Liquid Bundles*

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April 16, 2014

Abstract

Parties in financial markets, industries, compensation design or politics may negotiate on either a piecemeal or a bundled basis. Little is known about the desirability of bundling when values are common and/or information endogenous. The paper shows that bundling encourages information-equalizing investments, thereby facilitating trade. It accordingly revisits and qualifies existing knowledge on security design.

Keywords: Liquidity, security design, tranching, information acquisition.
JEL numbers: D82, E51, G12, G14.

1 Introduction

This paper studies "liquidity" (here defined as the volume of rational trade) in environments in which buyers and sellers may exchange goods either piecemeal or bundled. The private and social desirability of bundling, or conversely tranching, hinges on whether it facilitates or hinders trade, and has two facets: a) does bundling facilitate trade for given information structures; and b) does bundling incentivize information structures that are conducive to trade? While we shed light on a), our main contribution concerns b): we

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show that bundling encourages information-equalizing investments, thereby facilitating trade, hence the title of the paper.

Section 2 develops the following canonical model. A good or asset has value $s\delta + S$ to the seller and $b\delta + B$ to the buyer, where $\delta = 1$ (high-quality) or 0 (lemon) and $S \leq B$ and $s \leq b$ (gains from trade). The seller and the buyer can privately learn δ at a cost (that may differ between the two parties). They then bargain. Equilibrium liquidity depends on information acquisition costs and on the parties' bargaining powers. An asymmetry of information about the quality of the good/asset creates a suboptimal volume of trade. Bundling implies that the bundle is sold wholesale, while tranching/piecemeal negotiations consist in negotiating separately over the safe (δ-insensitive) and the risky (δ-sensitive) parts.

"Common value" environments with bundling/tranching decisions abound:

- *Structured finance*: our lead example concerns the choice of whether to pool or tranche securities, say in safe debt and risky equity components.
- *Industrial organization*: common values arise when a higher quality is associated with a higher cost for the manufacturer or when parties enjoy resale options. Risk shifting through warranties, return options or additional coverage in insurance contracts may be tied to, or obtained separately from the acquisition of the basic product.
- *Compensation design*: An employer and an employee may negotiate over a fixed wage and a performance-based bonus, or directly over both. Common values arise from the employer' ability to know more about the profitability of the task and the employee's knowledge of his talent or capability in the task.
- *Politics*: Legislators have found that combining separate measures into one large bill, called an omnibus bill, often enhances the odds for passage but can also lead to a complete breakdown of legislative action.
- *International negotiations*: Opinions diverge as to whether climate change negotiations should be conducted at the sectoral level or globally. Piecemeal negotiations (the equivalent of tranching) affect incentives for information acquisition as well as incentives for lobbies to build up resistance to an agreement.
- *Banking regulation*: Separation between investment and retail banking (Glass-Steagall Act, Volker and Vickers rules)[1] is akin to the tranching of a universal bank into a

[1] We are grateful to Elu van Thadden for this suggestion.

relatively low-information-intensity entity (the retail bank) and a high-information-intensity entity (the investment bank). Buyers of claims on the bank (retail depositors – i.e. the banking regulator/taxpayers –, wholesale depositors, etc.) face different incentives to collect information in the two arrangements, an issue that has been overlooked in the policy discussions on the matter.

- *Project financing*: Public authorities may negotiate the construction and management & maintenance contracts separately (and usually sequentially); or the two may be bundled as in public-private partnerships.

Section 3 takes the information structure as given (like much of the literature), and unveils two conflicting effects of tranching. On the one hand, tranching protects the safe component from the risk of illiquidity. This insulation effect has attracted much attention in the finance literature (since Gorton and Pennacchi (1990)). On the other hand, the absence of bundled safe component in the risky component reduces the cost of not trading the risky part and thereby makes the trading of the risky part less likely: the bundling of the safe part is a trading adjuvant for the transfer of the risky part. The overall impact of these insulation and trading adjuvant effects depends on the liquidity of the bundle: if the bundle is liquid, then tranching can only hinder the transfer of value between parties. By contrast, if the bundle is illiquid, tranching increases liquidity by ensuring that the debt component is transferred.

Endogenizing the information structure, Section 4 argues that spinning off the safe component increases the incentive to acquire information when information is to be deterred (because one party finds it too expensive to acquire information) and reduces this incentive when information acquisition is to be encouraged (so to re-establish the symmetry of information). It thereby identifies an important cost of tranching.

The thrust of the argument goes as follows: Consider a situation in which both parties remain ignorant and so gains from trade are fully realized. One party's temptation to become informed is associated with the option not to trade. The seller would like to identify a gem so as to keep it and sell only if the good/asset has mediocre quality; likewise, the buyer aspires at identifying a lemon so as to refrain from acquiring it. Deterring information acquisition thus requires making the absence of trade costly. Spinning off the safe component reduces the cost of not trading the risky (information intensive) part; it thereby encourages information acquisition and may reduce the overall liquidity.[2]

[2]This mechanism is reminiscent of Whinston (1990)'s argument that bundling a monopoly good with a competitive one makes it more costly for a seller not to sell the competitive one and so increases his volume of sales in the competitive market. Whinston's application and focus - entry deterrence – are rather

By contrast, when one party is informed, the incentive of the other party to become informed is associated with an increase in the probability of trading as symmetric information delivers efficient trade. And bundling increases the cost of not trading. The literature has mostly considered situations in which at most one party to the potential trade is informed. When both sides can acquire information, ignorance may no longer be desirable. Indeed, liquidity stems not from the lack of information, but more generally from the commonality of information. And so if one party is likely to be informed, it is desirable to encourage information acquisition by the other party so as to reestablish the symmetry of information and thereby restore liquidity.

To highlight the adverse social impact of tranching on information acquisition, we then restrict attention to parameter values such that the insulation effect dominates the trading adjuvant effect, and so tranching is a superior alternative when parties are exogenously asymmetrically informed (tranching is obviously liquidity-neutral under symmetric information). Even in this most favorable case for tranching, tranching may become undesirable once information acquisition is endogenized.

To drive home the point that tranching works again the commonality of information, we also use a simple convexity argument to show that if commonality of information prevails when a security is tranched into n arbitrary securities, then it prevails a fortiori when the security is not tranched.

Section 5 concludes with some alleys for future research.

Related literature. Most of the existing literature is couched in the context of structured finance. Financial institutions and corporations need to store value to meet cash shortages and take advantage of acquisition and investment opportunities. The attractiveness of an asset as a store of value hinges on its liquidity – its owner's ability to rapidly part with the asset at a fair price. Liquidity in turn requires buyers not to cherry pick high-quality assets and sellers not to trade only their lemons. As the recent crisis and other episodes suggest, suspicions about asset quality may have serious consequences for the functioning of the economy.

Starting with Akerlof (1970), economists have investigated the impact of information held by either sellers or buyers on the volume of trade and efficiency. It has been established that informed sellers have an incentive to engage in limited securitization/resale in order to signal asset quality (Leland and Pyle (1977), Myers and Majluf (1984)) and

unrelated with the current paper, though.

Subrahmanyam (1991) and Gorton and Pennacchi (1993) point out that pooling different assets, each with its own underlying information, reduces asymmetries of information (by the law of large numbers) and therefore boosts liquidity. Their insight is unrelated to the one just developed, as we consider a single asset, which can be tranched or sold as is.

that security design prior to seller information acquisition may reduce signaling costs (DeMarzo and Duffie (1999), DeMarzo (2005), Plantin (2009)). Sellers' ability to part with their assets at fair prices is also hindered when buyers have private information, the focus of much market micro-structure economics; in this spirit, Gorton and Pennacchi (1990) recommend the use of tranching to create low-information-intensity (debt-like) securities that protect sellers from the "seller's curse", namely the risk of selling only high-quality assets when trading with an informed buyer.[3] Thus, low-information intensity (LII)/debt-like securities mitigate adverse selection (held by an informed seller in DeMarzo and Duffie (1999) and an informed buyer in Gorton and Pennacchi (1990).[4]

An important recent strand of this literature, initiated by Dang et al (2011), notes that information structures are endogenous and so argues that securities, to be liquid, should be designed with an eye on their impact on information acquisition.[5] Dang et al. show that debt contracts optimally deter buyer information acquisition and may thereby maximize seller welfare. Two central and recurring insights of the literature are:

- *Tranching is optimal*. The creation of debt-like securities alleviates buyer concerns about the seller's ability to foist a lemon, and seller concerns about the seller's curse. It further minimizes incentives for information acquisition. Tranching thus boosts liquidity, the value of assets and welfare.

