Journal of Cybersecurity, 2026, , 1–11
DOI added during production
Published: Date added during production
Paper

Breaking the Ice: Contract Transparency and Newcomers in an Underground Market

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Abstract

Anonymous traders in underground markets need to establish trust, and newcomers cannot rely on reputation to do so. We study one tool available to them: making the terms of a contract publicly visible. Hack Forums introduced a contract system in June 2018 in which contracts are private by default, but the contract maker can make the terms visible to all forum members. Using 205,869 contracts with observed visibility, together with each participant's trading history at the time of each contract, we document three patterns. First, public contracts are used mainly with newcomers rather than by them: visibility falls sharply with the experience of the accepting party, even when the maker is highly experienced. Second, experienced accepters take almost every private offer but decline public offers markedly more often, particularly when the offer comes from a newcomer, while new accepters show no such reluctance. Third, visibility is persistent: pairs and users who have traded publicly before are much more likely to do so again. These patterns hold both while contracts were optional and after the forum made them mandatory in March 2019. The mandate coincided with a sharp fall in public contracting across all experience categories, after which visibility was used almost only when the accepting party lacked a track record. The results are consistent with transparency serving as an accountability device for trading with strangers, one that complements rather than replaces market-level trust mechanisms. They also imply that public contracts are an unrepresentative window onto what is traded in such markets.

Keywords transparency, trust, underground markets, cold start problem, reputation, cybercrime

Introduction

Trade between strangers requires trust, and trust is hardest to establish where it is most needed. Participants in underground markets typically do not know who they are trading with, cannot verify the quality of what is offered, and have no recourse to courts or refund mechanisms if a trade goes wrong [8, 7]. Many such markets therefore rely on mechanisms provided by the market itself: reputation systems in which traders rate one another, moderators who adjudicate disputes, and restrictions on who may trade [23, 1, 6]. These mechanisms help established traders, but they offer little to a newcomer. A participant without a trading history has no reputation to show and no record for others to inspect. This is the cold start problem.

Newcomers in underground markets can try to overcome it by their own means. Prior work shows that new traders start with low-value contracts [21], adopt the slang and jargon that others associate with experienced members [10], and provide more detail in their advertisements [9]. In this paper, we study an additional tool that has received little attention: making the terms of a trade publicly visible. A public contract exposes what each party has promised to anyone who cares to look, including moderators and potential future trading partners. Making a contract public therefore makes a failure to deliver easier to verify.

We study this choice on Hack Forums, one of the largest English-language underground forums. In June 2018 the forum introduced a contract system through which members formalise trades, and in March 2019 it made the use of contracts mandatory. Contracts are private by default, so only basic information such as the parties and the status is shown to other members. The participant who creates a contract, the maker, can however choose to make it public, in which case its full terms become visible to all members. The other party, the accepter, can accept or decline the contract but cannot change it. This setting allows us to observe directly when traders choose to be transparent, with whom, and how their counterparties respond. The introduction of the mandate also allows us to compare the same choices under two regimes: one in which traders opted into the contract system, and one in which everyone had to use it.

We use 205,869 contracts made between June 2018 and September 2020, the period in which the visibility of each contract is directly observed, together with the trading history of both parties at the time of each contract. We ask three questions: in which contracts traders choose visibility, how counterparties respond to public offers, and whether the choice

Received: Date Month Year. **Revised received:** Date Month Year. **Accepted:** Date Month Year
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is made afresh for each contract or persists within particular pairs and users.

We find, first, that public contracts are used mainly *with* newcomers rather than *by* them. The probability that an offer is public falls steeply with the experience of the accepter. Under mandatory contracting, an offer to an accepter who has never traded before is public 12.9% of the time, compared with 1.9% for an accepter with more than 50 prior contracts. This pattern holds even when the maker is highly experienced and thus has little reason to signal their own trustworthiness. Second, experienced accepters are reluctant to trade on public terms. Under the mandate, they accepted almost all private offers but were 15.5 percentage points less likely to accept a public one, whereas newcomers accept public offers at least as often as private ones. This reluctance is concentrated on public offers from inexperienced makers: experienced accepters are 33.5 percentage points less likely to accept a public offer from a maker without prior contracts, but about as likely to accept one from another experienced trader. Third, visibility is persistent. When the previous contract between two traders was public, the next one is public far more often than when it was private, and makers and accepters who have previously been party to a public contract are more likely to be so again, even holding their experience fixed.

The comparison across regimes adds a further result. The mandate coincided with a sharp fall in public contracting across all categories of maker and accepter experience, so the decline in transparency was not simply the consequence of the market filling with experienced traders. While contracts were optional, both the maker's and the accepter's experience predicted visibility. Under the mandate, the maker's own experience matters little, and visibility is concentrated almost entirely on contracts with inexperienced accepters. Together, these patterns are more consistent with transparency serving to hold an unknown counterparty to account than with newcomers using it to signal their own honesty. They also suggest that market-level mechanisms and individual transparency are complements: as the former became universal, the latter narrowed to the cases the former did not cover.

Our work relates to a large literature on trust and reputation in online markets. Studies of eBay show that feedback is predictive of future trade, that buyers pay more to established sellers, and that a seller's first negative rating sharply slows their subsequent sales [17, 18, 3]; Tadelis [20] reviews this evidence. Reputation systems also operate in underground markets, where they filter out low-quality traders but lose informativeness as most ratings are positive [13, 4, 6], and where forum administrators and hierarchies of trusted members play an important role [11, 22]. The difficulty of entry for traders without a history is well documented in legitimate markets: Pallais [14] shows that inexperienced workers on an online labour platform are hired too rarely, because the public information generated by a first job benefits future employers rather than the employer who provides it. Underground markets face the same problem, with fewer remedies.

