Intermediation and Trust

It is well known that among a community of traders in which particular pairs of traders only transact occasionally, and have opportunities to cheat, cooperation can be sustained if information about traders' reputations can circulate within the group. In many applications, however, the potential for developing reputations is limited. This paper studies how intermediaries ("brokers") can help to sustain cooperation by removing the need for traders to have information about each other. Rather than trusting other traders, each of whom they interact with only occasionally, traders place their trust in the broker, with whom they each interact frequently. To illustrate, we explore the role of intermediaries in bribe transactions.

Ezaguna da merkatarien elkarte tradizional batean —merkatariek transakzioak egin ohi dituztela eta iruzurrak egiteko aukerak dituztela— lankidetzari eutsi nahi bazaio ezinbestekoa dela merkatarien ospeari buruzko informazioa taldearen barruan ibiltzea. Hala eta guztiz ere, sarritan, ospea garatzeko gaitasuna mugatuta dago. Lan honetan aztertu da bitartekariek («artekariek») lankidetza mantentzen lagun dezaketela, eta horrela ez dela beharrezkoa izango merkatariek gainerakoei buruzko informazioa izatea. Noizean behingo harremanetan parte hartzen duten gainerako merkatariez fidatu beharrean, eurekin merkataritza-harreman ugari dituzten artekariengan ipintzen dute euren ustea. Gai hori argitzeko, eroskeriadun transakzioetan bitartekariek duten egitekoa ikertu dugu.

Es bien conocido que en una comunidad tradicional de comerciantes en la que dos comerciantes realizan transacciones ocasionalmente, y tienen la oportunidad de hacer trampa, la cooperación se sostiene si la información sobre la reputación de los comerciantes puede circular dentro del grupo. Sin embargo, en muchas situaciones, la capacidad para desarrollar la reputación es limitada. Este trabajo estudia cómo los intermediarios («corredores») pueden ayudar a mantener la cooperación eliminando la necesidad de que los comerciantes dispongan de información sobre cada uno de los demás. En vez de confiar en los demás comerciantes, con quienes sólo comercian ocasionalmente, los comerciantes depositan su confianza en el corredor con quien se relacionan con frecuencia. Para ilustrar esta cuestión, investigamos el papel que desempeña el intermediario en las transacciones con soborno.

Christopher Kingston*
Amherst College

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1. INTRODUCTION

How can honest trade be sustained when players have opportunities to cheat, and particular pairs of players only transact occasionally? It is well established in the theoretical literature that cooperation can sometimes be sustained by "social norms": strategies such that deviators are punished by their future trading partners, although they have never cheated those players. For this to work, however, it is crucial that information about players' past actions be available to their future trading partners. Yet, in many real-world applications, the potential for such information to circulate is limited, either because transmitting information is costly, or because traders may lie about their experiences. The question therefore arises: can cooperation be sustained without information flows?

This paper considers a repeated random-matching game in which both trading partners have an opportunity to cheat, and all actions are strictly private information (only the cheater and the person cheated observe the cheating). It studies how specialized intermediaries ("brokers") can enable cooperation to be sustained by removing the need for trading partners to have information about each

* Department of Economics, Amherst College, Amherst MA 01002. I am grateful to Kurt Annen and seminar participants at the University of Guelph for helpful comments. Email correspondence to cgkingston@amherst.edu.

other's past actions. In effect, each transaction between a buyer and seller is split into two sub-transactions between the buyer and broker, and broker and seller, respectively. The trading partners need not trust each other, so long as they trust the broker; and they can trust the broker because they interact with him frequently as they use him to obtain goods or services from a variety of trading partners, each of whom they only occasionally have reason to trade with.

To illustrate, consider a bribe transaction in which a government official agrees to perform a favor for a member of the public in exchange for a bribe. For obvious reasons, bribe transactions are not enforced by the state, so enforcement problems frequently arise. If the bribe is paid in advance, the official then may have little incentive to perform the favor (perhaps risking punishment); conversely, if the bribe is to be paid after the favor is performed, the bribe-payer has an incentive to renege on payment. Furthermore, either or both parties may have opportunities to blackmail the other ex post. Unless the players can devise some way to overcome these enforcement problems, the (mutually beneficial) bribe transaction will not occur.

It is well known that transactions can be enforced if the game is repeated sufficiently often. But suppose any particular bribe-payer only rarely needs a favor from any particular official. Then the threat of a breakdown of the bilateral relationship may not be sufficient to prevent opportunism. Still, a multilateral reputation mechanism might work. That is, players might try to build a reputation for not cheating, and would not cheat because doing so would cause them to lose their reputation so that people would not trust them in the future. The problem is that this can only work if all the other players can observe or learn about cheating. In the case of bribe transactions, for example, this is problematic; sharing the information required to develop such a reputation might expose the parties to a bribe transaction to prosecution or blackmail.