- *Ignorance is bliss*. The acquisition of information by the potentially informed party is to be deterred or at least limited.

Our paper revisits and qualifies these conclusions in several ways that will be discussed in more detail in section 4.3. Besides the fact that we allow two-sided information

[3]See also Hennessy (2012), who further endogenizes the speculator's information acquisition.

In Lester et al (2012) agents are either fully knowledgeable about the asset that can be used to trade goods; or they cannot even recognize a counterfeit (and their counterparty knows that). Then trade can only occur between cognoscenti. "Money" then refers to assets which many agents in the economy are familiar with. In a closely related contribution, Banerjee and Maskin (1996) assume agents can trade only what they recognize. Goods come in two qualities, high and low. Gresham's law is derived from the lemons' model: only low-quality goods are candidates to be used as media of exchange and only low-quality goods are properly priced. In general, only one good (roughly that subject to the least adverse selection) emerges as a means of exchange.

[4]Biais and Mariotti (2005) shows that debt protects not only against adverse selection, but also against monopsony power. In their paper, the issuer receives a signal for the underlying asset's final payoff realization after the security design stage, but before trading takes place. The buyer offers a schedule specifying a transfer $T(q)$ for arbitrary fractions q in $[0,1]$ of the security. For example, when the signal is the future payoff realization, a debt claim has the same value for all realizations beyond the nominal debt claim; this creates an elastic demand curve and limits the buyer's market power.

[5]See Yang (2011) for a neat extension of the Dang et al framework, and Crémer and Khalil (1992) for an early paper on optimal mechanism design with endogenous information acquisition by the agent.

acquisition, thereby generalizing the second insight to "Commonality of information is bliss", we also assume that the seller cannot commit not to sell the risky component after having sold the safe one, thereby limiting the seller's ability to reduce incentives for information acquisition by limiting the volume of issuance. We are agnostic as to which of the two polar cases, that of the security design literature and our no-commitment assumption, is more realistic. For example, under limited seller liquidity needs, for which selling the safe component suffices, the commitment assumption is rather reasonable; by contrast for higher liquidity needs, it will be hard for the seller to commit not to bring the risky part to the market as well.

Our paper is also related to the literature on bargaining under endogenously asymmetric information. Like Dang et al (2011) and Yang (2011), this literature is preoccupied mainly with information acquisition deterrence, albeit in simpler games of bargaining with take-it-or-leave-it offers for the bundle (there is no security design). Shavell (1994) studies the voluntary and mandatory disclosure of hard, private-value information in a trading relationship between a seller and a buyer; he shows for instance that the seller has excessive incentives to acquire information about the buyer's valuation whether this information is socially useful or not, and that disclosure should be mandated. Dang (2008), in a common-value environment, points out that no trade and no information acquisition may simultaneously arise in equilibrium, and also shows that, in contrast with conventional wisdom, a party receiving the offer may obtain up to the full social surplus of the transaction when the offer is tailored to discourage him from acquiring information. Besides some modeling differences (in particular, we assume that parties decide whether to acquire their information before bargaining, so offers cannot by themselves deter information acquisition), these papers again have a different focus and do not address the two main themes of our paper, tranching and repeated trading.

Finally, there is a large, industrial organization literature on the impact of bundling in a context of asymmetric, exogenous information (the buyer knows his preferences) and the seller has full bargaining power: see e.g. Armstrong and Vickers (2010) and Armstrong (2013) for recent contributions and the references therein. In contrast with our paper, that literature assumes private values as well as exogenous, one-sided information; in a nutshell, the buyer knows his preferences and the seller price discriminates. This simpler framework allows the literature to consider much more general demand functions than that studied here.

2 Model

Consider a meeting between a seller and a buyer. The seller is endowed with an asset (we will use the terminology of our lead example). He can sell this asset to the buyer. The surplus from owning the asset for the seller and the buyer are given by respectively $s\delta + S$ and $b\delta + B$, where $\delta = 1$ with probability ρ and $\delta = 0$ with probability $1 - \rho$. Both the buyer and the seller are risk neutral. We make the following assumption, which ensures that there are gains from trade.

Assumption 1. ***(Gains from Trade).*** *$b \geq s$ and $B \geq S$.*

We assume that δ is initially unknown to both the buyer and the seller. The seller and the buyer can learn δ at a cost c^S and c^B respectively. One party cannot observe whether the other party is informed or not.

Bargaining takes place as follows. With probability α^S, the seller makes a take-it-or-leave-it offer, and with the complementary probability $\alpha^B = 1 - \alpha^S$, the buyer makes a take-it-or-leave-it-offer. Hence we can take α^S (α^B) to represent the bargaining power of the seller (buyer).

The timing is described in Figure 1. First, parties decide whether or not to become informed. Then nature determines who gets to make a take-it-or-leave-it offer. Finally the offer is made and is either accepted or rejected, and payoffs are realized.

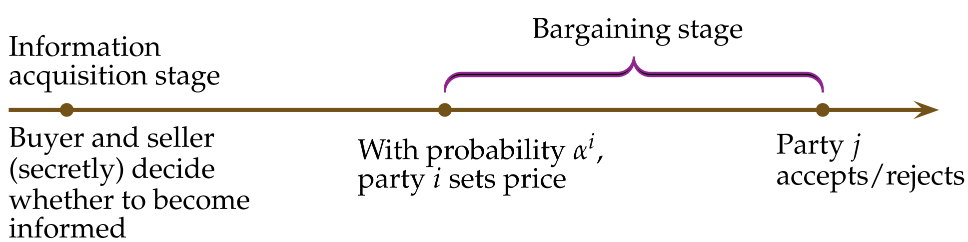

Figure 1: Timing

Equilibrium concept. Our equilibrium concept is that of Perfect Bayesian Equilibrium (PBE). We will often be confronted with a situation of bargaining under asymmetric information—both on the equilibrium path, and also off the equilibrium path when we consider the incentives of parties to acquire information. When an uninformed party makes an offer to an informed party, the uninformed party just sets its monopoly price, and the informed party either accepts or rejects the offer. Things are more complex when an informed party makes an offer to an uninformed party. The reason is that the offer potentially conveys information and acts as a signaling mechanism. This typically leads to multiple PBEs. We will always select the trade maximizing equilibrium. Imagine for example that the informed party is the seller, and the uninformed party the buyer. Then in the trade maximizing equilibrium, the seller sets a price and sells the asset only if δ is below a cutoff (0 or 1). The price is such that the buyer is indifferent between buying and not buying the asset, knowing that the asset is offered to him only if δ is below the cutoff. We can always construct beliefs such that this outcome is a PBE. It is the PBE that maximizes both the probability of trade and the welfare of the party making the offer.

In the paper, we will use the following wording convention. With a slight abuse, we will say that no offer is made when an offer is made but this offer is rejected with probability 1. This convention obviously has no material impact on our analysis.

Alternative assumptions on the liquidity of the bundle.

To conform to the literature, we will first assume that the bundle is illiquid when the two parties are asymmetrically informed. This assumption in turn decomposes into two conditions (conditions (1) and (2) below), depending on who has the bargaining power.

Assumption 2. ***(Illiquid Bundle)***

Inefficient Trade when Only S is Informed.

$$s + S > b\rho + B. \tag{1}$$

Inefficient Trade when Only B is Informed.

$$s\rho + S > B. \tag{2}$$

The left-hand side of (1) represents an informed seller's reservation value when $\delta = 1$. The right-hand side represents the most that an uninformed buyer is willing to pay. Similarly, the left-hand side of (2) represents the reservation value of an uninformed seller. The right-hand side represents an informed buyer's willingness to pay when $\delta = 0$.

