff is 1 in state  $G$  when both loan types do well,  $\lambda x$  in state  $B_1$  and  $(1 - \lambda)x$  in state  $B_2$ . The portfolio is sold as an

ABS, promising to repay a face value  $F = 1$ , which will be shown to be the face value that issuers will choose in equilibrium. So the ABS's payoff equals its face value  $F$  only in the good state, while default occurs in the two bad states.

The actual composition  $\lambda$  of the ABS in any period is random. It can take two values with equal probability: a low value  $\lambda_L = \bar{\lambda} - \sigma$  or a high value  $\lambda_H = \bar{\lambda} + \sigma$ . Therefore, the ABS composition  $\lambda$  has mean  $\bar{\lambda}$  and variance  $\sigma^2$ , where  $\sigma \leq \min(\bar{\lambda}, 1 - \bar{\lambda})$  ensures that  $\lambda \in [0, 1]$ . Instead of  $\lambda$ , below it will often be convenient to use the deviations from its mean  $\tilde{\lambda} \equiv \lambda - \bar{\lambda}$ , which equal  $-\sigma$  or  $\sigma$  with equal probability.

The randomness of the portfolio composition adds a layer of complexity to the ABS payoff structure relative to that of its underlying claims. For the ABS, there are six payoff-relevant states rather than three, because  $\lambda$  creates uncertainty about the ABS's exposure to systematic risk, as illustrated in Table 2. Specifically, since a high realization of  $\lambda$  lowers the payoff in the worst state ( $B_2$ ) while raising it in the intermediate state ( $B_1$ ), it corresponds to a higher systematic risk. Therefore,  $\lambda$  measures the ABS systematic risk in each contingency.

**Table 2. ABS Payoffs**

State	Probability	ABS payoff	State price
1H: $G, \lambda = \lambda_H$	$\frac{p}{2}$	1	$\frac{p}{2}q_G$
2H: $B_1, \lambda = \lambda_H$	$\frac{1-p}{4}$	$\lambda_H x = (\bar{\lambda} + \sigma)x$	$\frac{1-p}{4}q_{B1}$
3H: $B_2, \lambda = \lambda_H$	$\frac{1-p}{4}$	$(1 - \lambda_H)x = (1 - \bar{\lambda} - \sigma)x$	$\frac{1-p}{4}q_{B2}$
1L: $G, \lambda = \lambda_L$	$\frac{p}{2}$	1	$\frac{p}{2}q_G$
2L: $B_1, \lambda = \lambda_L$	$\frac{1-p}{4}$	$\lambda_L x = (\bar{\lambda} - \sigma)x$	$\frac{1-p}{4}q_{B1}$
3L: $B_2, \lambda = \lambda_L$	$\frac{1-p}{4}$	$(1 - \lambda_L)x = (1 - \bar{\lambda} + \sigma)x$	$\frac{1-p}{4}q_{B2}$

The correct price of the ABS will depend on its actual composition, that is, on the realized value of  $\lambda$ :

$$V(\lambda) = pq_G + \frac{1-p}{2}x [\lambda q_{B1} + (1 - \lambda)q_{B2}]. \quad (1)$$

This expression takes two different values depending on the realized value of  $\lambda$ , i.e. the ABS's actual exposure to systematic risk. We assume that the realization of  $\lambda \in (\lambda_L, \lambda_H)$  is not observed, but can be estimated from an information set  $\Lambda$  that the issuer has and can reveal to investors.

The key assumption of the model is that, if the information  $\Lambda$  is publicly disclosed, not all investors are able to use it to estimate the realization of  $\lambda$ : only a fraction  $\mu$  of investors (say, hedge funds) are sophisticated enough as to do so, and thus can price the ABS according to (1). The remaining  $1 - \mu$  investors are not skilled enough to learn  $\lambda$ , even if they can condition on information  $\Lambda$ . As a result, each pair of states indexed by  $H$  and  $L$  in Table 2 (for instance, states 1H and 1L) are indistinguishable to them. Therefore, their best estimate of the value of the ABS is obtained by setting  $\lambda$  at its average  $\bar{\lambda}$  in the pricing formula (1), so that on average they do not make mistakes in pricing the ABS. However, they are rational enough to realize that they incur in pricing errors, are aware of their variance, and therefore are willing to buy the ABS only at a discount large enough to offset their expected losses to sophisticated investors.

Interestingly, unsophisticated investors are at a disadvantage compared to sophisticated ones only in pricing the ABS, but not the individual loans of which the ABS is composed, since to value these only the payoffs in the three states  $G$ ,  $B_1$  and  $B_2$  (and their prices) are relevant. It is the complexity of the ABS that determines their disadvantage in security pricing.

## 2.2 Transparency Regimes

The issuer knows the probability of repayment  $p$ , the loss in each default state ( $x$  or  $1$ ), the distribution of  $\lambda$  and the information set  $\Lambda$  required to infer the realized value of  $\lambda$ .



He can choose between two regimes: a “transparent” regime where the issuer discloses all his information, and an “opaque” regime where he withholds the information  $\Lambda$ . In both cases he credibly certifies the information via a rating agency (for simplicity, at a negligible cost). The agency is assumed to be trustworthy, due to penalties or reputational costs for misreporting. Note that the information available in the opaque regime is akin to that reflected in real-world ratings, where S&P and Fitch estimate the probability of default  $1 - p$  and Moody’s assesses the expected loss from default  $(1 - p)(1 - x/2)$ . We assume both the issuer and the rating agency to be unsophisticated, and therefore unable to infer the realized value of  $\lambda$  from  $\Lambda$ , so that they do not have an informational advantage over investors.<sup>13</sup>

In the opaque scenario, where  $\Lambda$  is not disclosed, investors are on a level playing field: they *all* ignore the true ABS payoffs  $\lambda x$  and  $(1 - \lambda)x$  in the two default states  $B_1$  and  $B_2$ , so that both sophisticated and unsophisticated investors must rely on the average loan composition  $\bar{\lambda}$  to value the ABS. For all of them, its risk-adjusted Present Discounted Value (PDV) is

$$V_O = pq_G + \frac{1-p}{2}x [\bar{\lambda}q_{B1} + (1 - \bar{\lambda})q_{B2}] = pq_G + \frac{1-p}{2}xq_B, \quad (2)$$

where the subscript  $O$  stands for “opaque” and  $q_B \equiv [\bar{\lambda}q_{B1} + (1 - \bar{\lambda})q_{B2}]$  is the average discount factor of the ABS in each of the two default states. So in this regime the superior pricing ability of sophisticated investors (i.e., their ability to price separately consumption in states  $B_1$  and  $B_2$ ) is irrelevant.

Instead, in the transparent scenario,  $\Lambda$  is disclosed, so that sophisticated investors can infer the actual risk exposure  $\lambda$  of the loan pool. As a result, they correctly estimate the

PDV of the ABS according to expression (1):

$$V_T = V(\lambda) = V_O - \frac{1-p}{2} x \tilde{\lambda} (q_{B2} - q_{B1}). \quad (3)$$

This expression shows that with transparency the correct valuation of the ABS,  $V_T$ , is equal to the opaque-regime valuation  $V_O$  minus a term proportional to  $\tilde{\lambda}$ , i.e. the deviation of the ABS aggregate risk sensitivity  $\lambda$  from its average. This term captures the superior risk-pricing ability of sophisticated investors.

In contrast, unsophisticated investors are unable to use the information about the actual loan pool quality  $\lambda$ , and therefore will end up estimating the PDV of the ABS as expression (2). Therefore, they will misprice the ABS: if the sensitivity of the ABS to aggregate risk is high ( $\tilde{\lambda} = \sigma$ ), they will overestimate its PDV by

$$(1-p) \frac{\sigma x}{2} (q_{B2} - q_{B1}), \quad (4)$$

and in the opposite case ( $\tilde{\lambda} = -\sigma$ ), they will underestimate it by the same amount. As they incur into either pricing error with equal probability, this expression measures their average mispricing, which is increasing in the variability of the ABS risk sensitivity,  $\sigma$ , and in the difference between the two state prices  $((1-p)/2)(q_{B2} - q_{B1})$ . By the same token, expression (4) also measures the informational advantage of sophisticated investors, or more precisely their expected informational rent  $(1-p)R$ : as we shall see, whenever they know  $\lambda$ , sophisticated investors can extract a rent

$$R \equiv \frac{\sigma x}{2} (q_{B2} - q_{B1}) \quad (5)$$

in default states, i.e. with probability  $1-p$ . However, unsophisticated investors are fully rational: they realize to be at an informational disadvantage when bidding in the initial ABS sale under transparency (or when trading in the secondary market under opaqueness, if some sophisticated investors have become informed later on).

Sophisticated investors are assumed to lack the wherewithal to buy the entire ABS issue. Since the price they would offer for the entire issue is the expected ABS payoff conditional on the realized  $\lambda$ , the relevant condition is that their total wealth  $A_S < V_T(\lambda_L)$ .<sup>14</sup> In contrast, unsophisticated investors are sufficiently wealthy to absorb the entire issue: their wealth  $A_U > V_O$ , since their offer price for the entire ABS issue is the unconditional expectation of its payoff.<sup>15</sup> As in Rock (1986), these assumptions imply that for the issue to succeed, the price of the ABS must be such as to induce participation by the unsophisticated investors.

## 2.3 Time Line

The time line is shown in Figure 1. At the initial stage 0, the composition of the pool ( $\lambda$ ) is determined, and the issuer learns information  $\Lambda$  about it.

At stage 1, the issuer chooses either transparency or opaqueness, reveals the corresponding information  $\Lambda$ , and sells the ABS on the primary market at price  $P_1$  via a uniform price auction to a set of investors of mass 1.<sup>16</sup> If the issuer sets a price that cannot attract a sufficient number of investors to sell the entire issue, the ABS sale fails and the issuer earns no revenue.

At stage 2, people learn whether the ABS is in default or not. At the same time, a fraction  $\pi$  of the initial pool of investors is hit by a liquidity shock and must decide whether to sell their stake in the secondary market or else to liquidate other assets at a fire-sale discount  $\Delta$ . (Alternatively,  $\Delta$  may be seen as the investors' private cost of failing to meet obligations to their lenders or the penalty for recalling loans or withdrawing lines of credit.) Liquidity risk is uncorrelated with CDO payoffs.

If default is announced, the sophisticated investors not hit by the liquidity shock may

try to acquire costly information to learn the realization of  $\lambda$ , unless of course  $\Lambda$  was already disclosed at stage 1. Their probability  $\phi$  of discovering  $\lambda$  is increasing in the resources spent on information acquisition: they learn it with probability  $\phi$  by paying a cost  $C\phi$ . To ensure equilibrium existence, we assume that (i) before acquiring information about  $\lambda$ , sophisticated investors observe if liquidity traders have sold other assets or not,<sup>17</sup> and (ii) there is a zero-measure set of sophisticated investors who always become informed at no cost.<sup>18</sup>

At stage 3, secondary market trading occurs. Competitive market makers set bid and ask quotes for the ABS so as to make zero profits, and investors who have chosen to trade place orders with them. Market makers are sophisticated, in that they are able to draw the pricing implications of the information  $\Lambda$ , if this is publicly disclosed. Moreover, they have sufficient market-making capital as to absorb the combined sales of liquidity and informed traders. However, they cannot become informed themselves.<sup>19</sup>

At stage 4, the payoffs of the underlying portfolios and of the ABS are realized.