We contribute to this literature in four ways. First, we document transparency as a trust device in an underground market and show that it is directed mainly at counterparties without a track record, rather than used by newcomers to advertise their own honesty. Second, we show that established traders decline public terms, particularly when offered by newcomers, which helps explain why transparency is rare in mature markets dominated by experienced sellers. Third, we show how the use of transparency changes when a market-level mechanism, compulsory contracting, is introduced. This extends prior work on the Hack Forums contract system [21, 10] and revises the conclusion of an earlier version of this study [12] that experience and reputation gradually replace transparency. Finally, our results carry a methodological implication. Researchers and law enforcement frequently learn what is traded in underground markets from the information that participants make visible [16, 5]. Because public contracts are concentrated among newcomers and in particular periods, they form an unrepresentative window onto the market.

The remainder of the paper is organised as follows. Section 2 discusses the incentives to make a contract public and derives our predictions. Section 3 describes the forum, the contract system and the data. Section 4 presents the results, and Section 5 discusses their implications and limitations.

Incentives and predictions

This section sets out, informally, the costs and benefits of making a contract public, and derives the predictions we take to the data. We do not develop a formal model. Our aim is to state clearly which patterns each motive implies, so that the results in Section 4 can be read against them.

What visibility changes.

The two parties to a contract see its full terms regardless of its visibility. Making a contract public therefore reveals nothing new to the counterparty. What it changes is the audience: the terms become visible to every other member of the forum, including moderators who may later adjudicate a dispute and traders who may later consider dealing with either party. Any benefit or cost of visibility must therefore come through third parties. The choice rests with the maker, while the accepter can only accept or decline the contract as offered. As we discuss in Section 3, accepters are usually the sellers.

Benefits of a public contract.

The main benefit is accountability. When the terms of a contract are public, a failure to deliver can be verified by anyone, not only by the counterparty. A trader who reneges on a public contract therefore risks losing the trust of the wider market, and in a dispute, moderators can compare what was promised with what was delivered. This matters most when the counterparty has little else at stake. An established trader with a long and positive history already stands to lose a valuable reputation by cheating, so making their obligations public adds little discipline. A newcomer has no such reputation to lose, and a public record of their obligations partly substitutes for it. A public contract can also benefit the party who proposes it. Committing publicly to verifiable terms is costlier for a trader who intends to cheat, so a new maker may use a public offer to signal their own trustworthiness. Relatedly, a newcomer who completes public contracts accumulates a history that future partners can inspect in detail, beyond the ratings and contract counts shown on every profile.

Costs of a public contract.
The main cost is exposure. A public contract reveals what is traded, at what price and by which payment method. For a high-volume trader, this information is commercially valuable to competitors, and in an underground market it may also attract unwanted scrutiny from moderators, researchers or law enforcement. The exposure cost therefore grows with the volume and visibility of a trader's business, and it falls on both parties. A public offer may also be read as a sign of distrust. An established seller who receives a public offer from an unknown buyer may infer that the buyer doubts them, or is preparing to dispute the outcome, and a seller with many other buyers can afford to turn such an offer away.

Predictions.
A public contract involves two decisions: the maker decides whether to offer public terms, and the accepter decides whether to accept them. Each decision can depend on the experience of both parties, and the considerations above indicate in which direction.

For the maker's decision, the accountability motive implies that public offers should be concentrated on accepters with little history, and that this should hold even for experienced makers, who have no need to signal their own trustworthiness. The signalling and record-building motives, together with exposure costs, imply that inexperienced makers should be more likely to go public than experienced ones. Comparing the two sides indicates which motives dominate.

Prediction 1. The probability that an offer is public (a) decreases with the accepter's prior experience, including for experienced makers, and (b) decreases with the maker's own prior experience.

For the accepter's decision, exposure costs fall mainly on established sellers, who also gain least from the protection that a public contract offers. Since accepters cannot alter the contract, their only way to avoid these costs is to decline the offer. If public offers also signal distrust, this reluctance should be strongest when the offer comes from a maker without a track record.

Prediction 2. Relative to private offers, public offers are (a) less likely to be accepted by experienced accepters than by inexperienced ones, and (b) especially unlikely to be accepted by experienced accepters when they come from inexperienced makers.

Persistence.
The two motives above treat visibility as a response to the circumstances of each contract. If so, visibility should fade as a pair of traders, or an individual trader, accumulates history: a second contract with a partner who delivered the first time should require less accountability than the first. Visibility could, however, persist for other reasons. Some traders may simply prefer to trade publicly, some recurring kinds of deal may routinely be made public, and an accepter who asked for a public contract once may do so again. We do not derive a prediction here. We instead ask whether visibility is persistent within pairs and within users, holding experience fixed, as a way to assess how far the choice reflects the circumstances of each contract rather than stable habits or arrangements.

Optional and mandatory contracting.
The forum made contracts mandatory in March 2019. Before then, using a contract at all was a choice, and a contract already offered some accountability through ratings and the dispute system. Traders who opted into the system were therefore those who valued that accountability, and some of them may have sought more of it by going public. After the mandate, every trade required a contract, including trades between traders who saw no need for one. We therefore expect public contracts to be less common under the mandate. We also examine both predictions separately in the two regimes. If the patterns hold in both, they are unlikely to be an artefact of which traders chose to use contracts at all.

Setting and data

Hack Forums and its contract system

Hack Forums is one of the largest English-language underground forums, with over 5 million members and an archive of more than 62 million posts. Members have long traded informally on its marketplace, offering goods and services ranging from currency exchange and online accounts to hacking tools and malware. In June 2018, the forum administrators introduced a contract system through which members formalise their trades, and in March 2019 they made its use mandatory for all marketplace transactions.

A contract is created by one party, the *maker*, either by completing a blank contract form or by finalising a form pre-filled from a thread advertising goods or services. The maker specifies the contract type (sale, purchase, exchange, trade or vouch copy) and each party's obligations, including any payment terms. The other party, the *accepter*, can accept the contract, deny it, or let it expire, but cannot edit it. Once accepted, a contract is active until both parties mark it as complete. A contract that is not marked complete before its deadline is recorded as incomplete. Either party can open a dispute if they believe the other has not met their obligations, and administrators may then take action against the offending account, although the wronged party is not compensated.