To understand the role of these assumptions, it is necessary to anticipate the nature of the several types of equilibria that can arise in our model. There are equilibria with asymmetric information where only one party is informed. When only the seller is informed, we refer to the equilibrium as an (Only S) equilibrium. Similarly, when only the buyer is informed, we call the equilibrium (Only B). There are also equilibria with symmetric information. When both parties are informed, we call the equilibrium (I). When no party is informed, we call the equilibrium (NI).

Together with Assumption 1, Assumption 2 is sufficient for the equilibria with asymmetric information (Only S) and (Only B) to feature less than full trade—this is to be compared with equilibria with no or full information, where trade always occurs.[6]

We will contrast the results in the illiquid-bundle case with those obtained when the bundle is liquid. So let us state the "opposite" assumption:

Assumption 2′. ***(Liquid Bundle)***
Efficient Trade when Only S is Informed:

$$b\rho + B - (s + S) > (1 - \rho)(B - S). \tag{3}$$

Efficient Trade when Only B is Informed:

$$B > \rho(b + B) + (1 - \rho)S. \tag{4}$$

Note that conditions (3) and (4) are not the exact counterparts of conditions (1) and (2), respectively; they are mutually inconsistent, but do not cover the entire parameter space together. The reason for this is that, for expositional convenience, we want illiquidity or liquidity to be unambiguous, i.e. to hold regardless of whether the seller or the buyer has the bargaining power. For instance, a necessary and sufficient condition for (Only S) to feature less than full trade if the seller makes the offer is condition (1); a necessary and sufficient condition for (Only S) to feature full trade if the buyer makes the offer is condition (3). As confirmed by the comparisons between (1) and (3) and (2) and (4), respectively, it is in general easier to obtain full trade when the informed party makes the offer (s/he can then estimate precisely what the uninformed party is willing to accept) than when the uninformed party makes the offer. Hence, to avoid any ambiguity as to the (il)liquidity of the bundle, we restrict attention to the two parameter regions defined by {(1), (2)} and {(3), (4)}, respectively.

2.1 Equilibrium information structures when the bundle is illiquid

We derive conditions on the costs of acquiring information (c^S, c^B) for potential pure-strategy equilibria to exist assuming that the bundle is illiquid (Condition (1)); the analysis under Assumption 2′ is similar, and we will later derive only the relevant properties (see Proposition 8 below).

[6]They are also necessary and sufficient so that in (NI), a party who secretly becomes informed will trade less. They imply that in (I), a party who secretly becomes uninformed sets a monopoly price that features less than full trade. Similarly, they imply that in an equilibrium where only one party is informed (Only S or Only B), if the uninformed party makes the offer, it sets a monopoly price that features less than full trade. Finally, the conditions are also necessary and sufficient so that in an equilibrium where only one party is informed (Only S or Only B), if the informed party decides to secretly become uninformed, then there is no trade.

For each candidate equilibrium, we describe the equilibrium strategies, The reader can look at one equilibrium (e.g., (NI)) derivation and move directly to Figure 2, which summarizes the four possibilities.

2.1.1 Non-Informed equilibrium (NI)

Equilibrium. We first characterize equilibria where neither the seller nor the buyer are informed. If the seller makes the offer, he sets a price equal to $b\rho + B$. If the buyer makes the offer, he sets a price equal to $s\rho + S$. Trade always occurs. The party making the offer appropriates all the trade surplus $(b\rho + B) - (s\rho + S)$. The payoffs to the seller and the buyer are

$$\begin{aligned} v^S &= \alpha^S [b\rho + B] + \alpha^B [s\rho + S], \\ v^B &= \alpha^S [0] + \alpha^B [(b\rho + B) - (s\rho + S)]. \end{aligned}$$

Incentives to acquire information. Let us now turn to the incentives to acquire information. Suppose that the seller becomes informed. If the seller makes the offer, then he does not sell the asset if $\delta = 1$, and sells the asset at price $b\rho + B$ if $\delta = 0$. The fact that the seller prefers not to sell at price $b\rho + B$ if $\delta = 1$ is a direct consequence of Condition (1). To check that this outcome maximizes trade given the information structure, suppose that the seller makes an offer different from $b\rho + B$, generating off-the-equilibrium path beliefs $\hat{\rho} > \rho$ (if $\hat{\rho} \leq \rho$, the seller doesn't benefit from offering an unexpected price). The seller trades the high-quality asset only if $b\hat{\rho} + B \geq s + S$, but then the value to the buyer is only $b\rho + B$, leading to a rejection. Suppose now that the buyer makes the offer. The seller accepts the offer and sells the asset if $\delta = 0$ and keeps the asset if $\delta = 1$. As a result, the condition that the seller does not acquire information is

$$c^S \geq \alpha^B \rho [(s + S) - (s\rho + S)] + \alpha^S \rho [(s + S) - (b\rho + B)].$$

Similarly, using Condition (2) the condition that the buyer does not acquire information is

$$c^B \geq \alpha^B (1 - \rho) [s\rho + S - B] + \alpha^S (1 - \rho) [b\rho + B - B].$$

Define

$$\begin{aligned} \underline{c}^S &\equiv \alpha^B \rho (1 - \rho) s + \alpha^S \rho [(s + S) - (b\rho + B)], \\ \underline{c}^B &\equiv \alpha^B (1 - \rho) [s\rho + S - B] + \alpha^S \rho (1 - \rho) b. \end{aligned}$$

We then have the following proposition.

Proposition 1. ***(NI).*** *When the bundle is illiquid (Assumption 2), the Non-Informed (NI) equilibrium exists if and only if $c^S \geq \underline{c}^S$ and $c^B \geq \underline{c}^B$.*

The incentives to become informed in the (NI) equilibrium derive solely from the possibility of refusing disadvantageous trades, whether or not the party who becomes informed makes the offer. Importantly, the incentives to become informed do not arise from an ability to charge different prices when trade does occur. For example, if the seller becomes informed, he chooses not to sell when $\delta = 1$ whether or not he makes the offer.

2.1.2 Informed equilibrium (I)

Equilibrium. Here we characterize the equilibrium where both the seller and the buyer are informed. If the seller makes the offer, he sets a price equal to $b\delta + B$. If the buyer makes the offer, he sets a price equal to $s\delta + S$. Trade always occurs. The payoffs to the seller and the buyer are the same as in (NI) minus the information acquisition costs:

$$\begin{aligned} v^S &= \alpha^S \left[b\rho + B \right] + \alpha^B \left[s\rho + S \right] - c^S, \\ v^B &= \alpha^S \left[0 \right] + \alpha^B \left[(b\rho + B) - (s\rho + S) \right] - c^B. \end{aligned}$$

Incentives to acquire information. Let us now turn to the incentives to acquire information. Suppose that the seller decides not to become informed. Suppose first that the seller makes the offer. Provided that $\rho\,(b + B) + (1 - \rho)\,S \geq B$, which is implied by Condition (2), the seller sets a price equal to $b + B$ (rather than B), so that the buyer buys the asset if $\delta = 1$ and not if $\delta = 0$. Suppose now that the buyer makes the offer. Then the buyer's offer reveals δ, and the seller always accepts the buyer's offer. Hence the condition that the seller becomes informed can be written as

$$c^S \leq \alpha^S \left[(b\rho + B) - \rho\,(b + B) - (1 - \rho)\,S \right].$$

Similarly, provided that $(1 - \rho)\,[B - S] \geq b\rho + B - (s + S)$, which is implied by Condition (1), the condition that the buyer becomes informed can be written as

$$c^B \leq \alpha^B \rho \left[(b + B) - (s + S) \right].$$

Define

$$\begin{aligned} \bar{c}^S &\equiv \alpha^S (1-\rho) [B-S], \\ \bar{c}^B &\equiv \alpha^B \rho [(b+B)-(s+S)]. \end{aligned}$$

We then have the following proposition.

Proposition 2. ***(I).*** *When the bundle is illiquid (Assumption 2), the Informed (I) equilibrium exists if and only if $c^S \leq \bar{c}^S$ and $c^B \leq \bar{c}^B$.*

The incentives to become informed for a party in the (I) equilibrium come from the possibility to perfectly price discriminate the other party when making the offer. If instead the party under consideration does not become informed, he has to revert in this case to imperfect price discrimination. He thus extracts less surplus and trades less if it does not become informed.