This sequence of moves assumes that under opaqueness sophisticated investors wait for the secondary market trading to invest in information collection, rather than seeking it before the initial sale of the ABS. The rationale for such an assumption is that ABS risk is concentrated in default states, so that it pays to seek costly information about  $\lambda$  only once default is known to be impending. Indeed, for sophisticated investors the NPV from collecting information at stage 2,  $(1 - p) \left(\frac{R}{2} - C\right)$ , exceeds that of collecting it at stage 1,  $(1 - p) \frac{R}{2} - C$ , where  $R$  is defined by (5): in the former case they incur the cost  $C$  only once default is known to occur, rather than always as in the latter.

## 2.4 Private and Social Value of Liquidity

As we have seen, the investors who may seek liquidity on the secondary market are “discretionary liquidity traders”: their demand for liquidity is not completely inelastic, because they can turn to an alternative source of liquidity at a private cost  $\Delta$ . If the hypothetical discount at which the ABS would trade were to exceed  $\Delta$ , these investors will refrain from liquidating their ABS. In this case, as explained above, they may resort to fire sales of other assets; or default on debt and incur the implied reputational and judicial costs; or forgo other investments, for instance by recalling loans to others.

However, each of these alternatives may entail costs for third parties too. For instance, the illiquidity of the market for structured debt is more costly for society at large than for individual investors whenever it triggers a cumulative process of defaults and/or liquidation of assets in the economy, for instance due to “fire sale externalities” or to the knock-on effect arising from banks’ interlocking debt and credit positions. Fire-sale externalities can arise if holders of structured debt securities, being unable to sell them, cut back on their lending or liquidate other assets, thereby triggering drops in the value of other institutions holding them, as in Acharya and Yorulmazer (2008) and Wagner (2010). Alternatively, the illiquidity of the market for structured debt securities may force their holders to default on their debts, damaging institutions exposed to them, and thus triggering a chain reaction of defaults, as in Allen and Gale (2000) or Freixas, Parigi and Rochet (2000).

Insofar as secondary market liquidity spares these additional costs to society, its social value exceeds its private value. For simplicity, we model the additional value of liquidity to third parties as  $\gamma\Delta$ , where  $\gamma \geq 0$  measures the negative externality of secondary market

illiquidity. Thus the total social value of liquidity is  $(1 + \gamma)\Delta$ , and the limiting case  $\gamma = 0$  captures a situation where market liquidity generates no externalities.

### 3 Secondary Market Equilibrium

In this setting, what degree of transparency will issuers choose? In this section we solve for the symmetric Perfect Bayesian Equilibrium of the game. By backward induction, we start determining the secondary market equilibrium price at stage 3, conditional on either repayment or default: we first determine the market price and the sophisticated investors' information gathering decision depending on whether or not liquidity traders sell their ABS, both under transparency and under opaqueness. Then we turn to liquidity traders' optimal trading decisions at stage 2 in both regimes.

#### 3.1 Secondary Market Price

In the good state  $G$ , the ABS is known to repay its face value 1, and therefore its secondary market price at time 3 is simply  $P_3^G = q_G$ . The market is perfectly liquid: if hit by liquidity shocks, investors can sell the ABS at price  $P_3^G$ , and obviously collecting information about  $\lambda$  would be futile.

The interesting states, instead, are those where the ABS is expected to be in default (states  $B_1$  or  $B_2$ ), since only in this case the secondary market may be illiquid, as we shall see below. Therefore, all our subsequent analysis focuses on the subgame where default occurs at stage 3. In this subgame, to determine the level of the ABS price  $P_3^B$  we must consider three cases, depending on the information made available to investors at stage 1 and on the sophisticated investors' decision to collect information.

In the transparent regime, investors and market makers learn the realization of  $\lambda$ .

Since market makers are sophisticated, they interpret the information  $\Lambda$  provided to the market and impound the relevant state prices in their secondary market quotes. The ABS's price at stage 3 is simply the expected value of the underlying portfolio conditional on default, which can be computed as the sum of the payoffs in  $B_1$  and  $B_2$  shown in Table 1, each of which occurs with probability  $1/2$  conditional on default:

$$P_{3,T}^B = \frac{x}{2} [\lambda q_{B1} + (1 - \lambda) q_{B2}], \quad (6)$$

where the subscript  $T$  indicates that this price refers to the transparent regime. In this case, the secondary market is perfectly liquid, as prices are fully revealing: liquidity traders face no transaction costs. In this case the market price is a random variable, whose value depends on the realization of  $\lambda$  (or equivalently of  $\tilde{\lambda}$ ) and on average is equal to:

$$E(P_{3,T}^B) = \frac{x}{2} q_B, \quad (7)$$

which is the unconditional ABS recovery value in the default states  $B_1$  and  $B_2$ . So the secondary market price in the transparent regime can be rewritten as the sum of the expected ABS recovery value and a zero-mean innovation:

$$P_{3,T}^B = \frac{x}{2} q_B - \tilde{\lambda} \frac{x}{2} (q_{B2} - q_{B1}). \quad (8)$$

In the opaque regime, the secondary ABS market is characterized by asymmetric information: for the sophisticated investors who have discovered the true value of  $\lambda$ , the value of ABS is given by expression (8), while for all other investors the ABS value is given by expression (7). In the default states, the market maker will set the bid price  $P_{3,O}^B$  so as to recover from the uninformed investors what he loses to the informed, as in Glosten and Milgrom (1985). The choice of this price by the market maker will differ depending on whether liquidity traders choose to sell the ABS or an alternative asset.

Consider first the subgame where liquidity traders sell the ABS. Then, in the ABS market there will be a fraction  $\pi$  of liquidity sellers. A fraction  $\phi\mu$  of the remaining  $1 - \pi$  investors will be informed, and will sell if the bid price is above their estimate of the ABS value. This occurs if  $\lambda$  equals  $\lambda_H$ , or equivalently  $\tilde{\lambda} = \sigma$ , i.e. with probability  $1/2$ . To avoid dissipating their informational rents, informed traders will camouflage as liquidity traders, placing orders of the same size. Hence, the frequency of an investor submitting a sell order is  $\pi + \phi\mu(1 - \pi)/2$ . The market maker gains  $(x/2)q_B - P_{3,O}^B$  when he buys from an uninformed investor, and loses  $P_{3,O}^B - (x/2)[q_B - \sigma(q_{B2} - q_{B1})]$  when he buys from an informed one. Hence, his zero-profit condition is

$$\pi \left( \frac{x}{2}q_B - P_{3,O}^B \right) = (1 - \pi) \frac{\phi\mu}{2} \left[ P_{3,O}^B - \frac{x}{2}q_B + \sigma(q_{B2} - q_{B1}) \right], \quad (9)$$

and the implied equilibrium bid price is

$$\begin{aligned} P_{3,O}^B &= \frac{x}{2}q_B - \frac{(1 - \pi)\phi\mu}{2\pi + (1 - \pi)\phi\mu} \frac{\sigma x}{2} (q_{B2} - q_{B1}) \\ &= \frac{x}{2}q_B - \frac{(1 - \pi)\phi\mu}{2\pi + (1 - \pi)\phi\mu} R, \end{aligned} \quad (10)$$

where  $R$  is the rent that an informed trader extracts from an uninformed one (conditional on these both trading), from expression (5). The informed traders' rent  $R$  is weighted by the probability of a sell order being placed by an informed trader,  $(1 - \pi)\phi\mu/[2\pi + (1 - \pi)\phi\mu]$ . This expected rent translates into a discount sustained by liquidity traders in the secondary market: if hit by a liquidity shock, they must sell the ABS at a discount off the unconditional expectation of its final payoff.

Consider next what happens if liquidity traders decide to sell the alternative asset and keep the ABS. Then, market makers will rationally anticipate that any incoming order must originate from an informed investor (recall that, by assumption, there are always sophisticated investors who acquire information about  $\lambda$  at zero cost). Formally, in this



case the market makers' belief is that their probability of trading with an uninformed investor equals zero. Since informed investors sell only if  $\lambda$  equals  $\lambda_H$ , the break-even bid price set by market makers is

$$P_{3,O}^B = \frac{x}{2}q_B - \frac{\sigma x}{2}(q_{B2} - q_{B1}) = \frac{x}{2}q_B - R, \quad (11)$$

which is the lowest possible price at which any trade can occur and can be obtained by setting  $\pi = 0$  in (10). At this price, informed investors are indifferent between selling and not selling.

### 3.2 Decision to Acquire Information

In the transparent regime, sophisticated investors do not need to spend resources to acquire information, since  $\lambda$  is public knowledge and therefore is impounded in market makers' quotes. In contrast, in the opaque regime the sophisticated investors who are not hit by a liquidity shock at stage 2 may want to learn the realization of  $\lambda$ . Their willingness to acquire this information depends on whether liquidity traders are also selling the ABS or not (which they know because of the assumed sequence of moves). If liquidity traders are not in the ABS market, there are no rents from informed trading and therefore no gain from acquiring information. If instead liquidity traders are in the ABS market, the gain from learning  $\lambda$  equals the market makers' expected trading loss as determined above:

$$P_{3,O}^B - \frac{x}{2}[q_B - \sigma(q_{B2} - q_{B1})] = \frac{2\pi}{2\pi + (1 - \pi)\phi\mu}R, \quad (12)$$

where in the second step the gain is evaluated at the equilibrium price in (10). This gain accrues to informed investors with probability  $1/2$ , since only when  $\lambda = \lambda_H$  they make a profit by selling the ABS.<sup>20</sup> Hence, the expected profit from gathering information for a

sophisticated investor  $i$  is:

$$\frac{\phi_i}{2} \frac{2\pi}{2\pi + (1-\pi)\phi\mu} R - C\phi_i \quad (13)$$

where each sophisticated investor  $i$  chooses how much to invest in information taking the benefit of information ( $\frac{2\pi}{2\pi+(1-\pi)\phi\mu}R$ ) as given. From the first-order condition

$$\phi_i^* = \begin{cases} 0 & \text{if } \frac{\pi}{2\pi+(1-\pi)\phi\mu}R < C, \\ \phi_i \in [0, 1] & \text{if } \frac{\pi}{2\pi+(1-\pi)\phi\mu}R = C, \\ 1 & \text{if } \frac{\pi}{2\pi+(1-\pi)\phi\mu}R > C. \end{cases} \quad (14)$$

In a symmetric equilibrium,  $\phi_i^* = \phi$  for all  $i$ . Hence, the equilibrium probability of becoming informed will be

$$\phi^* = \begin{cases} 0 & \text{if } R < 2C, \\ \frac{\pi}{\mu(1-\pi)} \left( \frac{R}{C} - 2 \right) & \text{if } R \in [2C, 2C + \frac{1-\pi}{\pi}\mu C], \\ 1 & \text{if } R > 2C + \frac{1-\pi}{\pi}\mu C. \end{cases} \quad (15)$$

Therefore, sophisticated investors acquire information (that is,  $\phi^* > 0$ ) only if informational rents are sufficiently high relative to the corresponding costs ( $R > 2C$ ). For intermediate values of  $R$ , in equilibrium sophisticated investors choose their probability  $\phi^*$  of becoming informed so as to earn zero net profits from information. If  $R$  is so high as to make them always willing to become informed in equilibrium (that is,  $\phi^* = 1$ ), sophisticated investors will be at a corner solution where they expect to earn a net profit from information,  $\frac{\pi}{2\pi+(1-\pi)\mu}R - C > 0$ .

