# Asymmetric solutions to asymmetric information problems

Dari-Mattiacci, G.; Onderstal, S.; Parisi, F.

**DOI**
10.1016/j.irle.2021.105981

**Publication date**
2021

**Document Version**
Final published version

**Published in**
International Review of Law and Economics

**License**
CC BY

International Review of Law and Economics 66 (2021) 105981

Contents lists available at ScienceDirect

International Review of Law and Economics

# Asymmetric solutions to asymmetric information problems★

Giuseppe Dari-Mattiacci[a,*,1], Sander Onderstal[b,2], Francesco Parisi[c,d,3]

[a] Professor of Law and Economics, University of Amsterdam, Amsterdam Law School and Tinbergen Institute, The Netherlands
[b] Professor of Strategy and Markets, University of Amsterdam, Amsterdam Business School and Tinbergen Institute, The Netherlands
[c] Oppenheimer Wolff and Donnelly Professor of Law, University of Minnesota, School of Law, United States
[d] Professor of Economics, University of Bologna, Department of Economics, Italy

ARTICLE INFO

*Article history:*
Received 7 August 2020
Received in revised form 12 January 2021
Accepted 21 January 2021
Available online 6 February 2021

*JEL classification:*
D44
D82
D86
K12

*Keywords:*
Lemons
Gems
Adverse selection
Asymmetric information
Auction
Warranty
Block-booking

ABSTRACT

This paper studies markets plagued with asymmetric information on the quality of traded goods. In Akerlof's setting, sellers are better informed than buyers. In contrast, we examine cases where buyers are better informed than sellers. This creates an inverse adverse selection problem: the market tends to disappear from the bottom rather than from the top. In contrast to the traditional model, it is the high-value goods (gems) that are traded on the market, rather than the low-value goods (lemons). We refer to this asymmetric information scenario as the "market for gems." We investigate the consequences of this undisclosed knowledge of hidden qualities — which we refer to as inverse adverse selection — and the reasons why legal theorists have given this form of asymmetric information substantially less consideration. Conventional legal and contractual solutions to the lemons problem are often ineffective in the gems case: the uninformed buyer in a traditional market for lemons experiences the quality of the good he purchased; in a market for gems, instead, the uninformed seller may never know the quality of the good that he sold. We study three alternative solutions to the gems problem — auctions, suppression of information, and inverse warranties — and identify the condition under which each of them is feasible. We then show how the theory sheds light on real-life gems problems arising in the multi-million dollar transactions involving soccer players, artworks, M&As, Hollywood movies, and diamonds.


## 1. Introduction

In some contracts or relationships, one party may possess private information relevant to the contract, giving rise to an asymmetry of information. George Akerlof illustrated this concept in his 1970 article "The Market for Lemons." He considered how asymmetries in information impact markets where sellers know more about the quality of goods traded than buyers, examining its impact to the used-car market. When sellers possess more information about the quality of a good, buyer's uncertainty can depress prices. As a result, fewer owners of high-quality goods are willing to offer their goods for sale at the depressed prices, leading to a market dominated by low-quality goods (lemons). In turn, this reduces the quality of goods that buyers expect to find on the market, further depressing prices and driving any remaining high-quality goods out of the market. Sellers seek to exploit their information advantage over buyers by offering only goods of lower quality than the market price — a process is known as "adverse selection" — leading to a market failure. While Akerlof illustrated this concept with the used-car market, the problems of asymmetric information extend to many other markets. For example, adverse selection problems are present in insurance, pharmaceuticals, and labor markets. However, thus far, most analyses only focus on transactions between informed sellers and uninformed buyers, leaving out the important application of information asymmetries to transactions affected by the inverse problem — an uninformed seller and an informed buyer.

This paper illustrates and examines the dual problem of "inverse adverse selection" that occurs when buyers, rather than sellers, possess private information about the quality of a good. This might

★ The authors would like to thank the editor Emanuela Carbonara and two anonymous referees, Emanuele Indraccolo, Ariel Katz, Matej Marinč, and Jeroen van de Ven for very constructive comments. Ryan Fitzgerald, Ryan Patrick, and Elizabeth Springfield provided valuable research assistance. An earlier incarnation of this idea was circulated as "Inverse Adverse Selection: The Market for Gems", available at https://papers.ssrn.com/abstract=1661090.
* Corresponding author.
*E-mail addresses:* gdarimat@uva.nl (G. Dari-Mattiacci), onderstal@uva.nl (S. Onderstal), parisi@umn.edu (F. Parisi).
1 SSRN author page http://ssrn.com/author=333631.
2 SSRN author page http://ssrn.com/author=342318.
3 SSRN author page http://ssrn.com/author=227722.

https://doi.org/10.1016/j.irle.2021.105981
0144-8188/

be the case for unique goods of uncertain value, such as artwork, or for sales between an expert buyer and a one-time seller, such as a real estate investor and a homeowner. This problem may also be present in sales of assets from the estate of a bankrupt or deceased individual, where the seller — a trustee or executor — is often less informed about the quality of the good than potential buyers. In these cases, sellers find themselves in a situation that mirrors that of buyers in the lemons market because of their information asymmetry. Sellers may be induced to ask very high prices, suspecting that if an informed buyer shows interest in what they are selling, the good must have some hidden quality of which they are not aware. To paraphrase Akerlof's description, we refer to this case as the "market for gems" problem.[4] As in Akerlof's model, in a market for gems, the market may shrink or entirely collapse.

Consider the following simple example. Seller is uncertain about the value of a painting she wants to sell: it could have a high value ($750) or a low value ($250). Being uncertain about the painting's value, Seller may offer it for sale at its expected value, which is equal to $500. However, if Buyer knows the value of the painting, at this price he will only buy it if it is of high value. Anticipating that she will only be able to sell high-value paintings ("gems"), Seller will set the price at $750 and low-value paintings will remain unsold.