2.1.3 Only S Informed equilibrium (Only S)

Equilibrium. Here we characterize the equilibrium where the seller is informed but the buyer is not. If the seller makes the offer, then he sets a price equal to B and sells the asset only if $\delta = 0$. The buyer accepts the seller's offer if it is made. The other candidate price, $b\rho + B$, can be ruled out using Condition (1) which guarantees that if $\delta = 1$, the seller does not want to sell at this price. If the buyer makes the offer, then he sets a price equal to S, and the seller accepts the offer only if $\delta = 0$. Provided that *Assumption* $(b\rho + B) - (s+S) \leq (1-\rho)[B-S]$, which is implied by Condition (1), the other candidate price, $s+S$, is an inferior strategy for the buyer. The payoffs to the seller and the buyer are

$$\begin{aligned} v^S &= \alpha^S [\rho (s+S) + (1-\rho) B] + \alpha^B [s\rho + S] - c^S, \\ v^B &= \alpha^S [0] + \alpha^B (1-\rho) [B-S]. \end{aligned}$$

Incentives to acquire information. Let us now turn to the incentives to acquire information. We analyze the incentives of the seller and of the buyer in turn. Suppose that the seller decides not to become informed. If the seller makes the offer, then the seller does not want to sell—a strategy preferred to that of selling under Condition (2). Suppose now that the buyer makes the offer. Then the seller does not sell. Hence the condition that the seller becomes informed can be written as

$$c^S \leq \alpha^S [\rho (s+S) + (1-\rho) B - (s\rho + S)].$$

We now analyze the incentives of the buyer. Suppose that the buyer decides to become informed. If the seller makes the offer, then the buyer still accepts the offer of the seller if it is made, i.e. if $\delta = 0$. Suppose now that the buyer makes the offer. Then he sets a price equal to $s\delta + S$, and the seller always accepts the offer. Hence the condition that the buyer does not become informed can be written as

$$c^B \geq \alpha^B \left[\rho \left[(b+B) - (s+S)\right] + (1-\rho)\left[B - S\right] - (1-\rho)\left[B - S\right]\right].$$

We then have the following proposition.

Proposition 3. ***(Only*** S***).*** *When the bundle is illiquid (Assumption 2), the (Only S) equilibrium exists if and only if* $c^S \leq \bar{c}^S$ *and* $c^B \geq \bar{c}^B$.

The incentives for the seller to become informed in the (Only S) equilibrium are that if the seller makes the offer, he can sell at a low price if $\delta = 0$ and extract all the surplus of the buyer. By contrast, if the seller does not become informed, he finds it best not to sell at all, extracting less surplus and trading less. The incentives for the buyer to become informed in the (Only S) equilibrium come from the possibility to perfectly price discriminate the seller when the buyer makes the offer. If instead the buyer does not become informed, he has to revert in this case to imperfect price discrimination by charging a monopoly price. The buyer thus extracts less surplus if it does not become informed, and also trades less.

2.1.4 Only B informed equilibrium (Only B)

Equilibrium. Here we characterize the equilibrium where the buyer is informed but the seller is not. If the seller makes the offer, then he sets a price equal to $b + B$, and the buyer accepts the offer only if $\delta = 1$. Provided that $B \leq \rho\,(b+B) + (1-\rho)\,S$, which is implied by Condition (2), the other candidate price, B, is an inferior strategy for the seller. If the buyer makes the offer, then he sets a price equal to $s + S$ and buys the asset only if $\delta = 1$. The seller accepts the offer of the buyer if it is made. The other candidate price, $s\rho + S$, can be ruled out using Condition (2), which guarantees that if $\delta = 0$, the buyer does not want to buy at this price. The payoffs to the seller and the buyer are

$$\begin{aligned} v^S &= \alpha^S \left[\rho\,(b+B) + (1-\rho)\,S\right] + \alpha^B \left[s\rho + S\right], \\ v^B &= \alpha^S \left[0\right] + \alpha^B \rho \left[(b+B) - (s+S)\right] - c^B. \end{aligned}$$

Incentives to acquire information. Let us now turn to the incentives to acquire information. The analysis is similar to that of the (Only S) case.

Proposition 4. ***(Only*** B***).*** *When the bundle is illiquid (Assumption 2), the (Only B) equilibrium exists if and only if* $c^S \geq \bar{c}^S$ *and* $c^B \leq \bar{c}^B$.

The incentives to become informed in the (Only B) equilibrium are the mirror image of the corresponding incentives in the (Only S) equilibrium. We do not discuss them in detail for brevity.

2.2 Equilibrium regions with endogenous information acquisition

It is useful to note that the incentives to acquire information are the same for both parties in (I), (Only S) and (Only B). That is, the increase in expected payoff from becoming informed for a party who is uninformed in equilibrium, or the loss in expected payoff from becoming uninformed for a party who is informed in equilibrium, are the same in equilibria (I), (Only S) and (Only B).[7]

We depict equilibrium regions in the $\left(c^S, c^B\right)$ space. The configuration of the equilibrium regions is different depending on whether $\underline{c}^B$ ($\underline{c}^S$) is lower or greater than $\bar{c}^B$ ($\bar{c}^S$), i.e. depending on wether the incentives to become informed in (NI) are lower than in (I), (Only S) and (Only B) or vice versa.

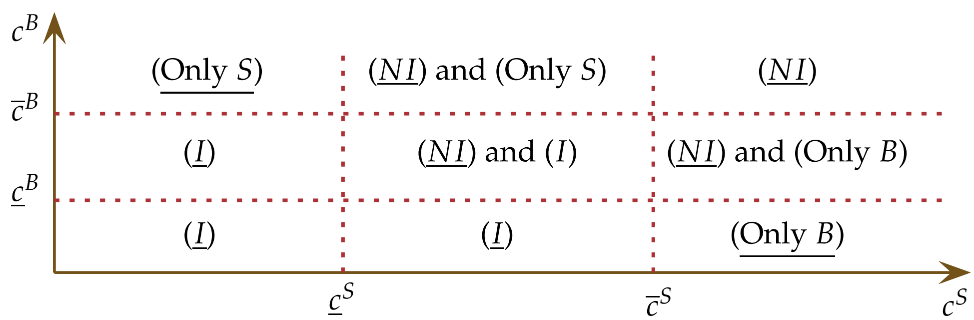

Figure 2: Equilibrium regions (the Pareto dominant equilibrium is underlined)

[7]Consider for example the incentives of the seller. In (I), (Only S), and (Only B), the gains from information arise only when the seller gets to make an offer. In (I), the seller always sells the good if he gets informed, but only if the good is high quality if he doesn't. The gain from getting informed $\alpha^S(1-\rho)[B-S]$ is therefore the probability of making an offer α^S times the probability $1-\rho$ that the quality of the good is low, times the difference in surplus $B-S$ when the good is low quality. In (Only S), the seller only sells the good when the quality is low if he gets informed, but doesn't sell the good if the quality is low. As a result, the gain from getting informed $\alpha^S(1-\rho)[B-S]$ is once again the probability of making an offer α^S times the probability $1-\rho$ that the quality of the good is low, times the difference in surplus $B-S$ when the good is low quality. Similarly, in (Only B), the seller only sells the good when the quality is high if he doesn't get informed, but always sells the good if he gets informed. As a result, the gain from getting informed $\alpha^S(1-\rho)[B-S]$ is once again the probability of making an offer α^S times the probability $1-\rho$ that the quality of the good is low, times the difference in surplus $B-S$ when the good is low quality.