Every contract is private by default. Other members can then see only basic information: the contract type, the parties, the date and the status. The maker can instead choose to make the contract public, in which case the obligations, payment details and terms become visible to all members. A member's profile shows their past contracts, disputes and ratings regardless of visibility. After each contract, the parties can rate one another as positive, neutral or negative, and these ratings accumulate into a visible reputation score.

Contract types are used inconsistently. Many contracts labelled as sales are in fact purchases by the maker, and the earlier version of this study found that in most contracts the accepter is the seller [12]. Accepters are twice as likely as makers to have posted threads advertising goods or services, and in contracts labelled as sales, accepters thank makers for a purchase eight times more often than the reverse. We therefore do not rely on the type labels to identify buyers and sellers, and refer to the parties by their roles in the contract throughout. Where interpretation requires it, we note that accepters are usually sellers.

Data

Our data come from CrimeBB, a collection of posts and related records scraped from underground forums and maintained by the Cambridge Cybercrime Centre, which makes it available to academic researchers under a data-sharing agreement [15]. The Hack Forums contract data contain 348,339 contracts created between June 2018 and November 2022. For each contract, we observe its type, status, visibility, the identities of both parties, and each party's ratings. From these, we reconstruct each party's history at the time of the contract: the number of contracts they had previously made or accepted, how many of these were completed, disputed or public, and the ratings they had received.

Visibility is not observed for every contract. The forum resets contracts to private six months after they are made. Contracts created between 7 September 2020 and 2 June 2022, around 35% of the full data, were collected only after this reset, so their original visibility is unknown. Contracts created from June 2022 onwards were collected within six months and their visibility is recorded correctly. The earlier version of this study imputed visibility for this period using a classifier. Because visibility is our main variable of interest, we instead restrict the analysis to contracts whose visibility is directly observed. Our main sample covers the continuous period from 10 June 2018 to 6 September 2020. We exclude contracts that were still active or awaiting approval at the time of collection, as their outcome is unknown. The resulting sample contains 205,869 contracts between 43,333 distinct participants. We use the 17,249 contracts made from June 2022 onwards, for which visibility is again observed, only as a robustness check.

Measures

Our main explanatory variables are the maker's and the accepter's experience, measured as the number of contracts each had taken part in, in either role, before the focal contract. Because experience is highly skewed, we group it into six categories: no prior contracts, 1–2, 3–5, 6–10, 11–50, and more than 50. The two roles differ sharply. Makers are often new to the market: 17.9% of contracts are the maker's first. Accepters are mostly established: only 3.1% of contracts are the accepter's first, while 70.5% involve an accepter with more than 50 prior contracts. This reflects a market in which many occasional buyers trade with a small number of high-volume sellers.

We classify each contract into one of five outcomes: not accepted (denied or expired), cancelled (cancelled or invalid), incomplete, complete, and disputed. To study acceptance, we compare not accepted contracts with those that were accepted, that is, incomplete, complete or disputed. We exclude cancelled contracts from this comparison, because a cancellation can occur either before or after acceptance. We also note that a contract recorded as incomplete need not have failed: a contract becomes incomplete whenever its deadline passes without both parties marking it complete, which may also happen after a successful trade that neither party formally closed.

For the analysis of persistence, we record whether the previous contract between the same two participants, in either role, was public, and whether each participant had previously been party to at least one public contract. Because visibility is unobserved during the gap, these histories are complete only within the main sample period. We also use each participant's prior completion rate, prior disputes, prior scam accusations, and the average of the ratings they had received.

Table 1. Contracts in the main sample by visibility

	Private	Public	All
Contracts	194,233	11,636	205,869
Contract type (%)			
Sale	65.6	47.8	64.6
Purchase	11.2	21.5	11.8
Exchange	21.4	27.7	21.8
Trade	1.1	2.4	1.2
Vouch copy	0.7	0.5	0.7
Outcome (%)			
Not accepted	5.7	14.3	6.2
Cancelled	8.7	16.8	9.2
Incomplete	41.5	16.9	40.1
Complete	43.1	48.9	43.4
Disputed	0.9	3.1	1.1

Note: Contracts made between 10 June 2018 and 6 September 2020, excluding contracts that were active or awaiting approval at the time of data collection. Not accepted contracts were denied or expired; cancelled contracts were cancelled or invalid.

Table 1 summarises the main sample. Public contracts make up 5.7% of the total. They differ from private contracts in several respects: they are more often purchases and exchanges and less often sales, and they are more than twice as likely to be declined, nearly twice as likely to be cancelled, and three times as likely to be disputed. Public contracts are also much less often recorded as incomplete, which is consistent with public contracts being more carefully closed.

Market development

Figure 1 shows how the market developed over the main sample period. Panel A shows the number of contracts made each month. Between June 2018 and February 2019, while the use of contracts was optional, between 2,000 and 4,000 contracts were made each month. When contracts became mandatory in March 2019, monthly volume nearly tripled, to around 10,600, and it remained mostly between 8,000 and 13,500 thereafter. Of the contracts in our sample, 28,147 were made under optional contracting and 177,722 under the mandate.

Panel B shows the share of contracts that were public. Around a quarter of contracts were public in the first months of the system. The share declined steadily to around 10% by February 2019, halved to 5% when contracts became mandatory, and drifted down to around 3% by mid-2020. Overall, 17.6% of contracts were public under optional contracting, compared with 3.8% under the mandate.