### 3.3 Liquidity Traders' Participation Decision

In the transparent regime, liquidity traders always sell the ABS, since the realization of  $\lambda$  is public knowledge and therefore the ABS market is perfectly liquid. In the opaque regime, the choice of each liquidity trader depends on his expectation of the ABS bid price and of the behavior of sophisticated investors and of other liquidity traders. Intuitively, if an individual liquidity trader envisages sophisticated investors to search information

with high intensity  $\phi^*$ , they will expect the ABS market to be illiquid, and therefore will be less inclined to participate to it. His participation decision will also be affected by the choice of other liquidity traders, since the more of them choose to participate, the more liquid the ABS market: in other words, the ABS market features a participation externality.

Since we restrict our attention to symmetric equilibria, there are two candidate equilibria in the liquidity traders' participation subgame: (A) one in which all liquidity traders sell the alternative asset, sophisticated investors do not seek information, and the market makers set the bid price (11); (B) another candidate equilibrium in which all liquidity traders sell the ABS, sophisticated investors search for information with intensity  $\phi^*$  from expression (15), and market makers set the bid price (10). In case (A), the ABS market is virtually inactive, since sell orders may only come from the zero-measure set of sophisticated investors who receive information at no cost: for brevity, we will refer to this as an "inactive market". In the Appendix we derive the conditions under which (A) or (B) are equilibria, by checking whether an individual liquidity trader wishes to deviate from his assumed strategy (we do not need to check deviations by other players, since by the sequential nature of the game their strategies are optimal). We prove that:

**Proposition 1** *In the opaque regime, there are three cases: (i) if  $R \leq \Delta$ , there is a unique equilibrium where the ABS market is active; (ii) if  $R \in \left(\Delta, \max\left(2C + \Delta, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta\right)\right]$ , there are two equilibria, one where the ABS market is inactive and one where it is active; (iii) otherwise ( $R > \max\left(2C + \Delta, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta\right)$ ), there is a unique equilibrium where the ABS market is inactive.*

The results in this proposition are illustrated in Figure 2: the probability of the

liquidity shock  $\pi$  is measured along the horizontal axis, and the informational rent in the secondary market  $R$  along the vertical axis. For  $R < \Delta$ , the informational rent in the ABS market is so small compared to the discount in the alternative market that a liquidity trader would participate to the ABS market even if he expected to be the only uninformed investor. Hence in this case the only equilibrium features an active ABS market. In polar opposite case where  $R$  is above the upper curve in Figure 2, the informational rent in the ABS market is so high as to exceed both the discount in the alternative market  $\Delta$  and the cost  $2C$  of gathering information about  $\lambda$ : in this case, liquidity traders will always prefer to sell an alternative asset, so that the only equilibrium features an active ABS market. In the intermediate region, instead, there are two symmetric equilibria, one with inactive and another with active ABS market. This multiplicity results from strategic complementarity in the liquidity traders' participation decision: the ABS market discount decreases in the fraction of liquidity traders selling on the market, because this reduces adverse selection in the ABS market. To overcome this multiplicity of equilibria, we assume that liquidity traders coordinate on the equilibrium where the ABS market is active, since its outcome entails a higher welfare for them, being associated with a lower discount.<sup>21</sup>

Based on this analysis, we can characterize the equilibrium in each parameter region by determining the secondary market price of the ABS and the fraction of sophisticated investors acquiring information:

**Proposition 2** *In the transparent regime, the secondary market is perfectly liquid, the ABS price is  $P_3^B = \frac{x}{2}q_B - \tilde{\lambda}\frac{x}{2}(q_{B2} - q_{B1})$ , and no sophisticated investor invests in information ( $\phi^* = 0$ ). In the opaque regime:*

- (i) if  $R \leq 2C$ , the secondary market is perfectly liquid with ABS price equal to  $P_3^B = \frac{x}{2}q_B$ , and no sophisticated investor acquires information ( $\phi^* = 0$ );
- (ii) if  $R \in (2C, \min(2C + \Delta, R_1)]$ , the secondary market is illiquid, with ABS price equal to  $P_3^B = \frac{x}{2}q_B - (R - 2C)$ , and sophisticated investors acquire information with probability  $\phi^* \in (0, 1)$ ;
- (iii) if  $R \in (R_1, R_2]$ , the secondary market is illiquid, with ABS price equal to  $P_3^B = \frac{x}{2}q_B - \frac{(1-\pi)\mu}{2\pi+(1-\pi)\mu}R$ , and all sophisticated investors acquire information ( $\phi^* = 1$ );
- (iv) if  $R > \max(2C + \Delta, R_2)$ , the secondary market is inactive, with price  $P_3^B = \frac{x}{2}q_B - R$ , and no sophisticated investors acquire information ( $\phi^* = 0$ ).

where  $R_1 \equiv 2C + \frac{(1-\pi)\mu}{\pi}C$  and  $R_2 \equiv \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta$ ,

The results in Proposition 2 are graphically illustrated in Figure 3 for the opaque regime, which is the only interesting one because the transparent market is perfectly liquid for all parameter values. In the lowest region (i), the ABS market is perfectly liquid, since the rents from information do not compensate for the cost of its collection. Hence the secondary market price does not contain any discount due to adverse selection. In the polar opposite region (iv) at the top of the diagram, the ABS market is inactive: the ABS trades at the largest possible discount, and is sold only by a zero-measure of sophisticated and informed investors.

There are two intermediate regions, in both of which the ABS market is active but illiquid. The difference between them is that in region (ii) sophisticated investors play a mixed strategy in acquiring information, so that they become informed with a probability  $\phi^* \in (0, 1)$  and earn zero net rents from such information. In region (iii), instead,

sophisticated investors find it optimal always to acquire information ( $\phi^* = 1$ ) and earn a positive net informational rent: this happens if the probability of liquidity trading is sufficiently large ( $\pi > \mu C / (\Delta + \mu C)$ ), since liquidity trading increases the rents to informed investors. In this area, informational rents  $R$  are large enough that informed investors expect to earn positive net profits (graphically, we are above the downward sloping curve in Figure 3), but low enough that liquidity traders still want to participate to the ABS market (graphically, we are below the upward sloping curve in Figure 3).

## 4 Primary Market Price and Choice of Transparency

With opaqueness, at the issue stage all investors share the same information, so that there is no underpricing due to adverse selection in the primary market. In contrast, with transparency sophisticated investors have an informational advantage in bidding for the ABS, so that unsophisticated investors participate only if the security sells at a discount.

### 4.1 Issue Price with Opaqueness

If the realization of  $\lambda$  is not disclosed, at stage 1 the two types of investors are on an equal footing in their valuation of the securities, so that the price is simply the unconditional risk-adjusted expectation of the ABS payoff,  $pq_G + (1-p)xq_B/2$ , minus the expected stage-3 liquidity costs, namely the product of the default probability  $1 - p$ , the probability of the liquidity shock  $\pi$ , and the relevant stage-3 discount. By Proposition 2, this discount is zero in region (i), and equals  $R - 2C$  in region (ii),  $\frac{(1-\pi)\mu}{2\pi+(1-\pi)\mu}R$  in region (iii), and  $\Delta$  in region (iv). It is important to notice that in region (iv), where liquidity traders do not sell the ABS, the relevant stage-3 discount is given by the liquidity traders' cost of

liquidating the alternative asset,  $\Delta$ , rather than by the larger discount  $R$  that they would have to bear on the ABS market. Hence, the price of the ABS at the issue stage is:

$$P_{1,O} = \begin{cases} pq_G + (1-p)\frac{x}{2}q_B & \text{if } R \leq 2C, \\ pq_G + (1-p)\left[\frac{x}{2}q_B - \pi(R - 2C)\right] & \text{if } R \in (2C, \min(2C + \Delta, R_1)], \\ pq_G + (1-p)\left[\frac{x}{2}q_B - \pi\frac{(1-\pi)\mu}{2\pi+(1-\pi)\mu}R\right] & \text{if } R \in (R_1, R_2], \\ pq_G + (1-p)\left(\frac{x}{2}q_B - \pi\Delta\right) & \text{if } R > \max(2C + \Delta, R_2), \end{cases} \quad (16)$$

## 4.2 Issue Price with Transparency

With transparency, the equilibrium price in the primary market is such that unsophisticated investors value the asset correctly in expectation, conditional on their information and on the probability of their bids being successful:

$$P_{1,T} = \xi V(\lambda_L) + (1 - \xi)V(\lambda_H), \quad (17)$$

where  $\xi$  is the probability that unsophisticated investors successfully bid for a low-risk ABS, if sophisticated investors play their optimal bidding strategy, and  $V$  is the risk-adjusted PDV of the security conditional on the realization of  $\lambda$ .

Recalling that at stage 1 the ABS is allocated to investors via a uniform price auction, the probability  $\xi$  with which unsophisticated investors secure a low-risk ABS depends on the bidding strategy of informed investors, which in turn depends on the realization of  $\lambda$ . To see this, consider that for sophisticated investors the value of the ABS is given by expression (3), so that they are willing to bid a price  $P > V_T(\lambda)$  if  $\lambda = \lambda_L$  (i.e.  $\tilde{\lambda} = -\sigma$ ) but they place no bids if  $\lambda = \lambda_H$  (i.e.  $\tilde{\lambda} = \sigma$ ). As a result, if  $\tilde{\lambda} = -\sigma$  both types of investors bid: sophisticated investors manage to buy the ABS with probability  $\mu$  and the unsophisticated do so with probability  $1 - \mu$ . If  $\tilde{\lambda} = \sigma$ , instead, unsophisticated investors end up buying the ABS with certainty.

Thus the probability of an unsophisticated investor's buying the ABS if  $\tilde{\lambda} = -\sigma$  is

$\xi = (1 - \mu)/(2 - \mu) < 1/2$  and, using equation (17), the issue price is

$$P_{1,T} = pq_G + (1 - p) \left( \frac{x}{2} q_B - \frac{\mu}{2 - \mu} R \right), \quad (18)$$

where  $(1-p)\mu R/(2-\mu)$  is the discount required by unsophisticated traders to compensate for their winner's curse. This price is decreasing in the fraction of sophisticated investors  $\mu$  and in their informational rent  $R$ , as both these parameters tend to exacerbate adverse selection in the primary market. So with transparency there is no discount due to secondary market illiquidity, but there is underpricing arising from adverse selection in the primary market.

### 4.3 Face Value of the ABS

The expressions (16) and (18) for the issue price are predicated on the assumption that the issuer sets the face value of the ABS equal to its payoff in the good state, that is,  $F = 1$ . Clearly, choosing  $F < 1$  would reduce the proceeds from the sale of the ABS. Since the issuer invests any proceeds from the sale of the ABS at a net return  $r > 0$ , he wants to choose  $F$  as high as possible while avoiding default in the good state. Hence, he will set  $F = 1$  independently of the choice of transparency (to be analyzed in the next section). This verifies the assumption made in Section 2.1 about the face value of the ABS.