It should be emphasized that the equilibrium configuration depends critically on the distribution of bargaining power $\left(\alpha^B, \alpha^S\right)$. The condition for $\underline{c}^B \leq \bar{c}^B$ holds for some distribution of bargaining power $\left(\alpha^B, \alpha^S\right)$ if and only if

$$(b\rho + B) - (s\rho + S) - \rho\,(1-\rho)\,s \geq 0, \tag{5}$$

i.e. if the gains from trade are large enough and the dispersion of δ is low enough. Similarly the condition for $\underline{c}^S \leq \bar{c}^S$ holds for some distribution of bargaining power $\left(\alpha^B, \alpha^S\right)$ if and only if

$$(b\rho + B) - (s\rho + S) - \rho\,(1-\rho)\,b \geq 0. \tag{6}$$

The two conditions $\underline{c}^B \leq \bar{c}^B$ and $\underline{c}^S \leq \bar{c}^S$ can simultaneously hold for some distribution of bargaining power $\left(\alpha^B, \alpha^S\right)$ if and only if

$$(b\rho + B) - (s\rho + S) \geq \rho\,(1-\rho)\,b$$

and

$$\frac{b\rho\,(1-\rho)}{(b\rho + B) - (s\rho + S) - \rho\,(1-\rho)\,s}\,\frac{\rho\,(1-\rho)\,s}{(b\rho + B) - (s\rho + S) - \rho\,(1-\rho)\,b} \leq 1. \tag{7}$$

In this case, the two conditions $\underline{c}^B \leq \bar{c}^B$ and $\underline{c}^S \leq \bar{c}^S$ hold simultaneously when the distribution of bargaining power (α^B, α^S) is in some non-empty convex set.

2.3 Ranking of equilibria

Note that when $\underline{c}^B \leq \bar{c}^B$ (respectively, $\underline{c}^S \leq \bar{c}^S$), there are complementarities between the beliefs that the buyer (respectively, the seller) is informed, and the incentives of the buyer (respectively, the seller) to become informed—as illustrated by the comparison of the incentives of the buyer (respectively, the seller) to acquire information in (NI) versus (Only *B*) (respectively (NI) versus (Only *S*)).[8] These complementarities lead to the existence of regions where multiple equilibria coexist: (NI) and either (I), (Only *S*) or (Only *B*).

The equilibria can be partially Pareto-ranked under the conditions leading to their coexistence. The equilibrium (NI) can potentially coexist with (I), (Only *S*) and (Only *B*). The equilibrium (I) can never coexist with (Only *S*) and (Only *B*), except in the knife-edge case where $c^B = \bar{c}^B$ and $c^S = \bar{c}^S$. The same is true of the equilibria (Only *S*) and (Only B).

[8] There are also complementarities between the seller's and the buyer's decisions to acquire information—as illustrated by the comparison of the incentives of the buyer (resp. seller) to acquire information in (NI) versus (Only *S*) (resp. (NI) versus (Only *B*))—although in this case, the buyer (resp. seller) actually makes the same decision not to acquire information in both equilibria, even though his incentives to acquire information are higher in the latter.

The following proposition formalizes these observations.

Proposition 5. ***(Pareto-Ranking of Equilibria)***. *When the bundle is illiquid (Assumption 2), the equilibrium payoffs are ranked as follows:*

$$v^S(NI) \geq \max\{v^S(I), v^S(Only\,S), v^S(Only\,B)\},$$
$$v^B(NI) \geq \max\{v^B(I), v^B(Only\,S), v^B(Only\,B)\}.$$

Therefore (NI) always Pareto dominates (I), (Only S), and (Only B) whenever they coexist.

The equilibrium with no information (NI) always dominates the equilibria with asymmetric information (Only S) and (Only B) since it is more liquid. It also dominates the equally liquid equilibrium with symmetric information (I) since it economizes on information acquisition costs.

Finally, while our emphasis is on Pareto comparisons, it is useful to discuss overall efficiency. Note first that $v^S + v^B = b\varrho + B$ in the (NI) equilibrium and $v^S + v^B = b\varrho + B - c^B - c^S$ in the (I) equilibrium. In either case, the potential gains from trade $((b-s)\varrho + B - S))$ are fully realized, but it is cheaper to realize them in the (NI) equilibrium. Similarly, in the case of the (Only S) equilibrium, $v^S + v^B = \varrho(s+S) + (1-\varrho)B - c^S$, which highlights that the full gains from trade are not achieved, and still there are some costs of information acquisition (the same consideration holds for the (Only B) equilibrium).

3 Tranching with exogenous information

Suppose that the payoff of the asset is $\Delta + \delta$ where Δ is known, $\delta = 0$ with probability $1-\rho$ and $\delta = 1$ with probability ρ. To apply the analysis of Section 2, we define B and S as $b\Delta$ and $s\Delta$, and so we can look at what happens when the asset is tranched into a pure debt tranche (right to cash flow Δ) and a pure equity tranche (right to cash flow δ). To sum up, the payoff for holding debt for the seller and the buyer are $S = s\Delta$ and $B = b\Delta$. The payoffs to holding equity are $s\delta$ and $b\delta$ with $\delta \in \{0,1\}$.

The timing is as follows. First, the asset is tranched. Then, parties decide whether to acquire information. Finally, bargaining takes place. Tranching thus has a direct effect on trading. It also modifies the incentives to acquire information. We examine these two effects in turn.

We first analyze the properties of tranching when information is exogenous. In our propositions we focus for simplicity on the case where c^B and c^S are either 0 or ∞.

Observe that in conformity with Modigliani-Miller, tranching is completely neutral if information is symmetric. For any (ρ, B, b, S, s), both the debt and the equity parts are traded with probability 1 and the game has the exact same equilibrium payoffs for all parties.

Proposition 6. ***(Neutrality of Tranching with Common Information).*** *Consider the (I) equilibrium ($c^B = 0$ and $c^S = 0$) or the (NI) equilibrium ($c^B = \infty$ and $c^S = \infty$). Under bundling, trade occurs with probability* 1*. Under tranching, trade of both the safe and the risky tranche occurs with probability* 1*. Bundling and tranching are Pareto-equivalent.*

When there is commonality of information, there is no illiquidity and both the insulation and the trading adjuvant effects have no bite.

By contrast, tranching is not neutral when information is asymmetric and trade only occurs with some probability. Indeed, when information is asymmetric, the effect of tranching on liquidity is ambiguous. Tranching isolates a safe debt part that is completely liquid (traded with probability one). Spinning off this safe tranche insulates it against the distrust generated by the risky tranche. This tends to increase overall liquidity.

But tranching also makes the residual equity part riskier and hence less liquid. The safe tranche no longer serves as an adjuvant in negotiations over the risk tranche. Another way to say it is that spinning off the safe tranche lowers the cost of not trading the risky tranche—the safe tranche no longer serves as a form of "mutual hostage". This effect is similar to the observation in Whinston (1990) that bundling leads to more competitive pricing. This tends to reduce overall liquidity.

Thus the liquidity benefit of tranching is an *insulation effect* while the liquidity benefit of bundling is a *trading adjuvant* effect. We illustrate these effects with two propositions, starting with the insulation effect.

Proposition 7. ***(Insulation Effect of Tranching when the Bundle is Illiquid).*** *When the bundle is illiquid (Assumption 2):*

i. In the (Only S) equilibrium ($c^B = \infty$ and $c^S = 0$), trade occurs only if $\delta = 0$ under bundling. Under tranching, the safe tranche is traded with probability 1 *but the equity tranche is traded only if $\delta = 0$. Tranching Pareto-dominates bundling.*

ii. Consider the (Only B) equilibrium ($c^B = 0$ and $c^S = \infty$). Under bundling, trade occurs only if $\delta = 1$. Under tranching, the safe tranche is traded with probability 1 *but the equity tranche is traded only if $\delta = 1$. Tranching Pareto-dominates bundling.*

Proof. Note that under tranching, the safe tranche is always traded. The rest of the proposition follows from the fact that the equivalent of Conditions (1) and (2) for the risky tranche, namely $s > b\rho$ and $s\rho > 0$ are implied by Conditions (1) and (2). $\square$

We continue with the trading adjuvant effect.

Proposition 8. ***(Trading Adjuvant Effect of Bundling when the Bundle is Liquid).*** *When the bundle is liquid (Assumption 2'):*

i. *In addition, assume that $s > b\rho$ (which is Condition (1) applied to the risky tranche, meaning that the risky tranche is illiquid under (Only S)). In the (Only S) equilibrium ($c^B = \infty$ and $c^S = 0$), trade occurs with probability 1 under bundling. Under tranching, the safe tranche is traded with probability 1 but the equity tranche is traded only if $\delta = 0$. The seller is better off under bundling than under tranching, and the buyer is worse off under bundling than under tranching.*

ii. *In the (Only B) equilibrium ($c^B = 0$ and $c^S = \infty$), trade occurs with probability 1 under bundling. Under tranching, the safe tranche is traded with probability 1 but the equity tranche is traded only if $\delta = 1$. The buyer is better off under bundling than under tranching, and the seller is worse off under bundling than under tranching.*

Proof. We treat the (Only S) equilibrium. The analysis for the (Only B) equilibrium is similar.