These two variants of adverse selection are dual to one another and are both detrimental to social welfare when compared to the ideal world where both sellers and buyers are informed about the quality of goods and prices reflect actual quality. In both cases, the cost to society results from the fact that some desirable transactions — when the buyer's valuation is greater than the seller's valuation — are foregone. While the standard case of adverse selection with uninformed buyers has been extensively analyzed, the inverse case of adverse selection with uninformed sellers has received virtually no attention in the economic literature.[5]

Two considerations may help explain the reduced attention paid by economists to market for gems problems. First, auctions, while rarely effective with lemons, can be an appropriate solution to gems problems. In an auction, bidders have an incentive to condition their bids on their private valuations, which helps bridge the asymmetric information gap between buyers and sellers. Uninformed sellers could thus rely on the bids to learn about the market value of the gem. However, auctions are not a panacea for market for gems problems because they are expensive to organize and are feasible only if there are multiple informed bidders for the same good. As an example, consider a geologist who makes a bid on an estate because he has private information about the value of the property, having learned about the existence of yet-undiscovered mineral resources in the land, and that information is not known by other bidders at the auction. The auction mechanism would not lead the geologist to reveal his private information through the competitive bidding unless he expects other potential buyers to have the same information. Thus, the gems problem would remain unresolved.

The second practical explanation for the reduced attention to gems problems in the literature lies in the fact that uninformed sellers can acquire private information about the value of their gem through independent experts who have access to the same information as the prospective buyer. This can solve the information asymmetry without any sunk costs. In contrast, in a market for lemons, if an uninformed buyer retains an independent expert to ascertain the presence of defects or other negative information and decides not to buy the good, the cost of the expertise is sunk. Other prospective buyers would similarly have to retain experts to discover the same negative information resulting in a sequential dissipation of resources (Shavell, 1994). But in a market for gems, only the seller needs to retain an expert to appraise the value of the good before the sale. Once the seller acquires that information, she is able to enter the transaction with symmetric information, knowing the value of her good. Hence, from a social point of view, in market for gems situations, the acquisition of information through experts is desirable. However, experts can only have a limited role in avoiding gems problems. Gems problems often arise because buyers have unique private information that not even diligently informed sellers or professional advisers possess. Independent advisers do not necessarily have access to the same set of information as every possible prospective buyer. Using the geologist example, a geologist may make an offer on an estate based on his private information because he knows about the existence of mineral resources at the estate, even when such private information cannot be easily ascertained by an independent adviser. Without knowing the reason for the prospective buyer's interest in the estate, the adviser would have no reason to invest resources to explore the existence of mineral resources or to investigate the other idiosyncratic reasons for the prospective buyer's interest in the land. Hidden qualities of the land would remain undiscovered prior to the sale and the adviser would give the prospective seller an appraisal based on his best professional expertise in real estate. Hence, also in this case the informed buyer could take advantage of his unique informational advantage, and the gems problem would remain unresolved.

In the following, we unveil the dualities between the lemons and gems markets and explore the economic consequences of these two forms of asymmetric information problems. In Section 2, we develop a model of adverse selection encompassing both lemons and gems. We show that, unlike in lemons markets, adverse selection in gems markets affects low-quality goods, leaving only high-quality goods on the market, pushing up prices. The race to the bottom in quality and prices observed in the lemons market mirrors the race to the top in the gems market. The fact that low-quality goods are not traded in the market for gems amounts to a social cost — the difference between the seller valuation and the valuation of a potential buyer — and hence is as relevant as the absence of high-quality goods in the market for lemons. In Section 3, we compare markets with no information to markets with asymmetric information and identify the conditions under which asymmetric information is preferable to the case of no information, and vice versa. In Section 4, we consider some of the qualitative differences between the two variants of adverse selection considered in this paper. In particular, we focus on the likelihood of post-transaction information acquisition for the uninformed party, which make contractual and legal solutions — such as warranties and duties to disclose — to the market for lemons problems generally ineffective in solving the market for gems problems. The traditional solutions to lemons problems are effective only if the uninformed party receives a signal indicating the true quality of the good after the transaction. In most real-life scenarios, uninformed buyers learn through use whether the goods they purchased are of low quality; in contrast, uninformed sellers may never learn that they sold a good of high quality. The absence of post-transaction signals of quality makes traditional solutions often ineffective in the case of gems; there are however exceptions, as explained below.

While the two problems of gems and lemons are symmetric and, under some conditions, dual, solutions differ. In lemon problems warranties and duties to disclose are most common; in contrast,

[4] While lemons have been made popular by Akerlof (1970), a reference to gems can be found in Kronman (1978, pp. 31–32), where he comments on an example given in the Restatement of Restitution where a jewelry shop mistakenly sells real gems for the price of junk. See also Wood v. Boynton, 64 Wis. 265, 25 N.W. 42 (1885) for the mirror case of an individual selling a diamond to a jeweler on the assumption that it was a (worthless) topaz.

[5] An exception is Barzel et al. (2006), who study IPO transactions between an uninformed underwriter (seller) and possibly informed investors (buyers) and focus on the desirability and implementability of a commitment to remain uninformed. Differently from us, they do not compare gems and lemons.

gems problems are tacked by resorting to a variety of solutions. We have observed above that experts are a typical gem's solution; in Section 5, we bring the theory to bear on the choice among auctions, suppression of information, and inverse warranties, and identify an under-appreciated function of auctions. We first note that auctions are most likely to be effective when there are a multitude of well-informed buyers, suppression of information is effective when buyers have systematically higher valuations than sellers, and inverse warranties are effective when the seller has easy access to post-transaction signals of quality. While auctions are a familiar phenomenon, we emphasize that an important feature of auctions is that goods of all qualities are sold, next to the fact that they may be sold for the highest possible price. The other two solutions are less commonly observed. Yet, they can be found in two multi-million-dollar markets that we examine: the markets for soccer players, artworks and M&As, and the markets for Hollywood movies and diamonds. In Section 6, we conclude with some ideas for future extensions.

## 2. Dual models of adverse selection: lemons and gems

We consider a setting in which a seller (she) owns an object which she values at $v_S$ while a potential buyer (he) assigns value $v_B$ to it. We study the effects of incomplete information about the value of the object on either the buyer's side (the lemons case) or the seller's side (the gems case); we examine these two cases in Sections 2.1 and 2.2, respectively. In order to emphasize that these two situations are each other's mirror image, we keep the set-up of these two sections as similar as possible. In Section 2.3, we compare gems to lemons. In Section 3, we will then compare the results obtained in a model of markets characterized by asymmetric information to those obtained when both parties are symmetrically uninformed.