### 4.4 Choice of Transparency

Initially, the issuer chooses the disclosure regime that maximizes the issue price. This choice boils down to comparing expressions (16) and (18). As shown in the Appendix, the result is that:



**Proposition 3** *Issuers choose opaqueness for all parameter values.*

The intuition for this finding is that under opaqueness the costs due to adverse selection are borne “less often” than under transparency: under opaqueness, the discount due to adverse selection is paid by investors only when they are hit by a liquidity shock, which only happens with frequency  $\pi$ ; under transparency, instead, the adverse selection problem arises on the primary market, and therefore invariably leads to a discounted issue price. Proposition 3 implies that the issue price of the ABS is simply the initial price under the opaque regime,  $P_{1,O}$  given in expression (16)

What is left to analyze is whether the issuer, who is the initial owner of the loan portfolio, will want to sell it as an ABS or hold it to maturity on his books. If he holds it to maturity, his payoff would be  $V_O$  because he does not know  $\lambda$ ; if instead he sells the ABS and reinvests the proceeds, he will gain  $(1+r)P_1$ . Hence, the net gain from securitization is:

$$(1+r)P_1 - V_O = rV_O - \begin{cases} 0 & \text{if } R \leq 2C, \\ (1+r)(1-p)\pi(R-2C) & \text{if } R \in (2C, \min(2C + \Delta, R_1)], \\ (1+r)(1-p)\pi \frac{(1-\pi)\mu}{2\pi+(1-\pi)\mu} R & \text{if } R \in (R_1, R_2] \\ (1+r)(1-p)\pi\Delta & \text{if } R > \max(2C + \Delta, R_2), \end{cases} \quad (19)$$

where for brevity we replace the unconditional risk-adjusted expectation of the ABS payoff  $pq_G + \frac{1-p}{2}xq_B$  with  $V_O$ , by (2). To make the problem interesting, we assume that the rate of return  $r$  that the issuer can obtain on alternative assets is high enough as to make the net gain (19) positive, this inducing him to issue the ABS at stage 1.

## 4.5 The Crisis

It is interesting to consider what the model can tell us about the ABS market in the 2007-08 financial crisis. This can be analyzed by looking at the behavior of the secondary

market prices as the economy moves from stage 1 to stage 3, that is, as it becomes known that the ABS will not repay its face value.

If default is announced at stage 3, the market price will obviously drop because of the negative revision in fundamentals, even if the market stays liquid because informational rents are low ( $R \leq 2C$ ). But, if informational rents are larger ( $R > 2C$ ), the ABS price drops further due to the illiquidity of the market. Drawing the secondary market price  $P_{3,O}^B$  from Proposition 2 and the primary market price  $P_{1,O}$  from equation (16), one obtains the following expression for the price change:

$$P_{3,O}^B - P_{1,O} = -p(q_G - \frac{x}{2}q_B) - \begin{cases} 0 & \text{if } R \leq 2C; \\ [1 - (1-p)\pi](R - 2C) & \text{if } R \in (2C, \min(2C + \Delta, R_1)]; \\ [1 - (1-p)\pi] \frac{(1-\pi)\mu}{2\pi + (1-\pi)\mu} R & \text{if } R \in (R_1, R_2]; \\ [R - (1-p)\pi\Delta] & \text{if } R > \max(2C + \Delta, R_2). \end{cases} \quad (20)$$

Equation (20) indicates that if informational rents are sufficiently high, the announcement of the ABS default can trigger a market crash and the transition from a liquid primary market to an illiquid or inactive secondary market. This is what Gorton (2010) describes as a “panic”, that is, a situation in which structured debt securities turn from being informationally insensitive to informationally sensitive, and “some agents are willing to spend resources to learn private information to speculate on the value of these securities ... This makes them illiquid” (p. 36-37).<sup>22</sup> It is worth underscoring that this steep price decline and drying up of liquidity would not occur if the initial sale were conducted in a transparent fashion.

The financial crisis of 2007-08 featured first a drop in ABS prices and then a market freeze. In our model, this would occur if the rents from informed trading were to rise over time, moving the economy first into the illiquidity region and then into the region where

the ABS market becomes inactive. This increase in  $R$  may arise from an increase in the variability of the risk sensitivity of ABS ( $\sigma$ ), in the discrepancy between the marginal value of consumption in the two default states ( $q_{B2} - q_{B1}$ ), or from both: in other words, greater uncertainty about the quality of ABS, the gravity of the recession, or both. This argument also illustrates why the drop in ABS prices and the market freeze occurred only for non-agency MBS, which were not insured against default risk, and not for agency MBS, which were insured by government agencies: in our setting the difference in exposure to credit risk of the two types of securities would be captured by a larger value of  $\sigma$  for non-agency than for agency MBS.

## 5 Public Policy

The social value of liquidity may exceed the private value  $\Delta$  placed on liquidity by distressed investors. As we saw in Section 2.4, this point is captured by denoting the social value of stage-3 liquidity as  $(1+\gamma)\Delta$ , where  $\gamma$  measures the intensity of the liquidity externalities, and therefore the deadweight loss of secondary market illiquidity. This creates the potential for welfare-enhancing public policies. A regulator can intervene *ex ante* by imposing on issuers mandatory transparency on the primary market, or *ex post* by injecting liquidity at the stage of secondary market trading. This liquidity injection can be targeted to investors hit by the liquidity shock or aimed at supporting the price on the ABS market. In this section we illustrate the effects of these interventions on transparency and social welfare.

## 5.1 Mandating Transparency

Suppose the government can mandate transparency at the issue stage, by forcing the issuer to disclose information  $\Lambda$  at the issue stage: in which parameter regions is this socially efficient? The first step in answering is to define social welfare. Notice that in this model any profits made by sophisticated investors come either at the expense of the issuer (in the primary market) or at expense of liquidity traders; and in turn any losses inflicted on liquidity traders are initially borne by the issuers in the form of a lower issue price. Hence, in the absence of externalities, social welfare is measured by the expected value of the issuer's net payoff:

$$W = (1 + r)E(P_1) - V_O, \quad (21)$$

where the value of  $P_1$  will differ depending on the transparency regime: it is  $P_{1,T}$  in (18) under transparency, and  $P_{1,O}$  in (16) under opaqueness.

Under transparency, the secondary market is always liquid, so that there are no externalities due to illiquidity. Hence, social welfare is

$$W_T = rV_O - (1 + r)(1 - p)\frac{\mu}{2 - \mu}R, \quad (22)$$

which shows that in this regime inefficiency arises only from adverse selection in the primary market (captured by the second term). With opaqueness, instead, welfare is

$$W_O = rV_O - \begin{cases} 0 & \text{if } R \leq 2C, \\ (1 + r)(1 - p)\pi(R - 2C) & \text{if } R \in (2C, \min(2C + \Delta, R_1)]; \\ (1 + r)(1 - p)\pi\frac{(1 - \pi)\mu}{2\pi + (1 - \pi)\mu}R & \text{if } R \in (R_1, R_2]; \\ (1 + r + \gamma)(1 - p)\pi\Delta & \text{if } R > \max(2C + \Delta, R_2). \end{cases} \quad (23)$$

This expression shows that in the opaque regime inefficiencies may arise from adverse selection in the secondary market, and that the externality from illiquidity contributes

to lower welfare in the region where the ABS market is inactive (as indicated by the presence of the parameter  $\gamma$  in the bottom line).

The socially optimal choice depends on the comparison between expressions (22) and (23). The result of this comparison is obvious for all the cases in which there is no illiquidity externality: in these cases, opaqueness is the socially preferable regime, since social welfare coincides with the issuer's payoff, which by Proposition 3 is larger under opaqueness. A difference between social welfare and issuers' private payoff exists only in the region where the ABS market is inactive and the liquidity externality arises. Graphically, this occurs in the top region of Figure 4, where  $R > \max\left(2C + \Delta, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta\right)$ , which is shown in Figure 4 as an upward sloping convex curve.

In this region, the social gain from transparency  $W_T - W_O$  is the sum of the issuer's net gain  $(1+r)\left[\frac{\mu}{2-\mu}R - \pi\Delta\right]$  and the social gain  $\gamma\pi\Delta$ . Transparency is therefore socially optimal in the region where  $R < \frac{2-\mu}{\mu}\left(1 + \frac{\gamma}{1+r}\right)\pi\Delta$ , whose upper bound in Figure 4 is a straight line in the space  $(\pi, R)$ . Hence, the region where transparency is socially – but not privately – optimal is the shaded area in Figure 4. It is easy to show that this region is non-empty for sufficiently large values of the externality parameter  $\gamma$  relative to the private rate of return  $r$ . To summarize:

**Proposition 4** *Mandating transparency increases welfare if and only if  $R \in \left(\max\left(2C + \Delta, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta\right), \frac{2-\mu}{\mu}\left(1 + \frac{\gamma}{1+r}\right)\pi\Delta\right)$ .*

Notice that, according to this proposition, mandating transparency is not universally welfare-improving. Quite to the contrary, it is never efficient in the area where the market is active even if illiquid, that is, whenever the informational rents are sufficiently low. Therefore, such a prescription would not apply to ABS that feature little credit risk

and therefore low information sensitivity, such as agency MBS, while it might apply to riskier and potentially information sensitive ones, such as non-agency MBS.

Mandating transparency is not the only public policy that can address the inefficiency arising from the lack of transparency. Another type of effective policy would be for the government to precommit to gathering and disseminating information about the ABS's risk sensitivity  $\lambda$  at the stage of secondary market trading. This would enable issuers to reap the benefits from opaqueness on the primary market while avoiding the attendant costs in terms of secondary market illiquidity. In principle, issuers themselves may wish to commit to such a delayed transparency policy, but such a promise may not be credible on their part: ex post they may actually have the incentive to reveal their information about  $\lambda$  to a sophisticated investor so as to share into his informational rents from secondary market trading.

## 5.2 Liquidity Provision to Distressed Investors

An alternative form of policy intervention is to relieve the liquidity shortage when the secondary market is inactive at  $t = 3$ , that is, when  $R > \max\left(2C + \Delta, \Delta \frac{2\pi}{(1+\pi)\mu} + \Delta\right)$ . In this case ABS holders hit by the liquidity shock choose to sell other assets at the “fire-sale” discount  $\Delta$ . Hence, the government may target liquidity  $L \leq \Delta$  to these distressed investors, for instance by purchasing their assets at a discount  $\Delta - L$  rather than  $\Delta$ . In the limiting case  $L = \Delta$ , it would make their assets perfectly liquid. Alternatively, the government may acquire stakes in the equity of distressed ABS holders and thereby reduce the need for fire sales of assets. In either case, the liquidity injection reduces the reservation value of liquidity from  $\Delta$  to  $\Delta - L$ . This has a social cost  $(1 + \tau)L$ , where the parameter  $\tau > 0$  captures the cost of the distortionary taxes needed to finance the

added liquidity.

How large should the liquidity injection  $L$  be when the ABS market is inactive? In this case, social welfare has three components: (i) the net value of the ABS,  $rV_O - (1 + r)(1 - p)\pi(\Delta - L)$ ; (ii) the negative externality  $-(1 + r)(1 - p)\gamma\pi(\Delta - L)$ ; and (iii) the expected cost of distortionary taxation  $-(1 + \tau)\pi(1 - p)L$ . Therefore, social welfare is

$$W = rV_O - (1 + r + \gamma)(1 - p)\pi(\Delta - L) - (1 + \tau)\pi(1 - p)L. \quad (24)$$

If the government chooses  $L \in [0, \Delta]$  so as to maximize  $W$ , its optimal liquidity injection is

$$L^* = \begin{cases} 0 & \text{if } \tau > r + \gamma, \\ L \in [0, \Delta] & \text{if } \tau = r + \gamma, \\ \Delta & \text{if } \tau < r + \gamma. \end{cases} \quad (25)$$

The following proposition summarizes these results:

**Proposition 5** *The public provision of liquidity to traders who need liquidity is welfare-enhancing if  $R > \max\left(2C + \Delta, \Delta \frac{2\pi}{(1+\tau)\mu} + \Delta\right)$  and  $\tau < r + \gamma$ .*

Providing liquidity to distressed ABS holders is optimal in the entire “inactive market” region in Figure 4 (which combines the light and dark grey areas), provided that the net benefits from ex-post liquidity (given by the sum of the net proceeds from the ABS sale  $r$  and the liquidity externality  $\gamma$ ) exceeds the net costs of liquidity (given by the marginal cost of taxes  $\tau$ ). If this condition is satisfied, the region where the ex-post injection of liquidity is optimal is larger than the area where transparency of optimal (the dark grey area in Figure 4). This happens because imposing transparency reduces the proceeds for ABS issuers. Conversely, ex-post liquidity provision does not affect the proceeds from the ABS sale. However, it is important to realize that, in the dark grey area, where investors are more likely to need secondary market liquidity (high  $\pi$ ),

mandating transparency ex ante dominates ex-post liquidity provision: here, not only transparency dominates opaqueness, but it removes the need for ex-post intervention and thus avoids distortionary taxes. In the light grey area where investors are less likely to need liquidity (low  $\pi$ ), instead, mandatory transparency is unwarranted, while ex-post provision of liquidity is socially optimal, provided that  $\tau < r + \gamma$ . Hence, our model provides a role for both ex-ante mandatory disclosure and for ex-post liquidity provision.