Consider first the case of bundling. The trade maximizing equilibrium can be described as follows. If the seller makes the offer, then he sets a price equal to $b\rho + B$ and sells the asset with probability 1. The seller is better off selling at that price even if $\delta = 1$ because $b\rho + B > s + S$. If the buyer makes the offer, then he sets a price equal to $s + S$ and buys the asset with probability 1. The other candidate price, S, leads to a lower payoff for the buyer since $(1 - \rho)(B - S) < (b\rho + B) - (s + S)$. The payoffs are

$$\begin{aligned} v^S &= \alpha^S [b\rho + B] + \alpha^B [s + S], \\ v^B &= \alpha^S [0] + \alpha^B [(b\rho + B) - (s + S)]. \end{aligned}$$

Consider now the case of tranching. Then the safe tranche is traded with probability 1, so we focus on the risky tranche. If the seller makes the offer, then he sets a price equal to 0 and sells the risky tranche only if $\delta = 0$ (in which case the risky tranche is worth 0 to both the buyer and the seller). The other candidate price, $b\rho$, can be ruled out since $s > b\rho$ which guarantees that if $\delta = 1$, the seller does not want to sell at this price. If the buyer makes the offer, then he sets a price equal to 0, and the seller accepts the offer only if $\delta = 0$ (in which case the risky tranche is worth 0 to both the buyer and the seller). Since $s > b\rho$, the other candidate price, s, is an inferior strategy for the buyer. The payoffs are

$$\begin{aligned} v^S &= \alpha^S [s\rho + B] + \alpha^B [s\rho + S], \\ v^B &= \alpha^S [0] + \alpha^B [B - S]. \end{aligned}$$

It is apparent that the seller is better off under bundling and that the buyer is better off under tranching. □

Under the hypotheses of Proposition 8, bundling always increases liquidity. As a result, there are more gains from trade. However, these additional gains from trade are entirely captured by the informed party. This emphasizes that bundling has both a trading adjuvant effect and also a *tilting of bargaining power effect* that always favors the informed party.

Actually, while bundling makes the informed party better off, it also makes the uninformed party worse off. Intuitively, when the uninformed party makes the offer, it prefers to propose a very attractive offer in order to trade the asset with probability 1 under bundling, whereas under tranching it can make a less attractive offer, trade the equity tranche only with some probability but trade the debt tranche with probability 1. In other words, under bundling, the informed party extracts some surplus even when the uninformed party makes the offer.

4 Tranching with endogenous information acquisition

When information acquisition is endogenous, tranching modifies the incentives to acquire information. This plays out differently in different cases. Indeed, starting at some bundling equilibrium, tranching can either increase or decrease the incentives to acquire information. Whether this *information effect* of tranching enhances or hinders liquidity depends on whether parties were both informed, asymmetrically informed, or both uninformed at the original bundling equilibrium.

4.1 Impact of tranching on information acquisition

For conciseness, we consider only the buyer's incentives to acquire information, and focus on the case where the seller is either uninformed ($c^S = \infty$) or informed ($c^S = 0$). To give tranching its best chance, we make Assumption 2 (illiquid bundle) and so the insulation effect dominates the trading adjuvant effect. Hence any eventual adverse effect of tranching must be due to the information effect.

Recall that

$$
\begin{aligned}
\bar{c}^B &= \alpha^B \rho \left[(b+B) - (s+S)\right], \\
\underline{c}^B &= \alpha^B (1-\rho) \left[s\rho + S - B\right] + \alpha^S \rho (1-\rho) b.
\end{aligned}
$$

As long as $\alpha^B > 0$, $\underline{c}^B$ is decreasing in $B - S$ and that $\bar{c}^B$ is increasing in $B - S$, implying that $\underline{c}^B$ increases with tranching, and that $\bar{c}^B$ decreases with tranching. We find it convenient to indicate the dependence of these information thresholds on tranching with a (T), for Tranching and on bundling with an (NT), for No Tranching. We have established the following proposition.

Lemma 1. ***(Information Effect of Tranching)***. *Assume that the bundle is illiquid (Assumption 2). As long as $\alpha^B > 0$:*

i. when $c^S = \infty$, tranching increases the incentives of the uninformed buyer to become informed in equilibrium (NI), $\underline{c}^B(T) > \underline{c}^B(NT)$;

ii. when $c^S = 0$, tranching reduces the incentives of the buyer to acquire information in equilibrium (I), $\bar{c}^B(T) < \bar{c}^B(NT)$.

Part (i) of the Lemma shows that at the equilibrium where both parties are uninformed (NI), tranching increases the incentives of the buyer to acquire information. This is because at the (NI) equilibrium, the benefit of becoming informed for the buyer hinges on refusing some trades. Under bundling, refusing trades for the risky tranche comes with the *collateral damage* of not trading the safe tranche. This collateral damage is absent under tranching—another implication of the trading adjuvant effect of bundling which disappears under tranching. Therefore, refusing trades is less costly under tranching than under bundling. This enhances the incentives of the buyer to become informed.[9]

[9] Indeed, when the seller makes an offer (probability α^S) and the buyer identifies the asset as a lemon $\delta = 0$ (probability $1-\rho$), the latter can simply turn down the trade. This increases his payoff compared to the case where he does not acquire information by $\alpha^S(1-\rho)[b\rho + B - B]$. Similarly, when the buyer makes an offer (probability α^B), and identifies the asset as a lemon $\delta = 0$ (probability $1-\rho$), the buyer can simply not make an offer. This increases his payoff compared to the case where he does not acquire information by $\alpha^B(1-\rho)[(s\rho + S) - B]$. In the first case, the gain of the buyer from becoming informed is independent of tranching. In the second case, under tranching, the buyer's gain from becoming informed is increased from $\alpha^B(1-\rho)[(s\rho + S) - B]$ to $\alpha^B(1-\rho)s\rho$: the buyer can still purchase the safe tranche and not make an offer on the risky tranche.

Let us discuss Part (ii). At the equilibrium where both parties are informed (I), tranching reduces the incentives of the buyer to acquire information. This is because at the (I) equilibrium, the benefit of becoming informed for the buyer hinges on the possibility of making some trades. Under bundling, making trades for the risky tranche comes with the *collateral benefit* of making trades for the safe tranche. This collateral benefit of bundling disappears under tranching. Tranching therefore reduces the incentives of the buyer to acquire information.[10]

Uninformed seller ($c^S = \infty$) We start by analyzing the case where the seller is uninformed but the buyer can decide to acquire information. This is the case considered by Dang et al (2011) and Yang (2011). Note also that the case analyzed by Gorton and Pennacchi (1990) is a particular case where in addition $c^B = 0$ so that the buyer is informed.

We now translate Lemma 1 into equilibrium predictions and show that, despite the fact that making Assumption 2 stacks the deck in favor of tranching, bundling may dominate tranching once information is endogeneized.

Proposition 9. ***(Tranching with Uninformed Seller)****. Assume that the bundle is illiquid (Assumption 2). Assume that $c^S = \infty$, $\alpha^B > 0$ and $\underline{c}^B(T) < \bar{c}^B(T)$ (and so from Proposition 1, we have $\underline{c}^B(NT) < \bar{c}^B(NT)$ as well). Then:*

i. for $c^B \in [\underline{c}^B(NT), \underline{c}^B(T))$, bundling Pareto-dominates tranching;

ii. for $c^B \in [0, \underline{c}^B(NT))$, tranching Pareto-dominates bundling.

Proof. Under both bundling and tranching, for $c^B < \underline{c}^B$ the only equilibrium is (Only B), for $\underline{c}^B \leq c^B \leq \bar{c}^B$, there are two possible equilibria (Only B) and (NI), and for $\bar{c}^B < c^B$, the only equilibrium is (NI). When $\underline{c}^B \leq c^B \leq \bar{c}^B$, we select the Pareto-dominant equilibrium (NI). Hence the equilibrium is (Only B) for $c^B < \underline{c}^B$ and (NI) for $\underline{c}^B \leq c^B$.