### 2.1. Adverse selection: the market for lemons

Suppose that the seller is informed about her value $v_S$ while the buyer is not (but knows the distribution of values). We assume that $v_S$ is distributed with differentiable cumulative distribution function $F_S$ on $\left[\underline{v}_S, \overline{v}_S\right]$. The buyer's value is $v_B \equiv b(v_S)$.[6] The seller sells at price $p$ if $v_S \leq p$. Consequently, the buyer buys if the average value of the goods offered for sale on the market $b^*(p)$ is larger than the price $p$, where $b^*(p)$ can be expressed as

$$b^*(p) \equiv E[b(v_S)\,|v_S \leq p] = \frac{\int_{\underline{v}_S}^{p} b(v)\, dF_S(v)}{F_S(p)}$$

Because only those sellers with valuations lower than the market price will sell, trade is only feasible for $v_S \in \left[\underline{v}_S, p^B\right]$, where $p^B$ is the highest possible price that is still lower than the average quality of the goods on the market (as perceived by the buyer):

$$p^B = \max\left[p \in \left[\underline{v}_S, \overline{v}_S\right] |p \leq b^*(p)\right]$$

This threshold identifies the price that supports the highest level of trade in equilibrium. Note that high-value goods are not traded in the market. Conditional on trade at price $p^B$, the expected gains from trade for the buyer are $b^*\left(p^B\right) - p^B = 0$. A buyer might make a loss or a gain in each of the different cases as he does not know the real value of the individual good, only the average value. In contrast, in the case of trade, a seller with valuation $v_S$ always makes a gain $p^B - v_S > 0$. The expected gains from trade for sellers are

$$\int_{\underline{v}_S}^{p^B} \left(p^B - v_S\right) dF_S(v) = F_S\left(p^B\right)\left(p^B - \tilde{v}_S\right)$$

where $\tilde{v}_S \equiv E[v_S|v_S \leq p]$ is the average seller valuation of the goods on the market. This leads to the following proposition.

**Proposition 1** (Market for lemons). *If the seller has complete information and the buyer does not, trade will be feasible only for goods with low seller valuation* $v_S \in \left[\underline{v}_S, p^B\right]$.

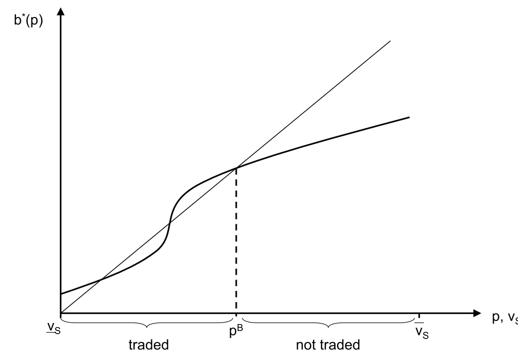


**Fig. 1.** The market for lemons.

Fig. 1 illustrates these findings. As a result of asymmetric information, goods of higher quality are driven out of the market.[7] In fact, under some conditions, the market may completely disappear, even if trade is always efficient because the buyer values each good more than the seller does.[8]

### 2.2. Inverse adverse selection: the market for gems

Now suppose that the buyer is informed about his value $v_B$ while the seller is not (but knows the distribution of values). We assume that $v_B$ is distributed with differentiable cumulative distribution function $F_B$ on $[\underline{v}_B, \overline{v}_B]$. The seller value is $v_S \equiv s(v_B)$.[9] The buyer buys at price $p$ if $v_B \geq p$. Consequently, the seller sells if the average value of goods that buyers are willing to buy on the market $s^*(p)$ is smaller than $p$, where $s^*(p)$ can be expressed as

$$s^*(p) \equiv E[s(v_B)\,|v_B \geq p] = \frac{\int_{p}^{\overline{v}_B} s(v)\, dF_B(v)}{1 - F_B(p)}$$

Because only those buyers with valuations higher than the market price will buy, trade is only feasible for $v_B \in \left[p^S, \overline{v}_B\right]$, where $p^S$ is the lowest price that is still higher than the average quality of the goods on the market (as perceived by the seller):

$$p^S = \min\,]p \in [\underline{v}_B, \overline{v}_B]\,|p \geq s^*(p)[$$

Note that now low-value goods are not traded in the market. Conditional on trade at price $p^S$, the expected gains from trade are

[6] The function $b$ is a Riemann-integrable function from $\left[\underline{v}_S, \overline{v}_S\right]$ to the positive reals.

[7] Suppose that $v_S \sim U[0, 1]$ and $v_B = b(v_S) = \alpha + (1-\alpha)v_S, \alpha \in [0, 1]$. Trade is feasible if $b^*(p) = E[b(v_S)|v_S < p] = \alpha + \frac{(1-\alpha)p}{2} \geq p$ which is equivalent to $p \leq \frac{2\alpha}{1+\alpha}$. Therefore, there will be trade only if $v_S \in \left[0, \frac{2\alpha}{1+\alpha}\right]$, i.e., in at most a fraction $\frac{2\alpha}{1+\alpha}$ of the cases.

[8] Assume $v_S \sim U[0, 1]$ and $v_B = b(v_S) = \beta v_S, \beta \in [1, 2)$. Trade is feasible if $b^*(p) = E[b(v_S)|v_S < p] = \frac{\beta p}{2} \geq p$. The latter inequality implies $\beta \geq 2$, which is a contradiction to the assumption that $\beta < 2$ and the fact that trade will only take place if $p > 0$. Therefore, the market will collapse.

[9] The function $s$ is a Riemann-integrable function from $\left[\underline{v}_B, \overline{v}_B\right]$ to the positive reals.