Part of this decline reflects the changing mix of traders. As the market matured, a growing share of contracts involved experienced participants, who use public contracts less often. To gauge how much of the decline this explains, the dashed line in Panel B shows the public share that would have arisen if the public rate within each combination of maker and accepter

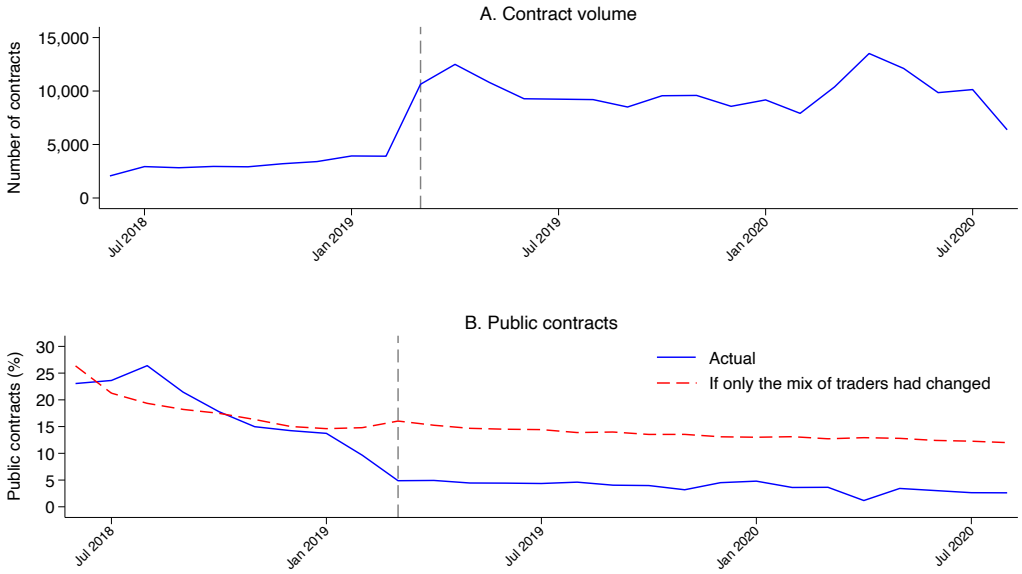


Figure 1 Contract volume and public share by month. Panel A shows the number of contracts made each month. Panel B shows the share of contracts that were public (solid line) and the share implied by each month's mix of maker and accepter experience, holding the public rate within each combination of experience categories at its level before March 2019 (dashed line). The vertical line marks March 2019, when the use of contracts became mandatory. September 2020 is omitted because only six days are observed.

experience had stayed at its level before March 2019, so that only the mix of traders changed. The changing mix accounts for much of the gradual decline during 2018, when the two lines move together. It does not account for the fall at the mandate. In March 2019 the actual share halved, while the share implied by the mix of traders stayed between 12% and 16% for the rest of the period. Public contracting thus fell within experience groups when contracts became mandatory, as Figure 2 confirms for every category of maker and accepter experience, consistent with the arrival of traders who used contracts only because they had to. For this reason, we report our main results separately for the optional and mandatory periods.

Empirical approach

We estimate linear probability models in which the outcome is whether an offer is public (Prediction 1) or whether it was accepted (Prediction 2). Every contract in our data begins as an offer by the maker, including those that were later declined, so the first outcome describes the maker's choice. All models include the experience categories of both parties, the contract type, and calendar month fixed effects, which absorb any change over time that is common to all contracts. To compare the two regimes, we interact the experience categories with an indicator for the mandatory period, and we report adjusted predicted probabilities for each experience category within each period. To examine whether acceptance depends on who makes the offer, we additionally interact visibility, the accepter's experience and three groups of maker experience (none, 1 to 50, and more than 50 prior contracts), pooling the two periods to retain enough public offers in each cell. Standard errors are clustered by maker, since the same maker appears in many contracts. Our estimates describe associations, conditional on these controls, and we do not interpret them as causal effects of experience or visibility.

Ethics

This study was approved by the Department's research ethics committee.[1] CrimeBB is collected using web scrapers, so the individuals concerned have not given informed consent. Established guidelines for online research into criminal activity indicate that informed consent may not be required where data are publicly available and the research focuses on collective rather than individual behaviour [2]. We report only aggregate results, publish no information that could identify individual users, and do not quote usernames. The data are stored and handled securely under the terms of the CrimeBB data-sharing agreement.

Results

Who offers public terms

Because the maker sets the visibility of a contract, the question of who goes public is a question about the maker's choice: which makers offer public terms, and to which counterparties. Figure 2 shows both sides of this choice, separately for the optional and mandatory periods. Panel A shows how the probability that an offer is public varies with the experience of the accepter, corresponding to part (a) of Prediction 1. Panel B shows how it varies with the maker's own experience, corresponding to part

[1] Approval was provided by the Department of Computer Science and Technology at the University of Cambridge; ethics approval number #2152.