Lemma 1 shows that as long as $\alpha^B > 0$, we have $\underline{c}^B(T) > \underline{c}^B(NT)$, so that (NI) is more likely to be the equilibrium under bundling than under tranching. Indeed for $c^B \in [\underline{c}^B(NT), \underline{c}^B(T))$, the equilibrium is (NI) under bundling and (Only B) under tranching. Both parties are then better off under bundling than under tranching. This illustrates the

[10] Indeed when the buyer makes an offer (probability α^B), and the buyer identifies that $\delta = 1$ (probability ρ), he can offer $s + S$ and get the seller to sell him the asset yielding a benefit $(b + B) - (s + S)$. If the buyer is uninformed, he prefers not to generate that trade because he fears being sold a lemon $\delta = 0$. An uninformed buyer offers to pay S and the informed seller accepts if $\delta = 0$. Hence acquiring information increases the payoff of the buyer by $\alpha^B \rho \left[(b + B) - (s + S)\right]$. Under tranching, this gain is reduced to $\alpha^B \rho(b - s)$ because an uninformed buyer can still buy the safe tranche at price S when confronted with an informed seller who observes $\delta = 1$.

adverse information effect of tranching, which reduces overall liquidity by increasing the incentives of the buyer to acquire information.

By contrast, when $c^B \in [0, \underline{c}^B(NT))$, then the equilibrium is (Only B) under both tranching and bundling. Both parties are then better off under tranching. This is a manifestation of the benefits of the insulation effect: tranching allows to trade the safe tranche with probability 1. $\square$

Informed seller ($c^S = 0$) We now deal with the case where the seller is informed and the buyer can decide whether to acquire information. Myers-Majluf (1984) and DeMarzo-Duffie (1999) can be considered as special cases where in addition $c^B = \infty$ so that the buyer is uninformed.

Proposition 10. ***(Tranching with Informed Seller)****. Assume that the bundle is illiquid (Assumption 2), $c^S = 0$ and $\alpha^B > 0$. Then:*

i. for $c^B \in (\bar{c}^B(T), \bar{c}^B(NT)]$, the buyer is worse off and the seller is better off under bundling than under tranching;

ii. for $c^B \in (\bar{c}^B(T), \min\{\bar{c}^B(NT), \frac{1}{\alpha^B}\bar{c}^B(T)\}]$, bundling increases total welfare $v^S + v^B$ and for $c^B \in (\min\{\bar{c}^B(NT), \frac{1}{\alpha^B}\bar{c}^B(T)\}, \bar{c}^B(NT)]$, bundling decreases total welfare $v^S + v^B$.

iii. for $c^B \in (\bar{c}^B(NT), \infty)$, tranching Pareto-dominates bundling.

Proof. Under both bundling and tranching, for $c^B < \bar{c}^B$ the only equilibrium is (I), for $\bar{c}^B < c^B$, the only equilibrium is (Only S).

Lemma 1 shows that as long as $\alpha^B > 0$, we have $\bar{c}^B(T) < \bar{c}^B(NT)$, so that (I) is more likely to be the equilibrium under bundling than under tranching. Indeed for $c^B \in (\bar{c}^B(T), \bar{c}^B(NT)]$, the equilibrium is (I) under bundling and (Only S) under tranching. Using Lemma 2 in the Appendix, we know that under tranching, we have $v^B(I) \geq v^B$(Only S) if and only if $c^B \leq \bar{c}^B(T)$. Using the fact that $v^B(I)$ is the same under tranching and bundling, we conclude that the buyer is worse off under bundling. By contrast, the seller is obviously better off. Lemma 2 in the Appendix also shows that bundling increases total welfare $v^S + v^B$ for $c^B \in (\bar{c}^B(T), \min\{\bar{c}^B(NT), \frac{1}{\alpha^B}\bar{c}^B(T)\}]$ and decreases it for $c^B \in (\min\{\bar{c}^B(NT), \frac{1}{\alpha^B}\bar{c}^B(T)\}, \bar{c}^B(NT)]$.

By contrast, when $c^B \in (\bar{c}^B(NT), \infty)$, then the equilibrium is (Only S) under both tranching and bundling. Both parties are then better off under tranching. This is a manifestation of the benefits of the insulation effect: tranching allows to trade the safe tranche with probability 1.

$\square$

Case (i) in Proposition 9, and cases (i) and (ii) in Proposition 10 illustrate the adverse information effect of tranching. When the seller is uninformed, tranching *increases* the incentives of the buyer to acquire information. When the seller is informed, tranching *decreases* the incentives of the buyer to acquire information. In both cases, tranching works against commonality and information and towards asymmetric information, to the detriment of liquidity and welfare.

4.2 Tranching and commonality of information

We finally provide a more general argument solidifying the intuition, provided in the introduction, that tranching encourages information acquisition when it should be deterred and discourages it when it should be promoted. We thereby also shed further light on Lemma 1, and Propositions 9 and 10. *The analysis relies on a simple convexity argument, allows arbitrary tranching and does not require Assumption 2.*

Suppose that the asset is split into I tranches $(i = 1, ..., I)$; each tranche i is composed of a fraction x_i of equity (cash-flow right on δ) and of a fraction y_i of debt, such that $\Sigma_i x_i = \Sigma_i y_i = 1$. The seller and the buyer bargain over the entire bundle under bundling, and enter piecemeal negotiations for each tranche under tranching.

Proposition 11. ***(Tranching Works Against Commonality of Information)***

i. If (NI) is an equilibrium under tranching, then (NI) is a fortiori an equilibrium under bundling;

ii. if (I) is an equilibrium under tranching, then (I) is a fortiori an equilibrium under bundling.

Proof. We start with (i). Suppose that (NI) is an equilibrium. Let us compute the buyer's gain from information acquisition under tranching $(G_T^B(NI))$ and under bundling $(G_{NT}^B(NI))$ (the reasoning is symmetrical for the seller). Under tranching, when the seller makes the offer, the seller offers price $y_i B + x_i \rho b$ for tranche i. The buyer's gain from being informed is then $(1-\rho)x_i(\rho b)$, so the total gain over all tranches is $\Sigma_i (1-\rho)x_i(\rho b) = (1-\rho)\rho b$, and so is the same as under bundling. Suppose now that the buyer makes the offer. When uninformed, the buyer offers $y_i S + x_i \rho s$ for tranche i and this offer is accepted. The buyer's gain on tranche i from being informed is $\max\{a_i, 0\}$, where

$$a_i \equiv (1-\rho)\left[y_i S + x_i \rho s - y_i B\right].$$

Under bundling the gain from being informed is $\max\{a, 0\}$, where

$$a \equiv (1-\rho)\left[S + \rho s - B\right] = \Sigma_i a_i.$$

And so,

$$G^B_T(NI) \equiv \alpha^B \Sigma_i \max\{a_i, 0\} \geq G^B_{NT}(NI) \equiv \alpha^B \max\{\Sigma_i a_i, 0\}.$$

We now deal with (ii). Suppose that (I) is an equilibrium and let us compute the losses $L^B_T(I)$ and $L^B_{NT}(I)$ for the buyer from not being informed (again the reasoning is symmetrical for the seller).

With probability α^S, the seller offers price B in the bad state and price $B+b$ in the good state. The buyer has no surplus and therefore there is no loss from being uninformed (besides, the offer reveals the state of nature). So suppose that the buyer makes the offer. The loss for tranche i from not being informed is

$$a_i \equiv (1-\rho)y_i(B-S) + \rho\left[y_i(B-S) + x_i(b-s)\right] - y_i(1-\rho)(B-S)$$
$$\text{if} \quad y_i\rho(B-S) \leq x_i(s-\rho b)$$

and

$$b_i \equiv (1-\rho)y_i(B-S) + \rho\left[y_i(B-S) + x_i(b-s)\right] - \left[y_i(B-S) + x_i(\rho b - s)\right]$$
$$\text{if} \quad y_i\rho(B-S) \geq x_i(s-\rho b).$$

And so

$$L^B_T(I) \equiv \alpha^B \Sigma_i \min\{a_i, b_i\} \leq L^B_{NT}(I) \equiv \alpha^B \min\{\Sigma_i a_i, \Sigma_i b_i\}.$$

□

While it is instructive to compute actual gains and losses (in particular, we see that both are associated with the possibility of making an offer), the reasoning in the proof does not hinge on the exact expressions. The key insight is that the gain from becoming informed in a non-informed equilibrium is linked to the possibility of refusing a disadvantageous trade (buying a lemon, selling a high quality asset). In this respect, tranching offers more flexibility in the trade pattern and therefore a higher gain from deviating from the non-informed equilibrium. Similarly, the loss associated with not being informed in an informed equilibrium is associated with the possibility of either not trading or not capturing the other side's surplus. Minimizing this loss piecewise is easier than minimizing it globally, and so the incentive to deviate from an informed equilibrium is greater under tranching.