**Table 1**
Duality in adverse selection.

| | Adverse selection | Inverse adverse selection |
|---|---|---|
| Buyer | Uninformed<br>Buyer's valuation $b(v_S)$ | Informed<br>Buyer's valuation $v_B$ |
| Seller | Informed<br>Seller's valuation $v_S$ | Uninformed<br>Seller's valuation $s(v_B)$ |
| Market | Size of the market: $F_S\left(p^B\right)$<br>Disappears for high-value goods | Size of the market: $1-F_B\left(p^S\right)$<br>Disappears for low-value goods |
| Goods on the market | Low-value goods (lemons)<br>Price: $p^B=b^*\left(p^B\right)$ | High-value goods (gems)<br>Price: $p^S=s^*\left(p^S\right)$ |
| Buyer's surplus | Zero | Positive: $\left(1-F_B\left(p^S\right)\right)\left(\tilde{v}_B-p^S\right)$ |
| Seller's surplus | Positive: $F_S\left(p^B\right)\left(p^B-\tilde{v}_S\right)$ | Zero |

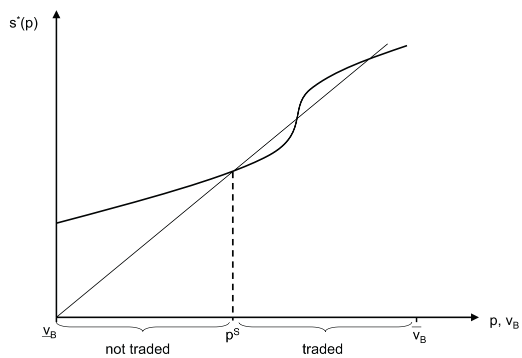


**Fig. 2.** The market for gems.

$p^S-s^*\left(p^S\right)=0$ for the seller. A seller might occasionally make a loss or a gain in each of the different cases as she does not know the real value of the individual good, only the average value. In contrast, in the case of trade, a buyer with valuation $v_B$ always makes a gain $v_B-p^S>0$. The expected gains from trade for buyers are

$$\int_{p^S}^{\bar{v}_B}\left(v_B-p^S\right)dF_B(v)=\left(1-F_B\left(p^S\right)\right)\left(\tilde{v}_B-p^S\right)$$

where $\tilde{v}_B\equiv E\left[v_B|v_B\geq p^S\right]$ is the average buyer valuation of the goods on the market. We have then the following proposition.

**Proposition 2** (Market for gems). *If the buyer has complete information and the seller does not, trade will be feasible only for goods with high buyer valuation* $v_B\in\left[p^S,\bar{v}_B\right]$.

Fig. 2 illustrates these findings. Similar to the market for lemons, the market for gems may shrink[10] or completely disappear.[11]

**Example 1.** Suppose that a representative seller would like to sell an old photograph that she found in her attic.[12] However, she is uncertain about its value. The photograph might be worth \$100 (if taken by a famous photographer), \$40 (if taken by a less famous photographer) or \$10 (if taken by an amateur). Also suppose that potential buyers are expert collectors who value the photograph at \$120, \$80 or \$30, respectively (these valuations are known to the seller). In expectation, the seller values the photograph at $\frac{\$100+\$40+\$10}{3}=\$50$, but, if she offers the photograph for sale at \$50, a buyer would accept the offer only if the photograph has high or intermediate value. Thus, any photograph that the seller successfully sells must have an expected value of $\frac{\$100+\$40}{2}=\$70$ and it is therefore not worth it for the seller to sell such a photograph for \$50. If the price is increased to, say, \$75, a buyer will be willing to buy a photograph of high or intermediate value, which corresponds to the seller's expectations. However, at this price the least valuable type will remain unsold, even though the buyer values each type more than the seller. If we change the example slightly and assume that buyers value the photograph at \$120, \$60 or \$30, respectively, then the intermediate-quality photographs also disappear from the market and only the highest-quality photographs will be traded.

### 2.3. Duality in adverse selection

From the analysis of the previous sections, it is straightforward to notice that adverse selection and inverse adverse selection are dual problems. Table 1 below illustrates this point.

If one assumes that the functions $b$ and $s$ are strictly increasing and continuous, there is a direct one-to-one relationship between the adverse selection and inverse adverse selection models in the sense that one can transform a problem into its dual and vice versa in the following way:

**Proposition 3** (Duality). *If the functions* $b$ *and* $s$ *are strictly increasing and continuous, adverse selection and inverse adverse selection are dual problems with* $s=b^{-1}$ *and* $F_B(v)=P[v_B\leq v]=P[b(v_S)\leq v]=P\left[v_S\leq b^{-1}(v)\right]=F_S\left(b^{-1}(v)\right)$.

The hypothesis of strictly increasing and continuous functions implies that there is a positive correlation between the seller's and the buyer's valuations. In other words, higher quality goods are more valuable to both buyers and sellers, notwithstanding their different subjective valuations of the goods.

## 3. Asymmetric information versus symmetric lack of information

In this section, we compare the results of markets characterized by both types of asymmetric information (adverse selection and inverse adverse selection) with those obtained in markets where participants are symmetrically uninformed (that is, where both parties are incompletely informed about value). In our model, a lack of information implies that parties may occasionally enter into transactions that prove to be undesirable since the buyer's valuation is lower than the seller's valuation. Therefore, we can distinguish between two types of transactions: desirable transactions and unwanted transactions. Desirable transactions are those transactions involving a good that the buyer values more than the

[10] Suppose that $v_B\sim U[0,1]$ and $v_S=s(v_B)=(1-\alpha)v_S$, $\alpha\in[0,1]$. Trade is feasible if $s^*(p)=E[s(v_S)|v_B>p]=\frac{(1-\alpha)(1+p)}{2}\leq p$ which is equivalent to $p\geq\frac{1-\alpha}{1+\alpha}$. Therefore, there will be only trade if $v_B\in\left[\frac{1-\alpha}{1+\alpha},1\right]$, i.e., in at most a fraction $\frac{2\alpha}{1+\alpha}$ of the cases.

[11] Assume $v_B\sim U[0,1]$ and $v_S=s(v_B)=1+\left(\beta-1\right)(v_B-1)$, $\beta\in[1,2)$. Trade is feasible if

$$s^*(p)=E[s(v_B)|v_B>p]=1-\frac{1}{2}\left(\beta-1\right)(1-p)\leq p$$

which yields $\beta\geq 3$ and is a contradiction to the assumption that $\beta<2$ and the fact that trade will only take place if $p<1$. Therefore, the market will collapse.