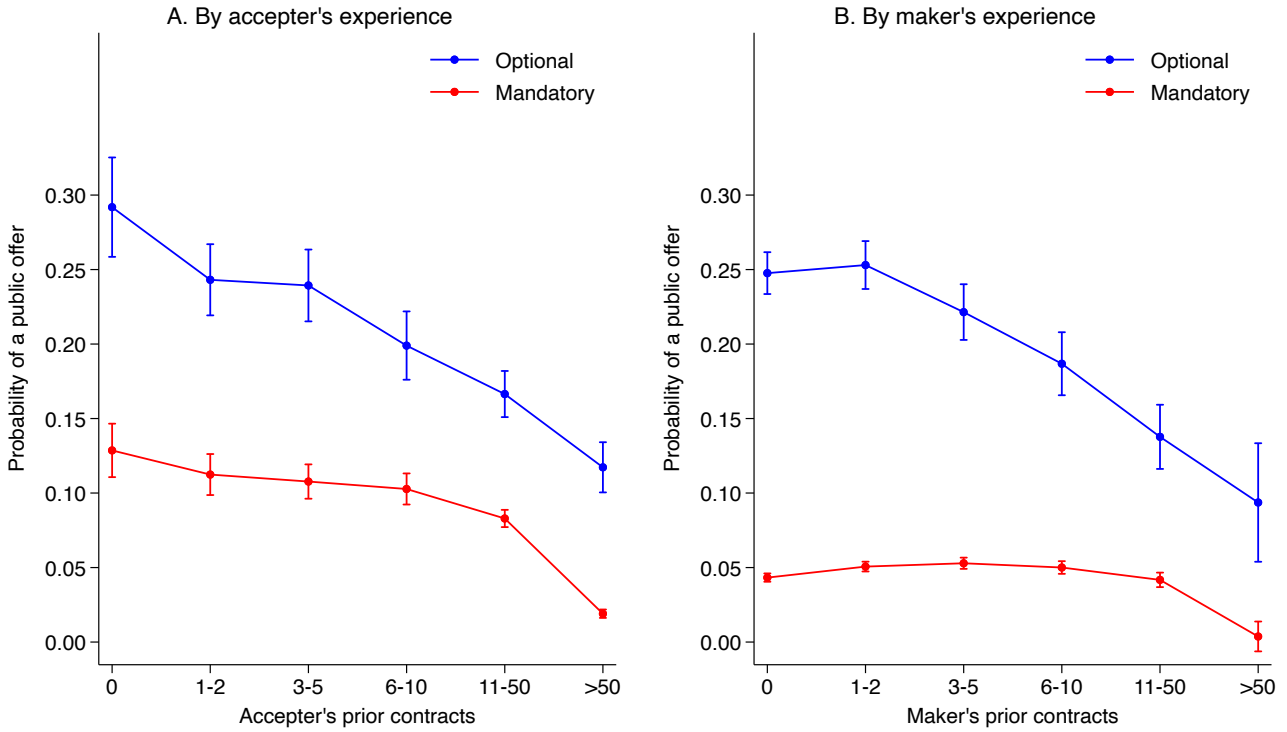


Figure 2 Probability that an offer is public, by the prior experience of the accepter (Panel A) and of the maker (Panel B), under optional (before March 2019) and mandatory contracting. Predicted probabilities from a linear probability model that interacts both parties' experience categories with an indicator for the mandatory period and controls for contract type and calendar month. Bars show 95% confidence intervals based on standard errors clustered by maker.

(b). Each probability is computed from a model that includes both parties' experience, the contract type and the calendar month.

Panel A is consistent with part (a) of Prediction 1. In both regimes, the probability that an offer is public falls steadily with the accepter's experience. Under optional contracting, an offer to an accepter who had never traded before was public 29.2% of the time, compared with 11.7% for an accepter with more than 50 prior contracts. Under the mandate, the corresponding figures are 12.9% and 1.9%. The decline is smaller in percentage points under the mandate, because public offers are less common overall, but it is steeper in relative terms: an offer to a new accepter is about seven times as likely to be public as one to a highly experienced accepter, compared with about two and a half times under optional contracting.

The pattern also holds for experienced makers, who have little reason to signal their own trustworthiness. Among makers with more than 50 prior contracts, 11.0% of offers to a new accepter were public, compared with 2.0% of offers to an accepter with more than 50 prior contracts. Such makers nevertheless chose public terms markedly more often when their counterparty lacked a track record.

Panel B shows that part (b) of the prediction holds mainly under optional contracting. In that period, the maker's experience mattered almost as much as the accepter's: the probability of a public offer fell from 24.8% for makers without prior contracts to 9.4% for makers with more than 50. Under the mandate, it varies little, staying between 4% and 5.5% for makers with up to 50 prior contracts, before falling to near zero for the most experienced makers. The difference in both gradients between the two regimes is statistically significant ($p < 0.001$ for each). Under mandatory contracting, therefore, visibility was used almost only when the accepter lacked experience.

Taken together, these patterns indicate that accountability is the more important motive. The accepter's experience is the stronger and more stable predictor of visibility, and experienced makers, who have no need to signal their own trustworthiness, respond to it. The maker's own inexperience mattered while contracting was voluntary, when makers who opted into the contract system were more likely to go public when they were new to it, but it largely ceased to matter once contracts became mandatory.

Who accepts public terms

Prediction 2 concerns the other side of the contract: once the maker has chosen visibility, the accepter decides whether to accept. Figure 3 shows the difference between the probability that a public offer is accepted and the probability that a private offer is accepted, by the accepter's experience. A positive value means that public offers are accepted more often than private ones. Panel A shows this difference separately for the optional and mandatory periods, corresponding to part (a) of