Finally, we note that we have taken the view that opportunities for trade are unaffected by security design: The buyer, say, can buy the same overall security under tranching and bundling. For instance, an informed buyer can under tranching acquire in several negotiations the various pieces of the whole bundle that he can acquire in a single negotiation under bundling. In making this assumption, we implicitly follow the literatures on market microstructure and on mechanism design. An opposite view would be that one should cut securities in an arbitrary number of different tranches that would be traded by different groups of agents; in such a world, it would be difficult to see how asymmetric information would ever emerge, since the cost of acquiring information could never be recouped through purchasing a tiny piece of the overall cake. In our view, the reason why the formalism adopted in this section is more relevant is that there is in practice, a second kind of information acquisition. Economic agents who trade an asset must have a minimum amount of familiarity with the properties of this asset (as in Lester et al (2012)). Thus, cutting into small pieces would create illiquidity rather than enhance liquidity. We hope that future research will develop and clarify this line of thought, that seems crucial for market microstructure and security design.

4.3 Discussion of the related literature

The security design literature is more general in some respects, and less general in some others. Outcomes can usually take a continuum of values instead of being binary. And optimal tranching involves mixing the safe part with as much equity as is consistent with keeping the former liquid. On the other hand, the literature usually considers special cases, as we do in this section (for example in DeMarzo and Duffie (1999), $c^S = 0$ and $c^B = \infty$). More importantly, the literature makes two key assumptions: (a) the seller has full bargaining power ($\alpha^S = 1$); and (b) the seller can commit to sell some tranche and keep the rest. Concerning this commitment assumption, note that the seller benefits from selling the equity tranche after disposing of the safe one. Whether the seller is likely to be able to abide to such a commitment to forego beneficial trades is context-dependent, and we find both cases to be of interest.

Despite these differences, we can compare our results with those of the literature. DeMarzo and Duffie (1999) considers the case of an exogenously informed seller. Our Condition (1) corresponds to their assumption that the bundle leads to wasteful undertrade; and Proposition 7 (i) is broadly consistent with their identification of the insulation effect.

Dang et al (2011) study the case of an uninformed seller ($c^S = \infty$) and endogenous information acquisition by the buyer ($0 < c^B < \infty$). In addition, they also make Assumptions (a) and (b) stated above. They find that, in contrast with the analysis of this section, tranching always optimally deters information acquisition by the buyer. The difference with Proposition 11 can be grasped by returning to assumptions (a) and (b). To understand the role of the commitment assumption (b), suppose that $\alpha^S = 1$. While tranching deters information acquisition by the buyer in Dang et al, it is neutral with respect to information acquisition in our model (when $\alpha^S = 1$): Recall that the buyer's incentive to acquire information in the (NI) equilibrium is the ability to refuse trading when $\delta = 0$. Regardless of how many tranches one constructs out of the bundle and of how these tranches are structured, acquiring information allows the buyer to economize a total of ρb when $\delta = 0$. And so the buyer's incentive to acquire information is independent of financial engineering. This is not so when the seller can commit not to trade (risky) tranches as in Dang et al; the buyer's incentive to acquire information is then reduced. To understand the role of the bargaining power assumption (a), consider now what happens in our model when $\alpha^S < 1$. Tranching is no longer neutral as shown by Proposition 7 (i). Tranching enables the buyer to make a finer use of his information, i.e. to pick and choose, and thereby encourages information acquisition.

5 Conclusion

The paper analyzed bundling with common values and endogenous information. After pitting the insulation effect (tranching confines and liquefies the safe part) against the trading adjuvant effect (bundling makes the risky part more liquid), the paper's first substantive contribution was to show that tranching always has adverse welfare effects on information acquisition: Tranching reduces a party's cost of not trading and therefore works against the commonality of information and thereby against the realization of gains from trade. As a result, tranching encourages (discourages) information acquisition when it should be deterred (encouraged). The paper provides conditions under which tranching reduces welfare even when the insulation effect dominates the trading adjuvant effect.

The focus of this paper leaves many alleys open to future research. In Farhi and Tirole (2014) we study the velocity of an asset that is repeatedly traded. We show that the dynamic model can be nested into the static one, enabling us to make use of this paper's results. The central insight is that liquidity is self-fulfilling: A perception of future illiquidity creates current illiquidity. Insights on velocity are shown to be closely related to those on tranching.

One of the most challenging, but also potentially most rewarding ones is to embody these considerations in a general equilibrium framework with a shortage of stores of value. Endogenously varying demand for liquidity impacts the velocity of existing stores of value and therefore the supply of liquidity. Another extension would look at security design once the veil of ignorance is lifted. The issuer then would use security design to signal underlying security values, as in Nachman and Noe (1994). A third extension would allow for arbitrarily fine tranching options and for a larger set of information acquisition strategies. On the arbitrary-tranching front, Proposition 11 demonstrates that the key insight that tranching works against the commonality of information is robust; but it leaves open the general characterization of optimal security design. On more general information acquisition strategies, we have followed much of the literature in assuming that the parties can acquire a piece of information about the value of the asset; this was natural in our binary-state environment. Had we considered a continuum of outcomes, say, we could have allowed, in the spirit of Yang (2011) and the rational inattention literature, parties to focus their attention on specific regions of the outcome space; the impact of tranching on focused attention is an interesting alley for research. Yet another extension would consider regulatory attitudes toward tranching and its consequences for later govenment attempts at restarting asset markets when bad news make the latter freeze.[11]

Finally, the introduction has stressed that the framework and questions apply well beyond the realm of security design. It clearly would be worth extending and applying the results to policy-making in industrial organization, politics, international negotiations, compensation design or financial regulation. We hope that these and other topics related to this paper will be investigated in future research.

[11] As in, e.g., Camarzo et al (2013), Philippon and Skreta (2012) and Tirole (2012).

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Appendix: Lemma for Section 4

In Section 4, we make use of some comparison of payoffs across equilibria even when they might not coexist. For example, we establish that $v^S(I) > v^S(Only\,B)$ when $c^S < \bar{c}^S$ and $v^S(I) < v^S(Only\,B)$ when $c^S > \bar{c}^S$. As long as $c^B < \underline{c}^B$, the equilibrium is (I) or (Only B). It is (I) when $v^S(I) > v^S(Only\,B)$ and (Only B) when $v^S(I) < v^S(Only\,B)$.

Lemma 2. ***(Further Comparison of Payoffs).*** *The payoffs are ranked as follows:*

i. for the seller: $v^S(NI) \geq v^S(I) \geq v^S(Only\,S)$, *and* $v^S(NI) \geq v^S(Only\,B)$*; furthermore* $v^S(I) \geq v^S(Only\,B)$ *if and only if* $c^S \leq \bar{c}^S$*;*

ii. for the buyer: $v^B(NI) \geq v^B(I) \geq v^B(Only\,B)$, *and* $v^B(NI) \geq v^B(Only\,S)$*; furthermore* $v^B(I) \geq v^B(Only\,S)$ *if and only if* $c^B \leq \bar{c}^B$.

iii. for total welfare $v = v^S + v^B$: $v(NI) \geq \max\{v(I), v(Only\ S), v(Only\ B)\}$*; furthermore* $v(I) \geq v(Only\,B)$ *if and only if* $c^S \leq \frac{\bar{c}^S}{\alpha^S}$, *and* $v(I) \geq v(Only\,S)$ *if and only if* $c^B \leq \frac{\bar{c}^B}{\alpha^B}$.