[12] This example is inspired by the *Baldus* case, a landmark case decided by the French *Cour de cassation* (1e *chambre civile*, May 3, 2000).

seller — with $b(v_S) > v_S$, in the case of lemons, or $v_B > s(v_B)$, in the case of gems — while unwanted transactions are those transactions involving a good that the buyer values less than the seller — with $b(v_S) < v_S$ or $v_B < s(v_B)$, respectively. Note that if the valuations of buyers and sellers are equal, then the transaction does not affect social welfare, though it might be considered unwanted to save transaction costs.

If both parties are informed, only desirable transactions will take place. But with symmetric lack of information, there is no filter on transactions. The surplus is given by the average buyer valuation minus the average seller valuation: $E[b(v_S)] - E[v_S]$, in the case of lemons, and $E[v_B] - E[s(v_B)]$, in the case of gems. The market is either complete (if the surplus is positive) or disappears altogether (if the surplus is negative). This implies that if the unwanted transactions outweigh the desirable transactions, the market will disappear and no transactions will take place, including desirable ones. Conversely, if the desirable transactions outweigh the unwanted transactions, the market will persist and all transactions, including the unwanted ones, will take place.

The surplus in markets with asymmetric information is given by the surplus of the informed party; the uninformed party breaks even on average. As we have shown above, such surplus is always positive and is given by the number of transactions times the average surplus: $F\left(p^B\right)\left(p^B - \tilde{v}_S\right)$, in the case of lemons, and $\left(1 - F\left(p^S\right)\right)\left(\tilde{v}_B - p^S\right)$, in the case of gems. With asymmetric information, at least one party can filter transactions and prevent some unwanted transactions from taking place.

The balance between asymmetric information and symmetric lack of information depends on the comparison between these surpluses which in turn depends on the prevalence and distribution of unwanted transactions in the market. Asymmetric information imperfectly fulfills a matching function that symmetric lack of information is unable to fulfill: it takes goods out of the market that would most likely result in unwanted transactions.

**Proposition 4** (Asymmetric information v. symmetric lack of information). *Symmetric lack of information yields higher social welfare than asymmetric information if and only if* $E[b(v_S)] - E[v_S] > F\left(p^B\right)\left(p^B - \tilde{v}_S\right)$, *in the case of lemons, and if and only if* $E[v_B] - E[s(v_B)] > \left(1 - F\left(p^S\right)\right)\left(\tilde{v} - p^S\right)$, *in the case of gems.*

The following two corollaries emphasize two sub-cases in which one type of lacking of information is unambiguously better than the other. The first corollary points to those situations in which the buyer's valuation is always higher than the seller's valuation. In this case, symmetric lack of information lets all transactions take place, which is welfare improving. Asymmetric information might lead to some, or maybe even all, foregone transactions, although each transaction is still welfare improving (as we have seen in the examples above). Thus, symmetric lack of information is to be preferred over asymmetric information. We first provide an example and then state the corollary.

**Example 2.** Consider the case of gems (the case of lemons is analogous). A representative seller of a stamp is uncertain about its value: it could be a rare stamp (\$80) or a common stamp (\$20). Potential buyers are expert collectors who value the stamp at \$100 or \$40, respectively. If the stamp is offered for sale by the seller at its expected value $\frac{\$80+\$20}{2} = \$50$, a buyer would only buy it if it is rare. Knowing that she will only be able to sell the stamp if it is rare, the seller will ask a higher price. Therefore, only rare stamps will be traded at a price between \$80 and \$100, yielding an expected social gain from trade equal to $\frac{\$100-\$80}{2} = \$10$. If instead both parties are uninformed about value, all stamps will be traded for a price between the expected seller valuation (\$50) and the expected buyer valuation ($\frac{\$100+\$40}{2} = \$70$), resulting in an expected social gain equal to \$20.

**Corollary 1.** *Symmetric lack of information yields higher social welfare than asymmetric information (or at a minimum, the same level of social welfare) if* $b(v_S) \geq v_S$ *for all* $v_S \in \left[\underline{v}_S, \overline{v}_S\right]$, *in the case of lemons, or* $v_B \geq s(v_B)$ *for all* $v_B \in [\underline{v}_B, \overline{v}_B]$, *in the case of gems.*

Example 2 illustrates (and Corollary 1 formalizes) a situation in which the buyer's valuation is always above the seller's valuation. This could be the case when goods have a strong component of common value — that is, there are many characteristics of the goods that buyers and sellers are likely to value in a similar way, such as the fact that a stamp is rare — and the idiosyncratic component of the buyers' valuation is higher than that of the sellers. The fact that buyers attach higher subjective value to goods for sale may be justified by observing that prospective buyers self-select before approaching sellers, so that only those with relatively high subjective valuations will look for goods to buy or, vice-versa, that sellers with relatively low subjective valuations are more likely to offer their goods for sale.[13]

The next example emphasizes the opposite case in which asymmetric information is unambiguously more beneficial to social welfare than symmetric lack of information. This occurs when the average buyer valuation is less than the average seller valuation. With symmetric lack of information the market will collapse and no transactions will take place. Instead, with asymmetric information, some transactions might take place, thereby resulting in a higher level of social welfare.

**Example 3.** We focus again on the case of gems (the case of lemons is analogous). Consider a representative uninformed seller of an old book with valuation equal to \$80 (18th-century book) or \$40 (19th-century book) and a potential informed buyer with valuation equal to \$90 or \$10, respectively. At a price equal to or greater than the seller's expected valuation ($\frac{\$80+\$40}{2} = \$60$), a buyer would not buy a 19th-century book. Anticipating this behavior, the seller will offer the book for sale at a price equal to or greater than \$80. At this price, only 18th-century books will be traded with an expected social gain equal to $\frac{\$90-\$80}{2} = \$5$. Note that asymmetric information prevents unwanted transactions from taking place concerning recent, lower-valued books, which sellers value more than potential buyers. Due to these unwanted transactions, if both parties are uninformed, there will be no trade because the seller's expected valuation (\$60) is above the buyer's expected valuation ($\frac{\$90+\$10}{2} = \$50$).