### 5.3 Public Price Support in the ABS Market

In the previous section, the government was assumed to target the liquidity injection to the investors hit by a liquidity shock. Alternatively, the government may intervene to support the market price for ABS without targeting liquidity sellers, either by standing to buy the ABS at a per-set price or by subsidizing market makers. This was the main feature of the initial version of Paulson plan in the U.S., which envisaged “reverse auctions” aimed at buying back securitized loans from banks – a plan later replaced by an approach targeted at recapitalizing distressed banks, and thus closer to the intervention described in the previous section. However, in July 2009 the Federal Reserve started engaging in forms of indirect support of the ABS market, by providing cheap loans to investors such as hedge funds for the purchase of commercial MBS. In this section, we consider what should be the effect of such a public intervention in the ABS market.

Since in our setting a negative externality arises only when the ABS market is inactive, it is natural to assume that the government intervenes only in this case, that is, only when  $R > \max\left(2C + \Delta, \Delta \frac{2\pi}{(1+\pi)\mu} + \Delta\right)$ . The least-cost government policy to keep the ABS market active is buying the ABS at a discount  $\Delta$  (or at slightly higher price, so as to break the indifference of the liquidity traders). In other words, the government replaces



the market makers at  $t = 3$  and buys the ABS at the price

$$P_{3,O}^B = \frac{x}{2}q_B - \Delta. \quad (26)$$

This relieves the investors hit by a liquidity shock but also increases the sophisticated investors' incentive to acquire information. To see this, consider that now the net profit that sophisticated investors can expect from information gathering is:

$$\frac{\phi_i}{2} (R - \Delta) - C\phi_i, \quad (27)$$

where the first term is the gain that the informed investor obtains from selling at the price (26) the ABS, whose true value in the bad state is  $\frac{x}{2}q_B - R$ . As before, informed investors obtain this gain only with probability  $1/2$ , namely when the information about  $\lambda$  is negative. From the first-order condition, the equilibrium probability of becoming informed is

$$\phi^* = \begin{cases} 0 & \text{if } R < 2C + \Delta, \\ \phi \in [0, 1] & \text{if } R = 2C + \Delta, \\ 1 & \text{if } R > 2C + \Delta. \end{cases} \quad (28)$$

In the parameter region where the government intervenes ( $R > \max\left(2C + \Delta, \Delta\frac{2\pi}{(1+\pi)\mu} + \Delta\right)$ ), the bottom inequality in (28) always holds, so that the expression simplifies to  $\phi^* = 1$ . Hence, sophisticated investors always gather information.

How does the government decide whether to intervene? The gains from intervention come from avoiding the negative externality which costs  $\pi(1-p)\gamma\Delta$  to society. The cost is the deadweight loss associated with the taxes that the government must raise to cover its market-making losses in the secondary market. In its market-making activity, the government gains  $\pi(1-p)\Delta$  from liquidity traders but loses  $(1-\pi)(1-p)\mu\frac{R-\Delta}{2}$  to sophisticated investors. Because  $R > \Delta\frac{2\pi}{(1+\pi)\mu} + \Delta$ , on balance it loses money.

Notice that the intervention in the secondary market does not change the issue price since the government is buying the ABS at the same discount ( $\Delta$ ) that the liquidity traders would suffer by selling the alternative asset.

Hence, the government's choice about whether to support the ABS market depends on whether  $\pi\gamma\Delta - \tau \left[ (1 - \pi)\mu \frac{R - \Delta}{2} - \pi\Delta \right]$  is positive. Re-expressing this inequality as an upper bound on  $R$ , the government will support the ABS market if

$$R \leq \Delta \left[ 1 + \frac{2\pi}{(1 - \pi)\mu} \left( 1 + \frac{\gamma}{\tau} \right) \right]. \quad (29)$$

Recalling that  $R$  must also be large enough to place the economy in the region where the ABS market would otherwise be inactive, we have the following:

**Proposition 6** *It is optimal for the government to provide price support to the ABS market if  $R \in \left( \max \left( 2C + \Delta, \Delta \frac{2\pi}{(1 + \pi)\mu} + \Delta \right), \Delta + \frac{2\pi}{(1 - \pi)\mu} \left( 1 + \frac{\gamma}{\tau} \right) \Delta \right]$ .*

This result is illustrated in Figure 5, where the region where ex-post intervention in the ABS market is socially efficient is shaded in dark grey. The size of this region is increasing in  $\pi$ ,  $\Delta$  and  $\gamma$ , namely in the private and social value of liquidity: indeed, this locus would disappear if  $\gamma = 0$ . Conversely, its size is decreasing in the magnitude of  $\tau$ ,  $C$  and  $\mu$ : intuitively, a large  $\tau$  implies that government intervention is socially more costly, a large  $C$  reduces the scope for such intervention because sophisticated investors have little incentive to seek information anyway, and a large  $\mu$  increases the adverse selection cost that the government faces in supporting the ABS market.

It is worth noticing that the region where ABS price support by the government is optimal (the dark grey area in Figure 5) is smaller than the area where liquidity provision targeted to distressed investors is optimal (which also includes the light grey area in Figure

5). Both policies eliminate the negative externality. But they differ in another respect: targeting liquidity at distressed investors raises the ABS issue price (which produces a social gain  $r$ ), without generating profits for sophisticated investors; in contrast, giving public support to the secondary market price leaves the ABS issue price unaffected, and instead increases sophisticated investors' informational rents, and thus their incentive to seek information (which yields no social benefit, and may cause social losses).

## 6 Extensions

In this section we explore two extensions of the basic model. First, we endogenize the liquidity discount  $\Delta$  and the externality  $\gamma$ : we assume that investors in ABS securities also own real assets that are directly used in production, and may have to liquidate them at a discount if adverse selection in the secondary market for ABS is too severe. Liquidation of these assets disrupts the productivity of other input suppliers, such as employees used to work with these assets, so that extreme adverse selection in the ABS market generates a deadweight loss for society.

Second, we endogenize the fraction of sophisticated investors to deliver predictions on which markets can be expected have more of them. We suppose that investors choose whether to become sophisticated at some cost before knowing the degree of asymmetric information  $R$  associated with the security and the probability of the liquidity shock  $\pi$ .

### 6.1 Endogenous Value of Liquidity

Recall that, if the secondary market for the ABS were perfectly liquid, in the opaque regime sellers hit by a liquidity shock could sell their holdings in default states at the fair price  $q_B x/2$ . Suppose that this is precisely the sum of money that they need to offset

their liquidity shock. If instead the ABS is illiquid and were to sell at a discount larger than  $\Delta$  off this fair value, these investors abstain from selling the ABS, being able to liquidate an alternative asset in their portfolio at the fire-sale discount  $\Delta$ . However, the liquidation of this alternative asset is associated with a deadweight cost  $\gamma\Delta$  for society.

In this section, we endogenize both the private and the social value of liquidity, by assuming that the alternative asset owned by investors is a real asset used in production by a firm that they own, for instance a piece of manufacturing equipment or a plot of farmland. If an investor hit by the liquidity shock chooses to sell this alternative asset, he will need to sell enough of it as to raise the amount  $q_Bx/2$ . But, having invested in firm-specific know-how, the asset is more valuable to him than to potential acquirers. Specifically, assume that to the current firm owner the value of a unit of this asset is  $v_H$ , which exceeds the price  $v_L$  at which it can be sold to a potential buyer. To cover his need for liquidity, the owner would need to sell  $k$  units of this productive asset, with  $k = \frac{q_Bx}{2v_L}$ . Hence, adopting the terminology used before, the fire-sale discount on this alternative asset is  $\Delta = \frac{q_Bx}{2} \frac{v_H - v_L}{v_L}$ .

Now suppose that this productive asset is used jointly with labor – for simplicity, in equal proportions – and that, just like the owner of the firm, workers made firm-specific investments in human capital, which allow them to earn a quasi-rent  $w$ . Thus, liquidating  $k$  units of productive capital implies firing  $k$  workers, who collectively lose  $kw$ . This loss is not internalized by ABS holders when they choose to liquidate productive capital instead of their illiquid ABS. Hence, the fire sale induced by an illiquid ABS market generates a negative externality  $\gamma\Delta = \frac{q_Bx}{2v_L}w$ . The intensity of the externality,  $\gamma = \frac{w}{v_H - v_L}$ , is the ratio between the workers' loss  $w$  and the entrepreneur's loss  $v_H - v_L$  per unit of productive capital being liquidated. The analysis in Proposition 3 and 4 follows unchanged with

these specific values for  $\Delta$  and  $\gamma$ .

## 6.2 Endogenous Sophistication

So far the proportion  $\mu$  of sophisticated investors who buy a security has been treated as a parameter. In this section, we extend the model to encompass investors' choice to become sophisticated before the securities are issued, so that the fraction  $\mu$  of sophisticated investors is determined endogenously in equilibrium. A first result follows immediately from the previous analysis: whenever the government mandates transparency, there is no scope for incurring any cost to become financially sophisticated, because there are no rents to be had in secondary market trading. The fraction  $\mu$  of sophisticated investors can be positive only when the secondary market is expected to be opaque: sophisticated investors gain from opaqueness, just as issuers do (by Proposition 3). The next question is: assuming opaqueness, under which circumstances should we expect more investment in financial sophistication, and thus greater adverse selection in secondary market trading?

Recall that sophisticated investors earn positive net profits from investing in information only if  $R \in \left(2C + \frac{(1-\pi)\mu}{\pi}C, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta\right]$ , which corresponds to region (iii) in Figure 3: only in this region they have the incentive to become sophisticated. To make the problem interesting, we assume that the decision about whether to become sophisticated or not is made under uncertainty. Specifically, we assume that at date  $t = -1$  (before securities are issued) each investor  $i \in [0, 1]$  chooses how much to spend on financial education: by spending more on it, the investor raises the probability  $\mu_i$  of becoming sophisticated. For concreteness, the cost borne by the investor is taken to be a linear function  $s\mu_i$  of the probability of becoming sophisticated, where the parameter  $s$  determines how costly financial education is. When this decision is made, investors are assumed to be still un-

certain about the degree of asymmetric information  $R$  associated with the ABS to be issued. Specifically,  $R$  is a Bernoulli-distributed random variable, which can take values  $\{0, \bar{R}\}$  with  $\rho$  being the probability that  $R = \bar{R}$ .