This paper argues that brokers can enable the trading parties to generate the trust necessary to support exchange. Staying with the corruption example, suppose that there are many "villagers" and many officials. Each official is in a position to provide villagers with a particular sort of "favor", such as a driver's license, a telephone connection, or a subsidized loan. Each villager frequently wishes to obtain favors of one sort or another, but only rarely has cause to interact with any particular official (so a direct bilateral reputation mechanism cannot work), and all transactions are private (so a multilateral reputation mechanism cannot work).

Now introduce a broker.[1] Rather than approaching an official directly, a villager in need of a favor makes a deal with the broker, and the broker in turn transacts with the official. If all the villagers use the broker for all their bribe transactions,

[1] Case-study evidence suggests that bribe transactions are frequently carried out through brokers. See, for example, Oldenburg (1987), Lambsdorff (2002), Bray (2005).

then the broker will interact frequently with each villager and also with each official. This can enable the parties on both sides of the transactions to transact indirectly, without having to trust each other, as long as they both trust the broker instead. The villager need not even know the details of the transaction between the broker and official, which official is bribed, or how much is paid; instead, he can simply trust the broker to "get something done" on his behalf. The broker will not cheat the official or the villager, because he expects to deal with both of them frequently in the future, and they in turn will not cheat him because they value the access to favors and bribes that he provides.

1.1. Related Literature

This paper intersects with two theoretical literatures: the industrial organization literature on brokers, and the game-theoretic literature on trust and governance in repeated random-matching games with private information.

Several papers study how brokers can reduce the search costs of finding trading partners (Rubinstein and Wolinksy 1987, Rust and Hall 2003). In the bribery case, for example, brokers might have better information than villagers about which officials are in a position to provide particular favors, so they can play a match–making role (Oldenburg 1987; Bayar 2005). While reducing search costs is undoubtedly an important function of brokers in many real-world contexts, it is quite different from the role studied in this paper. In particular, we will consider what happens when the parties to a transaction, having found each other, have opportunities to cheat.

Another strand of literature on brokers shows how they can build a reputation to facilitate exchange when there is the possibility of cheating by the seller. In Biglaiser (1993), brokers can invest in acquiring the skills needed to evaluate the quality of goods ex–ante, and then cultivate a reputation for trading in high-quality goods. Biglaiser and Friedman (1994) present a model in which the broker is not an expert in evaluating quality ex–ante, but the broker sells goods produced by several different firms, and can credibly threaten to boycott ex–post any firm that sells a low-quality good, in order to maintain a reputation for trading only in high-quality goods. If a broker sells a low-quality good to one customer, other customers will learn of this and cease to buy from the broker. The key difference in this paper is that all actions are private, so brokers cannot develop a general reputation for honesty. Also, we allow for the possibility of cheating by buyers as well as brokers and sellers.

A second literature to which this paper is relevant concerns governance and trust in repeated random-matching games. Kandori (1992) considers a community of players who are randomly matched into pairs each period to play a prisoner's dilemma, and shows that to sustain cooperation it is sufficient that players can observe a label that indicates (roughly speaking) whether their current trading partner is "a cheat", and that is honestly updated through some exogenous process.

Several papers ask how this kind of reputational information might be shared within a community. Greif (1994) provides an historical example of how gossip transmitted in correspondence among a network of traders enabled a reputation mechanism to dissuade cheating. Gazzale (2003) shows that players may have an incentive to gossip about their trading experiences because a reputation for gossiping can deter their future trading partners from cheating. Milgrom, North and Weingast (1990) argue that the mediaeval Law Merchant adjudicated disputes and transmitted information about traders' reputations at the Champagne fairs.

A harder question has to do with the content of the information: why would players report their past experiences truthfully if the outcome of trades are private information? The papers by Kandori, Greif and Gazzale cited above all assume the "gossip" is truthful; but this seems a strong assumption given that the whole point of the gossip is to control cheating. Other papers show that truthfulness can be maintained if outcomes are observed by third parties. For example, Milgrom et al. assume that the law merchant could discover the truth (at some cost), and show that he had an incentive to reveal this information truthfully so as not to lose the merchant's future business. Ben-Porath and Kahneman (1996) show that if each player's action is observed by at least two others, the monitors can be induced to report honestly because they would be punished if their reports differ.

For our purposes, the important point is that this literature shows that if the outcomes of trade are private information, obtaining truthful information to support a third-party enforcement mechanism is problematic. This paper therefore considers how to obtain cooperation without information flows. Several other papers have proposed possible ways in which this might work. Kandori (1992) shows that cooperation may be sustainable through "contagious" strategies in which, following any instance of cheating, cheating spreads rapidly throughout the community (as he points out, such an equilibrium is unattractively fragile). Ghosh and Ray (2001) show that cooperation may be sustainable if players can "opt out" of the random matching mechanism and form long-term trading relationships. In a sense, however, this throws the baby out with the bathwater: all the benefits from being able to change trading partners are lost, so it is not clear why random matching is relevant at all.