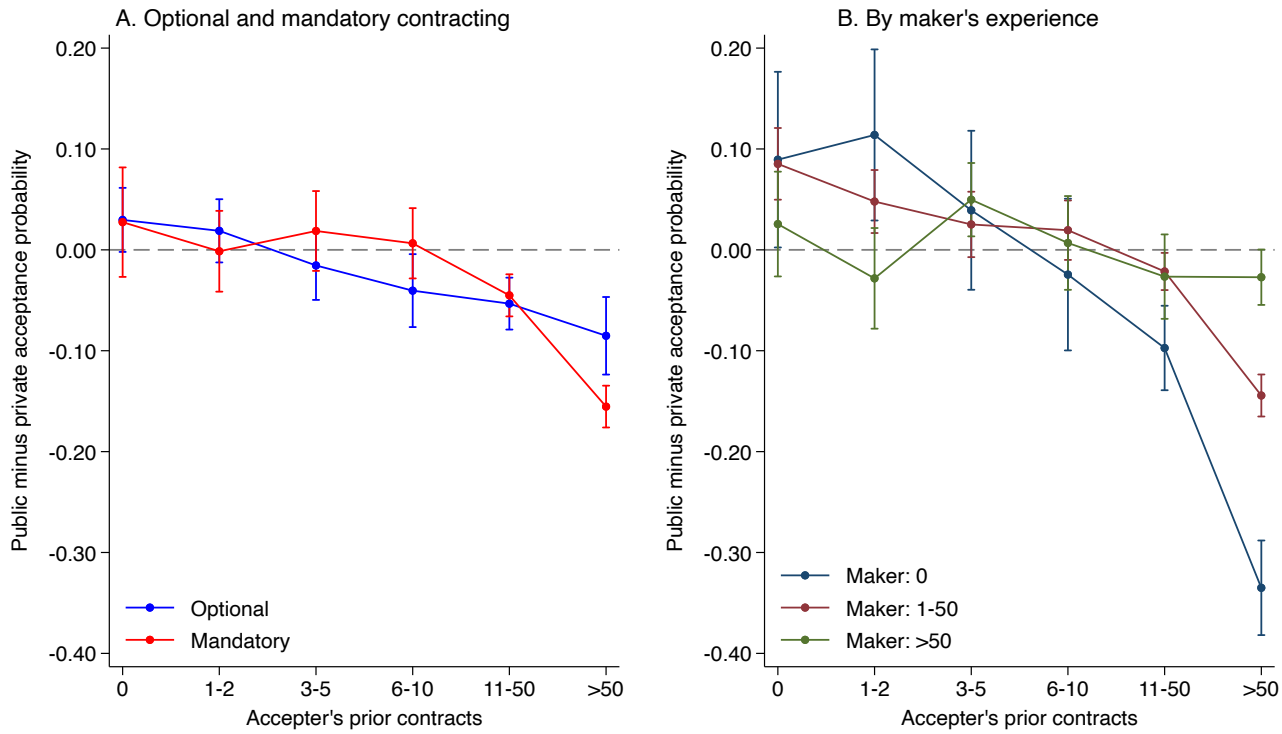


Figure 3 Difference between the probability that a public and a private offer is accepted, by the accepter's prior experience, under optional and mandatory contracting (Panel A) and by the maker's prior experience, pooling both periods (Panel B). Accepted contracts are those recorded as incomplete, complete or disputed; contracts not accepted were denied or expired. Cancelled and invalid contracts are excluded. Panel A: estimates from a linear probability model that interacts visibility, the accepter's experience and the mandatory period, and controls for the maker's experience, contract type and calendar month. Panel B: estimates from a model that interacts visibility, the accepter's experience and three groups of maker experience, and controls for the mandatory period, contract type and calendar month. Bars show 95% confidence intervals based on standard errors clustered by maker.

the prediction. Panel B shows it separately by the maker's experience, pooling the two periods, corresponding to part (b).

Panel A is consistent with part (a) of Prediction 2. Accepters without prior contracts accept public offers slightly more often than private ones, by 3.0 percentage points under optional contracting and 2.7 points under the mandate, although neither difference is precisely estimated. As the accepter's experience grows, the difference turns negative. For accepters with more than 50 prior contracts, public offers are 8.5 points less likely to be accepted than private offers under optional contracting, and 15.5 points less likely under the mandate. The change in this pattern between the two regimes is statistically significant ($p = 0.004$).

The levels behind these differences are informative. Experienced accepters under the mandate accepted 97.0% of private offers but only 81.4% of public ones. For new accepters, acceptance was lower overall but similar for public and private offers (76.3% and 73.5%). Experienced accepters, in other words, are not more reluctant to trade in general; they accept almost every private offer, and public offers lose this near-automatic acceptance.

Panel B is consistent with part (b). For accepters with up to ten prior contracts, the acceptance gap is similar whoever makes the offer. For experienced accepters, it depends strongly on the maker. Accepters with more than 50 prior contracts are 33.5 percentage points less likely to accept a public offer than a private one when it comes from a maker without prior contracts, and 14.4 points less likely when it comes from a maker with 1 to 50 prior contracts. When the offer comes from a maker with more than 50 prior contracts, the difference is small and not statistically significant (-2.7 points). The hypothesis that the acceptance gap does not depend on the maker's experience is clearly rejected ($p < 0.001$).

The reluctance of experienced accepters is therefore concentrated on public offers from strangers. This pattern is difficult to explain by exposure costs alone, which an established seller would bear whoever made the offer. It fits better with the view that a public offer from an unknown buyer signals distrust, which an established seller with many other buyers can afford to decline. Public offers between experienced traders, by contrast, may reflect routine arrangements between partners who have chosen to trade publicly, consistent with the persistence we document in Section 4.3.

One caveat applies. We observe only the offers that makers chose to make, and public offers to experienced accepters are rare: they make up 2.2% of offers to accepters with more than 50 prior contracts. If makers offer public terms to such accepters only in unusual circumstances, part of the lower acceptance rate

Table 2. Persistence of public visibility

	Pooled	Optional	Mandatory
A. Pair level			
Previous pair contract public	0.648***	0.733***	0.589***
	(0.020)	(0.022)	(0.028)
Mean share public	0.041	0.122	0.027
Contracts	62,553	9,367	53,186
B. Participant level			
Maker's previous contract public	0.333***	0.422***	0.284***
	(0.015)	(0.021)	(0.017)
Accepter's previous contract public	0.126***	0.157***	0.104***
	(0.008)	(0.019)	(0.007)
Mean share public	0.053	0.152	0.037
Contracts	163,174	21,701	141,473

Note: Linear probability models of whether an offer is public. All columns control for the maker's and the accepter's experience, the contract type and the calendar month. Panel A uses contracts between two participants who have previously traded with each other, in either role; the regressor indicates that their previous contract was public. Panel B uses contracts in which both participants have at least one prior contract; the regressors indicate that the maker's and the accepter's own previous contract, with any partner and in either role, was public. Optional: contracts before March 2019; mandatory: from March 2019. Standard errors clustered by maker in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

may reflect those circumstances rather than the visibility itself. Conversely, if makers anticipate rejection and avoid public offers to experienced accepters, the observed difference understates their reluctance.