Denoting the expected gain from being sophisticated by  $g$  (yet to be determined), each investor  $i$  will choose the investment in financial education – and therefore the level of  $\mu_i$  – that maximizes his net gain from financial education,  $g\mu_i - s\mu_i$ . The expected gain  $g$  from being sophisticated is

$$g = (1-p)(1-\pi)\rho \left[ \frac{\pi}{2\pi + (1-\pi)\mu} \bar{R} - C \right] \quad (30)$$

if  $\bar{R} \in \left( 2C + \frac{(1-\pi)\mu}{\pi} C, \Delta + \frac{2\pi}{(1-\pi)\mu} \Delta \right]$ , and is zero otherwise. To understand this expression, notice that the term in square brackets is the rent that sophisticated investors earn from information, given by expression (13) if  $\phi_i = \phi^* = 1$  (which is the case in the region being considered). This rent accrues to sophisticated investors only if there is default (which happens with probability  $1-p$ ), if they are not hit by a liquidity shock (which happens with probability  $1-\pi$ ), and if  $R = \bar{R}$  (which happens with probability  $\rho$ ), since for  $R = 0$  there is no informational rent to be gained.

In the Appendix we prove the following results:

**Proposition 7** *If the cost of financial education is sufficiently high ( $s > \bar{s}$ ) and the maximum informational rent sufficiently large ( $\bar{R} > 2C + \frac{2s}{\rho(1-p)(1-\pi)}$ ), there is a unique symmetric equilibrium where the fraction of sophisticated investors is  $\mu^* = \frac{\pi}{1-\pi} \left[ \frac{\bar{R}}{\frac{s}{\rho(1-p)(1-\pi)} + C} - 2 \right] > 0$ . If instead  $\bar{R} < 2C + \frac{2s}{\rho(1-p)(1-\pi)}$ , the unique symmetric equilibrium features no sophisticated investors ( $\mu^* = 0$ ). For all other parameter values ( $s < \bar{s}$  and  $\bar{R} > 2C + \frac{2s}{\rho(1-p)(1-\pi)}$ ), there is no symmetric equilibrium.*

The threshold  $\bar{s}$  mentioned in Proposition 7 is computed in the Appendix. The intuitive rationale for our results is as follows. If  $\bar{R} < 2C + \frac{2s}{\rho(1-p)(1-\pi)}$ , the expected rent from becoming sophisticated is not large enough to cover the costs of financial education, so that investors have no incentive to become sophisticated. Conversely, when  $\bar{R} > 2C + \frac{2s}{\rho(1-p)(1-\pi)}$ , the rent from becoming sophisticated is high enough to induce investment in financial education. However, this is an equilibrium only if the cost of becoming sophisticated is high enough ( $s > \bar{s}$ ) to prevent excessive competition for these informational rents. If this condition on the cost of financial education is not met ( $s < \bar{s}$ ), there is no equilibrium: intuitively, the fraction of informed investors – and thus adverse selection in the ABS market – would be so high that liquidity traders would be driven out of the market.

The most interesting case is that in which  $s > \bar{s}$  and  $\bar{R} > 2C + \frac{2s}{\rho(1-p)(1-\pi)}$ , so that in equilibrium there is a positive fraction  $\mu^*$  of sophisticated investors. From the expression for  $\mu^*$  in Proposition 7, it is easy to see that the fraction of sophisticated investors is increasing in the likelihood  $1 - p$  of default states (because only in these states the ABS becomes informationally sensitive and thus can yield informational rents), in the likelihood  $\rho$  and magnitude  $\bar{R}$  of the informational rent (which both increase the payoff to financial sophistication), and in the probability of liquidity trading  $\pi$  (since informed investors gain at the expense of liquidity traders). Hence, investment in financial sophistication is elicited by the issuance of risky and informationally sensitive securities, and/or by the expectation of a strong volume of liquidity trading. Conversely, as one would expect, the fraction of sophisticated investors is decreasing in the cost parameter of financial education  $s$  and in the cost  $C$  of acquiring information.

## 7 Conclusions

Is there a conflict between expanding the placement of complex financial instruments and preserving the transparency and liquidity of their secondary markets? Put more bluntly, is “popularizing finance” at odds with “keeping financial markets a safe place”? The subprime crisis has thrown this question for the designers of financial regulation into high relief.

The answer we provide is that indeed the conflict exists, and that it may be particularly relevant to the securitization process. Marketing large amounts of ABS means selling them also to unsophisticated investors, who cannot process the information necessary to price them. In fact, if such information were released, it would put them at a disadvantage vis-à-vis the “smart money” that can process it. This creates an incentive for ABS issuers to negotiate with credit rating agencies a low level of transparency – that is, relatively coarse and uninformative ratings. Ironically, the elimination of some price-relevant information is functional to enhanced liquidity in the ABS new issue market.

However, opaqueness at the issue stage comes at the cost of a less liquid, or even totally frozen-up, secondary market, and of sharper price decline in case of default. This is because with poor transparency sophisticated investors may succeed in procuring the undisclosed information. Therefore, trading in the secondary market will be hampered by adverse selection, while with transparency this would not occur.

Though privately optimal, opaqueness may be socially inefficient if the illiquidity of the secondary market has negative repercussions on the economy, as by triggering a spiral of defaults and bankruptcies. In this case, regulation making greater disclosure mandatory for rating agencies is socially optimal. Our model therefore offers support for



current regulatory efforts to increase disclosure of credit rating agencies. However, it also indicates that there are situations in which opaqueness is socially optimal, for instance when the rents from private information are too low to shut down the secondary market or when its liquidity has little value.

We also show that, when opaqueness results in a frozen-up secondary market, *ex-post* public liquidity provision may be warranted, and that targeting such liquidity to distressed bondholders is preferable to providing it via support to the ABS secondary market price. The reason is that by supporting ABS prices, public policy ends up enhancing the trading profits of sophisticated investors, and thus subsidizes their information collection effort, which is not beneficial and may actually be harmful from a social standpoint. Anyway, whenever transparency is socially efficient, *ex-ante* mandatory transparency makes any form of *ex-post* liquidity provision unnecessary, thus sparing society the cost of the implied distortionary taxes.

Finally, we extend the analysis by endogenizing two parameters of the baseline model of this paper. First, we show that the liquidity externality assumed in the model can arise from the fact that an illiquid ABS market can trigger fire sales of productive assets, and thereby the socially wasteful loss of workers' firm-specific human capital. Second, we endogenize the proportion of sophisticated investors, by assuming investors can invest in financial education before the issuance of securities.

Interestingly, the problems analyzed in this paper – the complexity of the information required to invest in ABS and its implications for liquidity – have resurfaced as investors and policy makers debated how to restart securitizations after the crisis. A recent article in the Financial Times reports: “Investors want to buy more securitizations but many admit that they cannot fully analyze deals” (Hughes, 2010), while a 2009 public consul-

tation launched by the European Central Bank on loan-by-loan information requirements for ABS reveals that for the vast majority of market participants “the provision of more detailed information would help the market assess the risks associated with ABS ... it would unquestionably benefit all types of investors, as well as the general level of liquidity in the market” (ECB, 2010, p. 1).

## Appendix

**Proof of Proposition 1.** Consider first candidate equilibrium (A). If all liquidity traders choose to sell the alternative asset, they will not sell the ABS and therefore the price is given by expression (11). Hence, if any of them were to deviate by selling the ABS, he would suffer a loss  $R$ . This is to be compared to the discount  $\Delta$  that he would face on the alternative asset: hence, he will not deviate if  $R > \Delta$ . So (A) is an equilibrium if  $R > \Delta$ .

Let us now consider candidate equilibrium (B). If all liquidity traders choose to sell the ABS, individual deviations will not be profitable if the discount in the ABS market (from equation (10)) does not exceed the reservation value  $\Delta$  in the alternative market, namely if

$$\Delta \geq \frac{(1-\pi)\phi^*\mu}{2\pi+(1-\pi)\phi^*\mu}R. \quad (\text{A1})$$

Substituting for  $\phi^*$  from expression (15), we find that this condition becomes

$$\Delta \geq \begin{cases} 0 & \text{if } R < 2C, \\ R - 2C & \text{if } R \in [2C, 2C + \frac{1-\pi}{\pi}\mu C], \\ \frac{(1-\pi)\mu}{2\pi+(1-\pi)\mu}R & \text{if } R > 2C + \frac{1-\pi}{\pi}\mu C. \end{cases} \quad (\text{A2})$$

This condition implies that the set of strategies (B) are an equilibrium if either  $R < 2C$  or  $R \in [2C, \min(2C + \Delta, 2C + \frac{1-\pi}{\pi}\mu C)]$  or  $R \in (2C + \frac{1-\pi}{\pi}\mu C, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta]$ . Hence, more compactly, equilibrium (B) exists if  $R \leq \max(2C + \Delta, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta)$ .

Summarizing, (A) is the only equilibrium if  $R > \max(2C + \Delta, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta)$ ; (B) is the only equilibrium if  $R \leq \Delta$ ; both (A) and (B) are equilibria if  $R \in (\Delta, \max(2C + \Delta, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta)]$ .

**Proof of Proposition 2.** Recall that in the transparent regime  $P_3^B$  is given by equation (8), and since information about  $\lambda$  is already impounded in  $P_3^B$ , sophisticated have no

reason to acquire it.

In the opaque regime, consider first the case in which equilibrium (A) is played because  $R > \max(2C + \Delta, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta)$ . In this case,  $\phi^* = 0$  and  $P_3^B = \frac{x}{2}q_B - R$ .

In all other cases (where  $R \leq \max(2C + \Delta, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta)$ ), equilibrium (B) is played, so that  $\phi^*$  is given by equation (15) and  $P_3^B$  by equation (10). Hence:

$$\phi^* = \begin{cases} 0 & \text{if } R < 2C, \\ \frac{\pi}{\mu(1-\pi)} \left( \frac{R}{C} - 2 \right) & \text{if } R \in \left[ 2C, \min(2C + \Delta, 2C + \frac{(1-\pi)\mu}{\pi}C) \right], \\ 1 & \text{if } R \in \left( 2C + \frac{(1-\pi)\mu}{\pi}C, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta \right]. \end{cases} \quad (\text{A3})$$

and

$$P_3^B = \begin{cases} \frac{xq_B}{2} & \text{if } R < 2C, \\ \frac{xq_B}{2} - (R - 2C) & \text{if } R \in \left[ 2C, \min(2C + \Delta, 2C + \frac{(1-\pi)\mu}{\pi}C) \right], \\ \frac{xq_B}{2} - \frac{\mu(1-\pi)}{2\pi + \mu(1-\pi)}R & \text{if } R \in \left( 2C + \frac{(1-\pi)\mu}{\pi}C, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta \right]. \end{cases} \quad (\text{A4})$$

**Proof of Proposition 3.** The difference in issue price between opaqueness and transparency is:

$$P_{1,O} - P_{1,T} = \begin{cases} (1-p)\frac{\mu}{2-\mu}R > 0 & \text{if } R \leq 2C; \\ (1-p) \left[ \frac{\mu}{2-\mu}R - \pi(R - 2C) \right] & \text{if } R \in \left( 2C, \min(2C + \Delta, 2C + \frac{(1-\pi)\mu}{\pi}C) \right]; \\ (1-p) \left[ \frac{\mu}{2-\mu} - \pi \frac{(1-\pi)\mu}{2\pi + (1-\pi)\mu} \right] R & \text{if } R \in \left( 2C + \frac{(1-\pi)\mu}{\pi}C, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta \right); \\ (1-p) \left[ \frac{\mu}{2-\mu}R - \pi\Delta \right] & \text{if } R > \max(2C + \Delta, \Delta + \frac{2\pi}{(1-\pi)\mu}\Delta). \end{cases} \quad (\text{A5})$$

There are four cases to consider, which correspond to the four regions in Figure 3:

**Region (i):** In this region where  $R \leq 2C$ , the issuer chooses opaqueness. As the profits from information do not compensate for the cost of its collection, the secondary market is perfectly liquid. Hence, the issuer's only concern is to avoid underpricing in the primary market, which is achieved by choosing opaqueness.