**Corollary 2.** *Asymmetric information yields higher or equal levels of social welfare than symmetric lack of information if* $E[b(v_S)] \leq E[v_S]$, *in the case of lemons, or* $E[v_B] \leq E[s(v_B)]$, *in the case of gems.*

Example 3 and Corollary 2 focus on situations where common value plays a small role and idiosyncratic value plays a large role in the parties' valuations so that the average buyer valuation is lower than the average seller valuation. On a factual basis, this situation could occur when goods are already generally owned by the highest valuing individuals and where it is difficult for high-valuation buyers to identify and approach the few low-valuation sellers in

[13] Kaplow and Shavell (1996, pp. 759–760, 787–790) make a similar distinction between common value and idiosyncratic value in the context of choosing between property-type and liability-type remedies. They assume that owners (that is, potential sellers) typically have higher idiosyncratic value than potential takers (potential buyers) and in their formal analysis they focus on the cases in which parties do not bargain. Here we focus on bargaining parties in a context where there are property-type remedies. In our next example, we consider a situation where self-selection is less likely to occur and hence sellers (owners) will generally have a higher idiosyncratic valuation of the goods they own than buyers (as in Kaplow and Shavell, 1996, p. 787).

the market, and vice-versa, so that there will be no self-selection before transactions take place. In those situations, typically owners (sellers) attach more value to their goods than potential buyers. If an owner (seller) is randomly matched with a buyer, her average valuation will likely be higher than that of the buyer, and as a result, no transactions among uninformed parties will take place.

## 4. Post-transaction acquisition of information

In this section we investigate whether typical legal and contractual solutions — that is, default duties to disclose and implied or agreed-upon warranties — may be used to help facilitate transactions and reduce the negative impact a market for gems has on social welfare. In a market for lemons, prevalent legal and contractual solutions to asymmetric information problems are based on the attachment of particular consequences to the emergence of bad news. For instance, in a contract of sale, if a purchased good turns out to be a lemon, a warranty may provide the buyer the right to return the good or to obtain a repair or replacement. These solutions to lemons problems hinge upon the fact that previously unknown "negative" information reaches the uninformed buyer after the execution of the contract.

Conversely, in a market for gems, legal and contractual solutions would have to rely on the fact that "positive" information about quality reaches the uninformed seller at some point after the sale. While in a market for lemons we rely on duties to disclose negative information and warranties, in a market for gems we should have duties to disclose positive information and "inverse" warranties,[14] where the buyer warrants that the good's quality is *lower*, rather than higher, than a certain stated value. However, ex post acquisition of information is not always as easily accomplished in gems problems as in lemons problems. In lemons problems, it is much easier for the uninformed party to become informed about the good's quality ex post.

In lemons-type situations the uninformed party is the buyer, who consequently is in possession of the good after the transaction and, most commonly, will use the good —such as, for instance, a second-hand car — or show it to third parties — for instance, a painting. Use and experience with the good will in most cases generate information about the good's quality, which in turn will induce the buyer to claim — and, ideally, prove — the seller's breach of her legal or contractual obligations.[15] Moreover, such information acquisition is often not intended or paid-for, but rather it is the byproduct of regular use. In the classic case of *Obde v. Schlemeyer*, the buyer of a house discovered termites shortly after the purchase and, after calling an exterminator — who, by chance, was the same as the seller had already called months before — realized that the termites had been there long prior to the transaction and that the seller had failed to disclose the problem.[16]

In a market for gems, serendipitous information acquisition after the transaction is unlikely and, in general, information acquisition requires positive effort. The reason is that the uninformed party in a gems-like scenario is the seller. After the transaction, it is the buyer, not the seller, who is in possession of the good and is able to use it, show it to others and, generally, experience its quality. If the seller did not have information prior to the transaction, when she was in possession of the good, it is very unlikely that she will acquire it ex post, after relinquishing possession. For instance, the seller of a painting may never realize that she sold a valuable piece of art for the price of a mediocre picture. As a result of this asymmetry in the availability of post-transaction signals of quality, traditional legal and contractual solutions to the lemons problem may not have the same impact on social welfare in a market for gems and hence are less commonly used.

## 5. Solutions for gems problems

In this section, we discuss three potential solutions to gems problems: auctions, suppression of information and inverse warranties. In this section, we take stock of the theory presented in the previous sections to define the relative scope of application of these solutions, supplementing the theoretical analysis with a study of real-life practices.

As emphasized above, auctions may function as information-revelation mechanisms if there are multiple informed potential buyers for the same good. If this is the case, competition among buyers reveals (at least partially) the value of the good to the seller and mitigates the gems problem. In many situations, however, there may be a very limited set of potential informed buyers and, in the worst-case scenario, only one. In such cases, auctions are not likely to solve the gems problem.

Suppression of information works irrespective of the number of potential buyers but its efficacy rests on the presence of a strong common-value element. If the buyer values the goods more than the seller, at each quality level, then suppression of information is a fitting solution to the gems problem. This may often be the case when the seller deals with a professional buyer (a dealer) who is specialized in matching the good with higher-value users. If this is not the case, suppressing information may result in unwanted transactions — which lower social welfare — or in the total collapse of the market, as emphasize above.

Finally, warranties rely on yet another factor, the post-transaction acquisition of information by the uninformed seller, which is largely independent from the factors favoring the use of auctions and suppression of information. When information is likely to become available to sellers after the transaction, sellers are able to act upon the warranty, which in turn would induce buyers to reveal information ex ante. If not, the warranty will be ineffective. These considerations suggest that these three potential solutions have different domains of application and are likely to be used in different contexts. Next, we examine real-life cases in which each of these solutions is observed.

### 5.1. Auctions: selling everything versus selling at the highest price

Auctions are such common and well-studied market mechanisms that we need not stress their importance as a solution for the optimal matching of buyers and sellers.[17] Yet, our analysis sheds light on a possibly under-appreciated feature of auctions. While auction design is usually focused on revenue maximization in the sale of high-value goods, our analysis suggests that the main

[14] In our analysis, a warranty is a payment from the seller to the buyer triggered by the emergence of bad news; conversely, an inverse warranty is a payment from the buyer to the seller triggered by the emergence of good news.