Persistence of visibility

If visibility responded only to the circumstances of each contract, it should fade as traders accumulate history with one another. It does not. Holding both parties' experience fixed, the probability that an offer is public is essentially the same for the first contract between two traders as for later ones (5.6%, 5.6% and 5.7% for the first, second, and third or later contract; $p = 0.91$). Yet visibility is strongly persistent within pairs. When the previous contract between two traders was public, the next one was public 67.8% of the time, compared with 1.1% when the previous contract was private.

Table 2 reports this back-to-back persistence with controls for both parties' experience, the contract type and the calendar month. Panel A shows that a public previous contract within the pair raises the probability that the current offer is public by 65 percentage points overall, by 73 points under optional contracting and by 59 points under the mandate. Panel B shows that persistence also operates at the level of individual traders, whoever their previous partner was. A maker whose own previous contract was public is 33 points more likely to make the current offer public, and an accepter whose previous contract was public is 13 points more likely to receive a public offer, even though the maker sets the visibility. Persistence is thus strongest within pairs, weaker for makers across partners, and weakest for accepters. All three effects are larger under optional contracting in absolute terms, but because public contracts were much rarer under the mandate, they are larger relative to the average.

These effects fade only gradually. Among pairs with at least ten contracts together, those whose first contract was public still made 56% of their tenth contract public, compared with about 1% for pairs whose first contract was private, although only 36 such pairs began publicly. Among makers with at least nine later contracts with partners other than their first, the difference between those whose first contract was public and those whose first contract was private falls from 30 percentage points at the first such contract to 12 points at the ninth.

The accepter-level effect is notable because accepters cannot set visibility. It suggests that some accepters request public terms, or that they repeatedly engage in the kinds of trade that are made public. We cannot distinguish habits from stable preferences or recurring types of deal, and we do not interpret these estimates causally. The main implication is that visibility is not chosen afresh for every contract: a substantial share of public contracts beyond first encounters reflects the continued practice of particular traders and pairs.

Further patterns

We next report several further patterns. They are descriptive and are not tests of our predictions, but they help interpret the main results.

Track record.
Holding experience fixed, accepters with poorer ratings are offered public contracts more often. Compared with an accepter without any ratings, an accepter whose ratings were all positive is no more likely to be offered a public contract (-0.2 percentage points), while an accepter with a neutral average rating is 9.0 points more likely, and one with a negative average rating 18.2 points more likely. This is consistent with visibility being used for accountability when a counterparty's record gives reason for caution. Other measures of the track record give a less clear picture: a previous dispute is associated with a small increase in visibility (0.5 points), previous scam accusations with none, and a higher prior completion rate with slightly more public contracts. As noted in Section 3.3, completion rates partly reflect whether traders formally close their contracts, which limits their value as a measure of reliability.

Outcomes of accepted contracts.
Among accepted contracts, 70.9% of public contracts were completed and 4.5% disputed, compared with 50.4% and 1.1% of private contracts. After controlling for both parties' experience and track records, the pair's history, the contract type and the month, public contracts with new accepters are 4.1 percentage points more likely to be completed, while the difference is close to zero for accepters with six or more prior contracts. Disputes show the reverse pattern: there is no significant difference for accepters with up to two prior contracts, but public contracts with accepters with three or more prior contracts are 1.2 to 3.2 points more likely to be disputed. A higher dispute rate need not indicate worse behaviour. Public terms give moderators evidence against which to judge a complaint, so disputes over public contracts may be easier to raise and to resolve. We do not interpret these differences as effects of visibility, since public contracts differ from private ones in ways we cannot observe.

Subsequent activity of newcomers.
If visibility mainly helped newcomers build a record, those whose first contract was public might go on to trade sooner. We find little evidence for this. Among participants whose first contract was made at least 90 days before the end of the main sample, makers whose first contract was public were no more likely to trade again within 90 days than those whose first contract was private (a difference of 0.5 percentage points), and accepters were slightly less likely to do so (-3.9 points).

Forum discussions.
Discussions among forum members help to explain why visible terms might matter. To avoid reproducing identifiable text, we paraphrase rather than quote. The administrators describe the marketplace before the contract system as one in which traders had to protect themselves from scammers on their own, and participants broadly welcomed the system and its later mandate. In a discussion from July 2018, shortly after contracts were introduced and before they became mandatory, members were nevertheless sceptical that ratings and contract counts alone signal trustworthiness. Several pointed out that traders exchanged small sums for positive ratings, which undermines what a rating conveys, and that a profile with a hundred completed contracts says little unless others can see with whom those contracts were made and what they involved. Members suggested that contract values be displayed on profiles, and advised others to examine a partner's trade and dispute history rather than rely on their rating. Experienced members and administrators elsewhere give similar advice to check a partner's profile and previous contracts before trading, and newcomers, with little to inspect, are treated with more suspicion.

In the same discussion, members described public contracts as a remedy for these weaknesses. Listing contracts publicly was presented as useful information that helps to prove a trader's legitimacy, and one member concluded that legitimate traders keep their contracts public, while a profile with many private contracts should raise suspicion. This view treats visibility as a signal of the trader's own honesty. It fits the patterns we find while contracting was optional, the period in which this discussion took place, when the maker's own inexperience still predicted public terms. Under the mandate, as Section 4.1 shows, visibility became concentrated on contracts with inexperienced counterparties instead.

Robustness

The main results are robust to several alternative specifications. First, controlling for each party's reputation at the time of the contract (prior completion rate, prior disputes, prior scam accusations and average rating received) leaves both predictions essentially unchanged: under the mandate, a contract with a new accepter is public 14.1% of the time against 2.0% for an accepter with more than 50 prior contracts, and the acceptance gap for such accepters is -15.8 percentage points. Second, clustering standard errors by both maker and accepter leaves all key contrasts significant at the 1% level. Third, the pattern in Panel B of Figure 3 is unchanged when estimated on the mandatory period alone: for accepters with more than 50 prior contracts, the acceptance gap is -33.6 points for offers from makers without prior contracts, -14.4 points for makers with 1 to 50, and -3.8 points for makers with more than 50. Fourth, treating cancelled contracts as not accepted strengthens the evidence for part (a) of Prediction 2: the acceptance gap for accepters with more than 50 prior contracts widens to -9.8 points under optional contracting and -24.8 points under the mandate. Finally, in the 17,249 contracts made from June 2022, when visibility is again observed, contracts with new accepters are public 16.8% of the time against 4.8% for accepters with more than 50 prior contracts, and such accepters remain much less likely to accept public offers (-20.0 points). The acceptance gap for new accepters in this period is too imprecisely estimated to be informative.