**Region (ii):** In the intermediate region where  $R \in \left( 2C, \min \left( 2C + \Delta, 2C + \frac{(1-\pi)\mu}{\pi}C \right) \right]$ , the discount associated with transparency is

$\frac{\mu R}{2-\mu}$ , whereas the discount with opaqueness is  $\pi(R - 2C)$ . Hence, the regime with transparency dominates if  $R \left( \pi - \frac{\mu}{2-\mu} \right) > 2\pi C$  or  $R > \frac{2\pi C}{\pi - \frac{\mu}{2-\mu}}$ . This condition is violated, because  $\frac{2\pi C}{\pi - \frac{\mu}{2-\mu}} \geq 2C + \frac{(1-\pi)\mu}{\pi} C$  and in this region  $R \leq 2C + \frac{(1-\pi)\mu}{\pi} C$ . Thus in this region opaqueness is optimal.

**Region (iii):** In the intermediate region where  $R \in \left( 2C + \frac{(1-\pi)\mu}{\pi} C, \Delta + \frac{2\pi}{(1-\pi)\mu} \Delta \right]$ , the discount associated with transparency is  $\frac{\mu R}{2-\mu}$ , whereas the discount with opaqueness is  $\pi \frac{(1-\pi)\mu}{2\pi + (1-\pi)\mu} R$ . It is easy to show that  $\frac{\mu}{2-\mu} \geq \pi \frac{(1-\pi)\mu}{2\pi + (1-\pi)\mu}$ . Hence, also in this region opaqueness is optimal.

**Region (iv):** In the top region where  $R > \max \left( 2C + \Delta, \Delta + \frac{2\pi}{(1-\pi)\mu} \Delta \right)$ , opaqueness is also optimal. To see this, consider that by choosing opaqueness, the issuer bears the expected liquidity cost  $\pi\Delta$ , while saving the underpricing cost  $\frac{\mu}{2-\mu} R$ . Transparency dominates only if  $R < \frac{(2-\mu)\pi}{\mu} \Delta$ . This condition is violated, because in this region  $R > \Delta + \frac{2\pi}{(1-\pi)\mu} \Delta$  and we can show that  $\Delta + \frac{2\pi}{(1-\pi)\mu} \Delta \geq \frac{(2-\mu)\pi}{\mu} \Delta$ , which proves the result.

In conclusion, in no region transparency is optimal.

**Proof of Proposition 7.** Each investor  $i$  chooses  $\mu_i$  non-cooperatively, taking the choice of  $\mu$  made by other investors as given. Since the gain  $g$  from financial sophistication depends on the fraction  $\mu$  of sophisticated investors but not on the individual probability  $\mu_i$ , each investor  $i$  will take  $g$  as given in his choice. Hence, each investor  $i$  solves the following problem:

$$\max_{\mu_i \in [0,1]} g\mu_i - s\mu_i, \quad (\text{A6})$$

subject to

$$g = \begin{cases} (1-p)(1-\pi)\rho \left[ \frac{\pi}{2\pi + (1-\pi)\mu} \bar{R} - C \right] & \text{if } \bar{R} \in \left[ 2C + \frac{1-\pi}{\pi} \mu C, \Delta + \frac{2\pi\Delta}{(1-\pi)\mu} \right], \\ 0 & \text{otherwise.} \end{cases} \quad (\text{A7})$$

Since the objective function is convex in  $\mu_i$ , the necessary and sufficient condition for a maximum is

$$\mu_i = \begin{cases} 0 & \text{if } g < s, \\ \mu \in [0, 1] & \text{if } g = s, \\ 1 & \text{if } g > s. \end{cases} \quad (\text{A8})$$

In a symmetric equilibrium  $\mu_i = \mu$ . In equilibrium,  $\mu$  cannot be equal to 1: in this case all investors would be sophisticated and thus there would be no informational rent, which in turn implies that the optimal choice would be  $\mu_i = 0$ , leading to a contradiction. Hence, in a symmetric equilibrium  $\mu$  must be either 0 or take a value between 0 and 1 such that  $g = s$ . The condition for  $\mu = 0$  to be an equilibrium is obtained by replacing expression (A7) in the condition  $g < s$ :

$$\bar{R} < 2 \left[ C + \frac{s}{\rho(1-p)(1-\pi)} \right]. \quad (\text{A9})$$

The condition for  $\mu \in (0, 1)$  to be an equilibrium is obtained by replacing expression (A7) in the condition  $g = s$ :

$$\mu = \frac{\pi}{1-\pi} \left[ \frac{\bar{R}}{C + \frac{s}{\rho(1-p)(1-\pi)}} - 2 \right]. \quad (\text{A10})$$

Expression (A10) is positive if and only if  $\bar{R} \geq 2 \left[ C + \frac{s}{\rho(1-p)(1-\pi)} \right]$ , and it is smaller than 1 if and only if  $\bar{R} < \left[ C + \frac{s}{\rho(1-p)(1-\pi)} \right] \left( 1 + \frac{1}{\pi} \right)$ . The latter constraint is satisfied if and only if

$$s > \frac{\rho(1-p)(1-\pi)}{1+\pi} [\pi\bar{R} - (1-\pi)C] \equiv \bar{s}. \quad (\text{A11})$$

Summarizing, there is a unique symmetric equilibrium where  $\mu$  equals

$$\mu^* = \begin{cases} 0 & \text{if } \bar{R} < 2 \left[ C + \frac{s}{\rho(1-p)(1-\pi)} \right], \\ \frac{\pi}{1-\pi} \left[ \frac{\bar{R}}{C + \frac{s}{\rho(1-p)(1-\pi)}} - 2 \right] & \text{if } \bar{R} \geq 2 \left[ C + \frac{s}{\rho(1-p)(1-\pi)} \right] \text{ and } s > \bar{s}, \end{cases} \quad (\text{A12})$$

while there is no symmetric equilibrium if  $\bar{R} \geq 2 \left[ C + \frac{s}{\rho(1-p)(1-\pi)} \right]$  and  $s < \bar{s}$ .

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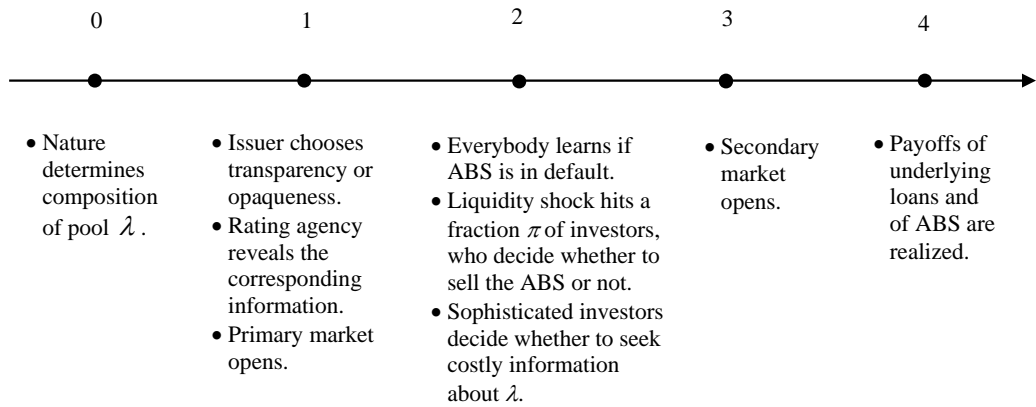


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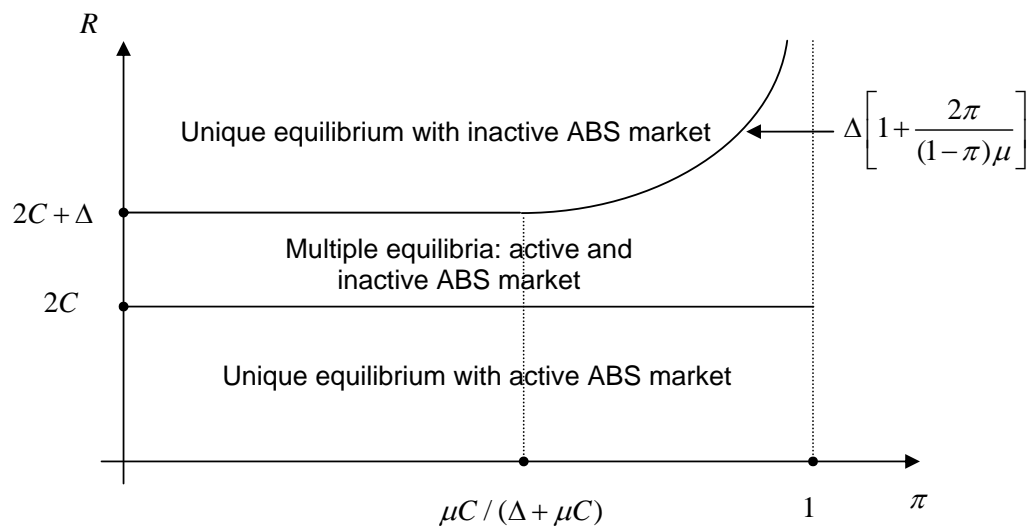
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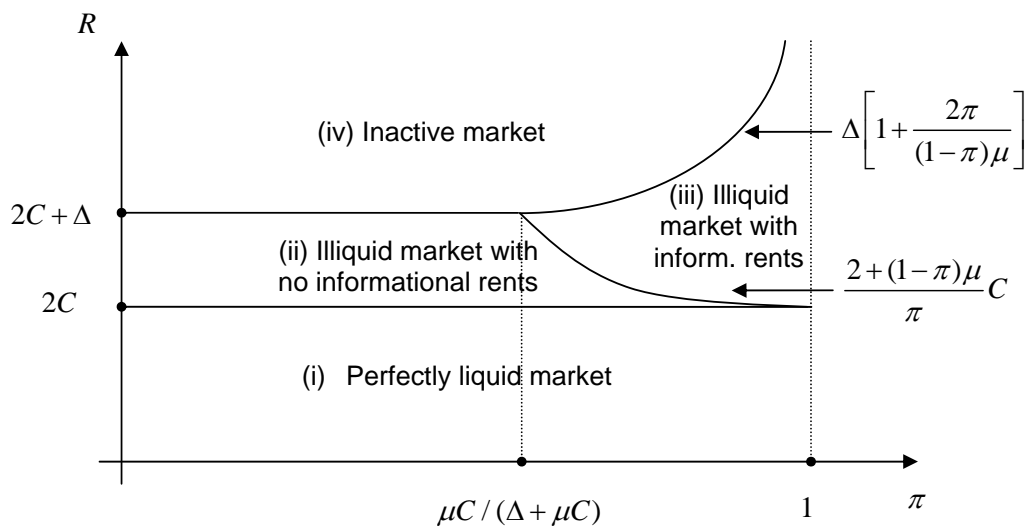
# Figures