[15] Also in some lemons settings information may come from expertise. For instance, a pharmaceutical company (the seller) is more informed than buyers of pharmaceutical products. But the pharmaceutical company derives its informational advantage from expertise rather than from use. For this reason, a pharmaceutical product buyer may never learn through experience whether the products he purchased contributed to or hindered his recovery. Therefore, the buyer of a drug cannot rely on warranties to the same extent as, for example, used car buyers. Along these lines, Katz (2007) argues that extensive ex ante regulation of pharmaceutical products stems from the ineffectiveness of ex post warranty-type solutions. Notwithstanding this counterexample, in lemons problems, asymmetric information generally derives from use and ex post signals are prevalent, while in gems problems asymmetric information derives from expertise and ex post signals are scarce.

[16] 56 Wn.2d 449 (1960) 353 P.2d 672, discussed in depth in Kronman (1978)).

[17] See Krishna (2010) for an overview of auction theory.

function of an auction in a gems-context is the sale of low-value goods for correspondingly low prices. These are in fact the goods that would remain unsold in a bilateral transaction between an informed buyer and an uninformed seller, so that, the added value of the auction is not too much that goods are sold for higher prices but that (low-quality) goods that would otherwise remain unsold are now profitably traded. Auctions are in fact often used for the sale of goods of uncertain value acquired *en masse*, such as the estates of deceased or bankrupt individuals.

### *5.2. Suppression of information: Block-booking in the movie and diamond industries*

Another way to mitigate asymmetric information problems is for uninformed sellers to suppress information revealed to informed buyers. The analysis in Section 3 shows that in settings where both sides of the market are uninformed, more transactions may take place than in settings where only buyers are informed. One way for the seller to suppress information about goods is to bundle them together randomly through block-booking. *Unclaimed Baggage*, a company that resells items found in unclaimed airport luggages buys unclaimed bags without first opening each bag. It relies instead on the fact that, on average, luggages contain known percentages of clothing, electronics and other items. Preventing the buyer from examining each bag saves the airline time and effort, and ensures that all bags are gone.[18]

Block-booking was once a common feature of the American motion picture industry[19] and an important feature of De Beers' selling practices.[20] In both cases, the seller can easily ascertain the average value of the goods for sale (movie licenses or diamonds in our two examples, respectively), though a precise evaluation of each item would be quite costly. Since the seller is ignorant of the quality of particular goods within a bundle, some goods are underpriced and others are overpriced, which induces buyers to expend efforts in trying to identify the underpriced goods. However, if all goods are sold together in a bundle, buyers can either accept or reject the offer, but they cannot discriminate among particular goods within the bundle. If the average quality of a bundle is known to the seller, block-booking solves the asymmetric information problem by bundling low-quality with high-quality goods and preventing the buyer from buying only the latter. Most likely, buyers in the movie and diamond markets are professional dealers with systematically greater valuations than sellers along the full quality spectrum, just like *Unclaimed Baggage* is. In turn, this is the condition we identified in the theory presented above for suppression of information to yield more desirable outcomes than unbridled asymmetric information.

### *5.3. Inverse warranties: FIFA rules on the transfer of players, artists'* droit de suit*, and M&A earnouts*

A third practical solution to gems problems is an inverse warranty, which is an implied or negotiated contractual term that triggers a payment from the buyer to the seller when the traded good turn out to be of higher quality than assumed at the time of the transaction. Essentially, an inverse warranty makes the buyer's statement about the quality of the goods for sale credible and hence allows the transfer of information from informed buyer to uninformed seller. The outcome of the transaction is, therefore, analogous to the one that would obtain under full, symmetric information.[21]

Such arrangements are not uncommon. The International Federation of Football Associations (FIFA) regulates the transfer of players between clubs and establishes that a "[t]raining compensation shall be paid to a player's training club(s): (1) when a player signs his first contract as a professional and (2) each time a professional is transferred until the end of the season of his 23rd birthday" (Article 20). Moreover, "[t]he training costs are set for each category and correspond to the amount needed to train one player for one year multiplied by an average "player factor," which is the ratio of players who need to be trained to produce one professional player," (Annex 4, Article 4), so that the training compensation covers the full ex ante costs of training professional players.[22]

The potential of young players is better revealed when they play with or against more advanced professional players. Clubs training young players are at a disadvantage when evaluating the potential of players, while professional clubs may have better insights, resulting in a potential market for gems. The FIFA Regulations do not establish directly an inverse warranty but the calculation of the payment to be made to the training club reflects fully the odds of training a professional player and sets the payment equal to expected monetary costs of training one champion among many ordinary players. Such payments may occur long after the transfer and can be claimed when the "seller" (one of the training clubs, in this case) receives information about the successful career of one of its former trainees. In the interconnected world of football clubs, the revelation of this post-transaction information is very likely even when transfers involve clubs situated in different countries. This makes an inverse-warranty-like solution viable, in accordance with the predictions of the theory we presented above.

Arrangements analogous to an inverse warranty in terms of their reliance on post-transaction information are also common in other markets. The *droit de suit* recognized to artists in the European Union (Directive 2001/84) gives them a right to a percentage of the resale price of their work.[23] Similarly, earnout clauses give the selling party in mergers and acquisitions the right to receive a percentage of the future profits of the target company on account of the (possibly bilateral) asymmetry of information between the parties.[24] In both cases, inverse-warranty-like arrangements are observed in environments where post-transaction signals are likely to reach the original seller.

## 6. Conclusions

This paper analyzes the mirror image of Akerlof's lemons model: inverse adverse selection in the market for gems. We have shown that the two problems are symmetric; in fact, under certain condi-

[18] See https://www.unclaimedbaggage.com/pages/how-it-works (last accessed on January 11, 2021.

[19] The practice was declared illegal by the Supreme Court in two decisions on grounds of monopolistic behavior: United States v. Paramount Pictures, Inc., 344 U.S. 131 (1948) and United States v. Lowe's, Inc., 371 U.S. 38 (1962).

[20] Barzel (1982) and Kenney and Klein (1983).

[21] Future work should build on the model of Emons (1989) and on the results of this paper to study the effects of inverse warranties and examine how they restore a second best equilibrium in markets with informed buyers and uninformed sellers and respond to additional parties' needs besides the problem of bypassing asymmetries of information.