Discussion

We have studied when traders in an underground market choose to make the terms of a contract public. Three patterns emerge. First, public contracts are used mainly with newcomers rather than by them: visibility falls steeply with the accepter's experience, including when the maker is highly experienced. Second, established accepters are reluctant to trade on public terms: they accept almost every private offer but decline public offers markedly more often, mainly when the offer comes from a newcomer. Third, visibility is persistent within pairs and within individual traders. All three patterns hold both while contracts were optional and after they became mandatory, and the mandate itself coincided with a sharp fall in public contracting across all experience categories.

Transparency as accountability.
These patterns are more consistent with transparency serving to hold an unknown counterparty to account than with newcomers using it to signal their own honesty. Making the terms of a contract public adds nothing to what the two parties already know; its value lies in what third parties can later verify. That value is greatest when the counterparty has no reputation at stake. Established sellers, in turn, are reluctant to accept public terms, especially from newcomers, whose insistence on public terms may itself signal distrust. The resulting pattern is a targeted tool, applied to strangers and resisted by veterans when strangers propose it.

The comparison between the two regimes qualifies the conclusion of the earlier version of this study [12], that experience and reputation gradually replace transparency as a market matures. The changing mix of traders does explain much of the gradual decline in public contracting during the first months of the system. But the largest fall coincided with the mandate, and it occurred across all categories of maker and accepter experience. After the mandate, the maker's own experience predicted visibility much less than before, and public contracts were concentrated on contracts with inexperienced accepters. Market-level mechanisms and individual transparency thus appear to be complements rather than substitutes. As contracting became universal, transparency did not disappear but narrowed to the cases that the market's own mechanisms covered least: trades with counterparties who had no track record.

Implications for market design.
The cold start problem arises in part because the information generated by a newcomer's first trade benefits future trading partners, not the partner who takes the risk [14]. Public contracts make some of that information available to the whole market, but on Hack Forums their use depends on the maker's initiative, and established sellers are reluctant to accept public terms from strangers. Defaults matter in such settings. A marketplace that made the terms of a trader's first few contracts visible by default, or let newcomers display a verifiable record of their obligations, might ease entry without singling out any particular buyer as distrustful. Whether such designs would help, and whether operators of underground markets would adopt them, are open questions; the tension between accountability for newcomers and the reluctance of established traders that we document would shape the answer.

Implications for research and law enforcement.
Researchers and law enforcement frequently learn what is traded in underground markets from the information that participants make visible [16, 5]. Our results imply that public contracts are an unrepresentative sample of trade. They are concentrated among newcomers and particular pairs of traders, were far more common before contracting became mandatory, and are avoided by the high-volume sellers who account for most trade. Studies that infer the composition of a market from its visible contracts, including the classification of public contracts in the earlier version of this study, should therefore be read as describing the trade of newcomers and of a subset of persistent traders, not of the market as a whole. Our results also caution against reading a decline in visible trading as a sign that a market has matured. On Hack Forums, the largest fall in public contracting coincided with a change in the rules rather than with a gradual change in who was trading.

Limitations.
Our results describe associations. We do not observe why makers choose public terms or why accepters decline them, and the patterns we document are consistent with, rather than proof of, the motives we discuss. Visibility is set by the maker, but terms are often negotiated beforehand, and the persistence of visibility among accepters suggests that accepters may sometimes request public terms; we cannot observe such requests. The acceptance results rely on the offers that makers chose to make, which may differ systematically between public and private contracts. The optional period is short and covers only the first months of the contract system, and the visibility gap prevents us from following traders continuously beyond September 2020. Our measures of contract outcomes are imperfect, because contracts can be recorded as incomplete when neither party formally closes them. Finally, we study a single forum, and the costs and benefits of transparency may differ in markets with other enforcement mechanisms, such as escrow.

Future research.
Other marketplaces that let traders choose how much of a transaction to reveal would allow these patterns to be tested more widely. Changes in platform defaults, where they occur, would offer a cleaner way to separate the effects of visibility from the selection of traders who choose it. Experimental markets that reproduce the main features of underground trade [19] could vary whether contracts are public, private or chosen by the traders, and so measure directly how transparency affects trust and trade between strangers.

Trade between strangers is hardest to sustain where there is no court to enforce promises and no history to judge them by. Our results suggest that, in such settings, traders use transparency selectively: not to advertise their own honesty, but to secure that of a partner they have no other reason to trust.

Conflicts of interest

The authors declare that they have no competing interests.

Funding

This work is supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 949127). Tina Marjanov is supported by King's College, Cambridge and the Cambridge Trust. Konstantinos Ioannidis gratefully acknowledges support through the Leverhulme International Professorship in Neuroeconomics awarded to the University of Cambridge.

Data availability

CrimeBB is available to academic researchers through the Cambridge Cybercrime Centre upon signing a data-sharing agreement.

Author contributions statement

K.I., T.M. and A.H. conceived the study. T.M. curated the data. K.I. conducted the analysis. K.I., T.M. and A.H. wrote and reviewed the manuscript.

Acknowledgments

We thank the Cambridge Cybercrime Centre for access to the CrimeBB dataset, Tom Hyndman and Nicolas Seyedzadeh for their contributions to an earlier version of this study, and our colleagues for their support and advice. Tom Hyndman and Nicolas Seyedzadeh were supported by the King's College Summer Research Programme.

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