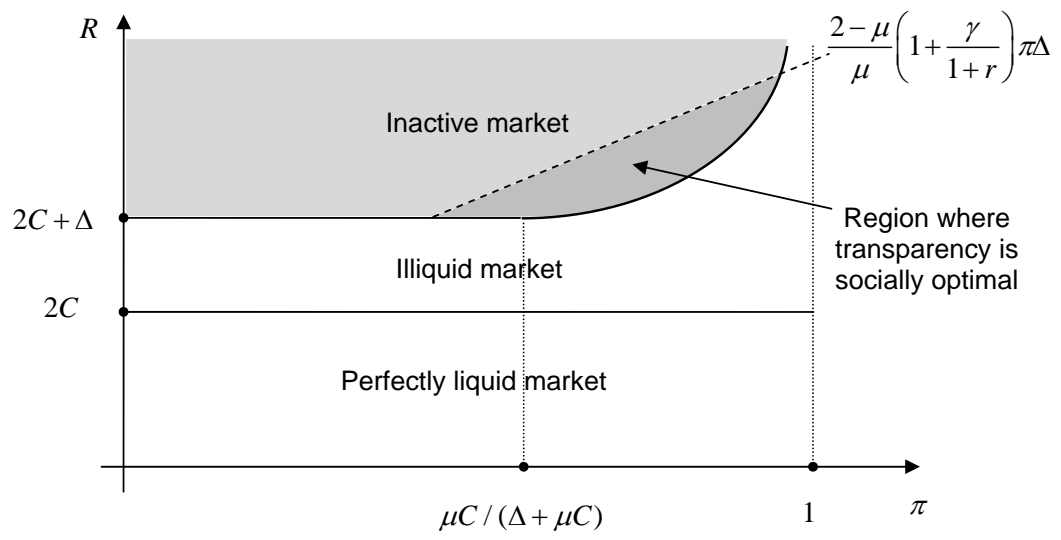
**Figure 1.** Time line.



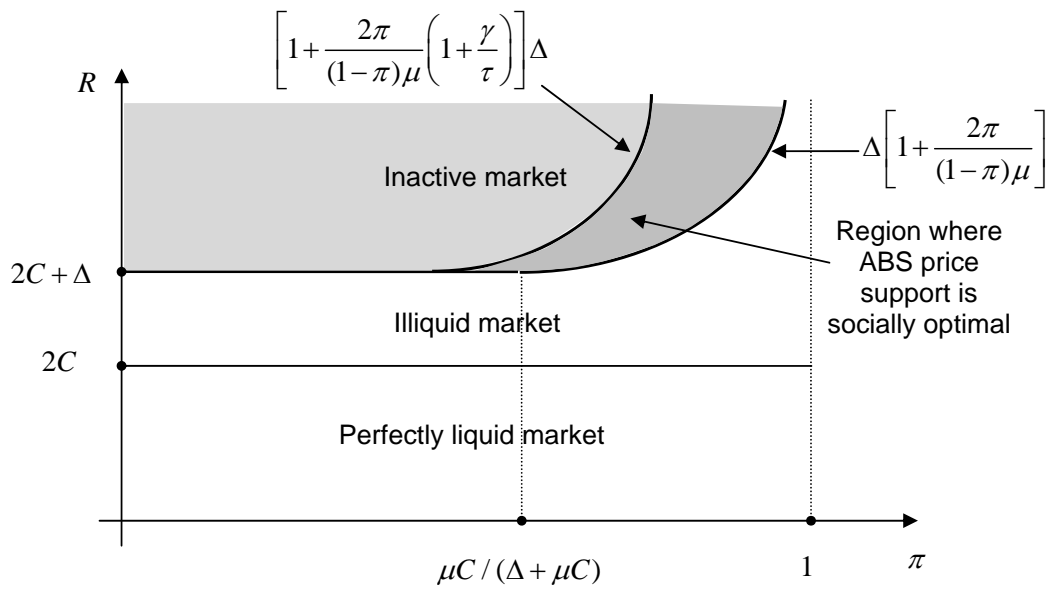
**Figure 2.** Secondary market equilibria with opacity.



**Figure 3.** Characterizing secondary market equilibrium regions with opacity.



**Figure 4.** Socially optimal choice of transparency.



**Figure 5.** Social optimality of ABS price support.



## Notes

<sup>1</sup>Ratings were coarse also in the sense that they were based on a very limited number of loan-level variables, to the point of neglecting indicators with considerable predictive power (Ashcraft, Goldsmith-Pinkham and Vickery, 2010). Indeed, it was only in 2007 that Moody's requested from issuers loan-level data that itself considered to be "primary", such as a borrower's debt-to-income (DTI) level, the appraisal type, and the identity of the lender that originated the loan (Moody's, 2007). In addition, rating agencies failed to re-estimate their models over time to take into account the worsening of the loan pool induced by securitizations themselves (Rajan, Seru and Vig, 2008).

<sup>2</sup>This insight is consistent with the results by Fahri, Lerner and Tirole (2008), who present a model where sellers of a product of uncertain quality buy certification services from information certifiers. In their setting, sellers always prefer certification to be transparent rather than opaque.

<sup>3</sup>The point that disclosing information about ABS may hinder their liquidity is also made intuitively by Holmstrom (2008).

<sup>4</sup>In keeping with this argument, Kim and Verrecchia (1994) show that earnings announcements lead to lower market liquidity if they allow sophisticated traders to increase their informational advantage over other traders. The same argument is used by Goel and Thakor (2003) to rationalize earning smoothing: to maintain a liquid market for their stocks, companies will smooth earnings so as to reduce the informational rents of sophisticated investors. A similar argument is used by Fishman and Hagerty (2003) to discuss the welfare implications of voluntary and mandatory disclosure.

<sup>5</sup>An often-quoted example of the same practice is the sale of wholesale diamonds by de Beers: diamonds are sold in pre-arranged packets ("sights") at non-negotiable prices. This selling method may eliminate the adverse selection costs that would arise if diamond buyers were allowed to negotiate a price contingent on the packets' content. Another (possibly complementary) rationale for "block booking" sales is that it avoids the duplication of information processing costs by investors, as argued by French and McCormick (1984).

<sup>6</sup>This is witnessed by a survey conducted by the Committee on the Global Financial System in 2005: "Interviews with large institutional investors in structured finance instruments suggest that they do not rely on ratings as the sole source of information for their investment decisions ... Indeed, the relatively coarse filter a summary rating provides is seen, by some, as an opportunity to trade finer distinctions of risk within a given rating band. Nevertheless, rating agency 'approval' still appears to determine the marketability of a given structure to a wider market" (p. 3).

<sup>7</sup>The point that opaqueness may encourage information collection by investors has already surfaced in the literature. For instance, Goldman (2005) shows that investors may have greater incentives to acquire information about a conglomerate firm than about single-division firms. Gorton and Pennacchi (1990), Boot and Thakor (1993), and Fulghieri and Lukin (2001) show that security design affects investors' incentives to acquire information by changing the information sensitivity of the security issued. We do not study security design in this paper.

<sup>8</sup>Gorton and Pennacchi (1990) make a similar point on the effect of deposit insurance on the liquidity of bank debt and deposits.

<sup>9</sup>Another difference is that our unsophisticated investors rationally take into account their unsophistication in their investment decisions, while rating shopping models assume some naïve investors who are gullied by inflated ratings.

<sup>10</sup>The assumption that the two bad states occur with equal probability is completely inessential to our results, and is made only for notational simplicity.

<sup>11</sup>We assume the two loans to have negatively correlated payoffs across default states in order to emphasize the portfolio's correlation as the source of uncertainty, holding its expected payoff constant. The results are qualitatively unaffected if one loan has greater exposure to default states than the other, i.e. it repays  $x$  in state  $B_1$  and 0 in state  $B_2$ , while the other repays  $x$  in both states  $B_1$  and  $B_2$ . In this case, the safer loan would also pay a larger expected payoff.

<sup>12</sup>The high cost is because the payoff of each claim has an idiosyncratic random component that is known to the issuer and can be certified by the rating agency at a cost but unknown to investors. So overcoming adverse selection problems would require each individual claim to be rated by the agency – as noted, a prohibitive expense. Pooling the claims diversifies away this idiosyncratic risk, removing the need for the rating agency to perform the detailed assessment.

<sup>13</sup>The assumption that the issuer is less informed about its asset than some specialized investors is commonplace in the literature on IPOs (e.g. Benveniste and Spindt, 1989), and is also made by Dow, Goldstein, and Guembel (2007) and Hennessy (2008), who show that companies may gain information about their investment opportunities from market prices. The assumption that rating agencies are also unable to extract information about  $\lambda$  from available data is in line with the fact that before the crisis they did not adjust their ratings to reflect changes in the sensitivity of ABS to aggregate risk, and that much evidence has underscored the limitations of their credit scoring models (Ashcraft et al., 2009, Benmelech and Dlugosz, 2009, and Johnson et al., 2009).

<sup>14</sup>The relevant constraint arises when  $\lambda = \lambda_L$ . In fact, if  $A_S \in (PDV(\lambda_H), PDV(\lambda_L)]$ , sophisticated investors can buy the entire issue if  $\lambda = \lambda_H$  at its PDV. If instead  $\lambda = \lambda_L$ , sophisticated investors are not wealthy enough, so unsophisticated investors are needed. However, the latter cannot distinguish between the two scenarios and can only participate in both cases or in neither. Hence, if  $A_S$  is in this range, placing the issue in all contingencies requires that prices are set so as to draw uninformed investors into the market.

<sup>15</sup>We assume that agency problems in delegated portfolio management prevent unsophisticated investors from entrusting enough wealth to sophisticated ones as to overcome this limited wealth constraint.

<sup>16</sup>In principle, the issuer may rely on another type of auction so as to elicit pricing information from sophisticated investors, such as a book-building method. However, even in this case sophisticated investors would earn some informational rents at the issue stage in the transparent regime, whereas they would not in the opaque one.

<sup>17</sup>If we were to reverse the order of moves, letting sophisticated investors play before liquidity traders, there will be no symmetric pure-strategy equilibrium. To see this, suppose that sophisticated investors do not acquire information: liquidity traders will then expect the ABS market to be perfectly liquid and will want to participate to the market; but this will induce sophisticated investors to acquire information. If instead sophisticated acquire information, the market will be illiquid, deterring liquidity traders' participation, and thus eliminating the informed investors' incentive to acquire information.

<sup>18</sup>This assumption implies that, even in the absence of liquidity traders, market makers anticipate that some informed investors may place orders with them, and therefore pins down their beliefs and thus the prices that they will quote in this contingency. As we shall see below, these beliefs ensure the existence of the equilibria in our game.

<sup>19</sup>Note that, even if market makers could become informed, they would have no incentive to do so: market making activity requires them to post publicly observable quotes at all times. Hence, even if they collected information about  $\lambda$ , their quotes would reveal this information to other market participants, and therefore they could not profit from it.

<sup>20</sup>With the same probability, sophisticated investors learn that  $\lambda = \lambda_H$ . But this piece of information cannot be exploited by buying the ABS, since by assumption there are no liquidity buyers.

<sup>21</sup>If liquidity traders were to play the other equilibrium, the results that follow would be qualitatively similar, except that the region of the parameter space with inactive ABS market would be larger.

<sup>22</sup>The crisis also triggered an increase in leverage (via a drop in fundamentals), which may also have

contributed to rendering both debt and equity more informationally sensitive and therefore less liquid, as shown by Chang and Yu (2010).