[22] FIFA Regulations on the Status and Transfer of Players (2020), available at https://www.fifa.com/who-we-are/legal/rules-and-regulations/documents/. There is a tension between the view that clubs have an alienable right to retain their players, which is held by most professional sports associations and federations, and the view that players are free to move, which is defended by national and international courts and legal scholars (see Indraccolo, 2011). For our purposes, the distinction is immaterial, since the core of the phenomenon that we describe is the viability of post-transaction payments — in the form of compensation or deferred price — based on the emergence of positive news.

[23] See Hansmann and Santilli (2001) for a discussion of the rationales for royalties and resale rights.

[24] See Kohers and Ang (2000) and Cain et al. (2011).

tions, the market for gems is the dual of the market for lemons. In both cases an informed party benefits from private information which adversely affects the uninformed party. In the standard case of adverse selection, market transactions only take place for low-value goods (market for lemons). Instead, in the mirror-image case of inverse adverse selection, only high-value goods are traded (market for gems).

Both of these variants are detrimental to social welfare when compared to the ideal world of where both parties are symmetrically informed about the quality of the good, because in both cases there are desirable transactions that do not take place. While lemons and gems markets generate similar — and, under some conditions, dual problems — their solutions differ. We have emphasized three dimensions along which gems and lemons require asymmetric solutions. First, competition among potential buyers may generate information that is valuable to the uninformed seller in a gems problem, but the same is not true in lemons problems. In an auction, competition forces informed parties to reveal their private information. In contrast, an auction in a lemons setting would not convey any information because the competition takes place among uninformed buyers. Similarly, informed sellers competing in a reverse auction would not convey private information that is unique to the specific items, such as defects or other negative information known by the seller that could reduce the market value of the items. Second, while buyers of potential lemons are likely to learn about the quality of the good after the transaction, sellers of potential gems may never learn the value of what they sold. This renders warranty-type instruments less effective in correcting gems problems than in correcting lemons problems. Third, while sellers of may-be gems may succeed in suppressing the superior information of their buyers, this strategy may be more difficult to implement for the potential buyers of lemons.

Along these dimensions, we have examined the feasibility and limits of three sets of solutions that for gems-like problems — auctions, block-booking, and inverse warranties — we have discussed their respective scope under different sets of circumstances. The analysis of real life remedies to gems problems shows that those solutions are in fact implemented in real-life situations under the conditions predicted by our theory.

While legal rules could create affirmative duties to disclose positive information by all buyers to their sellers, regardless of the professional expertise of the parties, commentators have observed that this requirement could end up hurting social welfare, and legal systems have generally been reluctant to impose a general duty to disclose positive information on contracting parties. The rationale for this exclusion is that a general requirement to disclose positive information would undermine the prospective buyers' incentives to search for such information (Kronman, 1978; Shavell, 1994). Resources would then be left in the hands of low-valuing uninformed parties rather than being sought and efficiently reallocated through the profit-seeking search of informed treasure hunters.

In addition to these problems, legal economists have warned against the use of legal solutions to correct for such market imperfections, stating that the respective roles of market and legal solutions to adverse selection problems should be carefully evaluated since legal intervention occasionally curtails the effectiveness of market solutions — e.g., a law that imposes mandatory warranties would eliminate the signaling value of the warranty. These unintended consequences of legal intervention could also occur in the case of inverse adverse selection, creating a prejudice for the very people that the law intended to protect.

Further research should carefully evaluate the tradeoffs between the efficiency gains obtainable by correcting inverse adverse selection problems and the potential efficiency losses created by diluting the ex ante incentives to search and use positive information to identify welfare-maximizing normative solutions in different legal scenarios, and the possible design of incentive-compatible contractual mechanisms.

On the empirical level, our analysis suggests that the inverse adverse selection problem may generate trading behavior similar to an endowment effect, i.e., the willingness-to-pay of traders is lower than their willingness-to-accept.[25] The reason is that owners of a good of unknown quality are only willing to sell it for a high price for fear of receiving a price that is too low compared to the actual quality of the good.

## References

Akerlof, G., 1970. The market for lemons: qualitative uncertainty and the market mechanism. Quart. J. Econ. 84, 488–500.

Barzel, Y., 1982. Measurement costs and the organization of markets. J. Law Econ. 25, 27–48.

Barzel, Y., Habib, M.A., Johnsen, D.B., 2006. Prevention is better than cure: the role of IPO syndicates in precluding information acquisition. J. Business 79, 2911–2923.

Cain, M.D., Denis, D.J., Denis, D.K., 2011. Earnouts: a study of financial contracting in acquisition agreements. J. Account. Econ. 51, 151–170.

Emons, W., 1989. The theory of warranty contracts. J. Econ. Surv. 3, 43–57.

Hansmann, H., Santilli, M., 2001. Royalties for artists versus royalties for authors and composers. J. Cult. Econ. 25, 259–281.

Indraccolo, E., 2011. L'indennitá di formazione degli atleti nell'ordinamento italo-comunitario. Rassegna di diritto ed economia dello sport 2, 237–269.

Kahneman, D., Knetsch, J.L., Thaler, R.H., 1990. Experimental tests of the endowment effect and the Coase theorem. J. Polit. Econ. 98, 1325–1348.

Kaplow, L., Shavell, S., 1996. Property rules versus liability rules: an economic analysis. Harv. Law Rev. 109, 713–790.

Katz, A., 2007. Pharmaceutical lemons: innovation and regulation in the drug industry. Michigan Telecommun. Technol. Law Rev. 14, 1–41.

Kenney, R.W., Klein, B., 1983. The economics of block booking. J. Law Econ. 26, 497–540.

Kohers, N., Ang, J., 2000. Earnouts in mergers: agreeing to disagree and agreeing to stay. J. Business 76, 445–476.

Krishna, V., 2010. Auction Theory, 2nd ed. Academic Press, New York.

Kronman, A.T., 1978. Mistake, disclosure, information, and the law of contracts. J. Legal Stud. 7, 1–34.

Shavell, S., 1994. Acquisition and disclosure of information prior to sale. Rand J. Econ. 25, 20–36.

[25] Kahneman et al. (1990).