Dixit (2003) contrasts an information-sharing intermediary (Info) and an enforcement intermediary (Enfo). Info is essentially similar to Milgrom et al.'s Law Merchant: it detects and publicizes cheating. Enfo, in contrast, has a technology (such as a capacity for violence) that enables him to punish cheaters directly. The brokers in this paper differ from Enfo in that they cannot punish cheats except by refusing to trade with them in future. Also, they differ from Info in that they do not publicize cheating and cannot develop a general reputation for honesty because the outcomes of all trades are private information.

To summarize, this paper studies how brokers can help to sustain cooperation in a random-matching model in which any party (including the broker) can cheat, and the outcomes of all trades are private information. The broker does not reduce search costs, as in Rubinstein and Wolinsky (1987), nor is he an expert at evaluating the quality of a good, as in Biglaiser (1993), punishing cheats, like Dixit's Enfo, or transmitting reputational information, like Milgrom et al.'s Law Merchant. Rather, the broker actively participates in the process of trade itself, staking his own reputation on the outcomes of transactions in which he engages. Thus, the broker's essential role is as a repository of trust. It is not necessary for the buyers and sellers to "trust" each other at all or to know each other's reputation or even each other's identity. Rather, they deal with the broker directly and place their trust in him.

2. **THE MODEL**

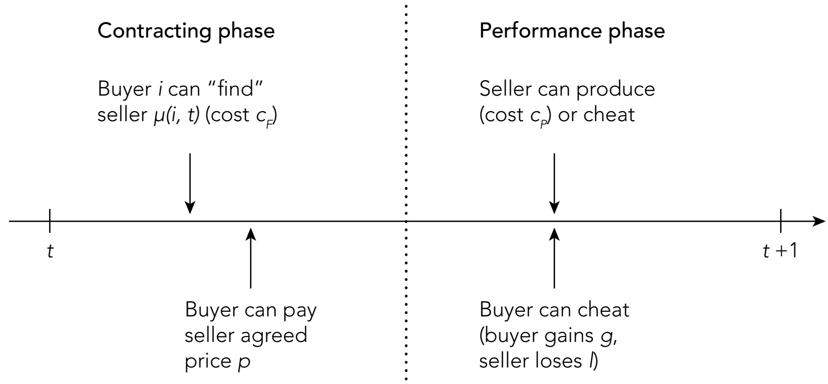
The trading community consists of N "buyers" indexed by $i \in \{1,\ldots, N\}$, and N "sellers" indexed by $j \in \{1,\ldots, N\}$. All players are infinitely-lived and discount future payoffs at a rate $\delta \in (0, 1)$. Each period, each seller, j, can produce one unit of a unique good (or service), also indexed by j. In each period, t, buyer i wishes to consume a particular good, $\mu(i, t) \in \{1, \ldots, N\}$ where μ is a random matching process such that buyer i will obtain one unit of utility if he consumes a unit of seller $\mu(i, t)$'s output in period t. Assume that μ is independent across periods and

$$\Pr[\mu(i,t) = j] = \frac{1}{N} \qquad \text{for all } i, j \text{ and } t.$$

The timeline for trade between a buyer and a seller is shown in Figure 1. Each period is divided into two phases, "contracting" and "performance".

During the contracting phase, in order to trade, buyer i must "find" seller $\mu(i, t)$. This costs the buyer $c_F > 0$, which can be thought of as the "transactions costs" of identifying, locating and negotiating with the appropriate seller. If the parties agree to trade, the buyer undertakes to pay the seller an agreed price p in exchange for delivery of a unit of good j. The exact price paid will presumably depend on the bargaining power of the parties, but it is not necessary to model this here; instead we will ask under what circumstances any price exists at which honest trade can be enforced.

Figure 1. **TIMELINE FOR DIRECT BUYER-SELLER TRADE**



During the second, "performance" phase, the parties each simultaneously choose whether to honor their side of the agreement. Seller j can produce a unit of the good *j* by incurring a production cost c_P , where $0 < c_P < 1$, or can "cheat" by producing nothing (alternatively, cheating by the seller could involve producing a good of low quality). Simultaneously, the buyer can cheat by taking some action which increases the buyer's payoff by *g* while reducing the seller's payoff by *l*, where $l \geq g > 0$,

Assumption 1. *There are potential gains from trade:* $c_P + c_F < 1$

Under Assumption 1, in the performance phase, trade is a simultaneous–move game with payoffs

		Seller: Cooperate	Seller: Cheat
Buyer	Cooperate	$1 - p - c_F, p - c_P$	$-p - c_F, p$
	Cheat	$1 - p - c_F + g, p - c_P - l$	$-p - c_F + g, p - l$

Note that the buyer gains *g* by cheating, and the seller gains c_P by cheating, but the resulting outcome {Cheat, Cheat} is inefficient.

For example, in the case of a bribe transaction, the seller (official) can cheat by failing to perform the service as promised, while the bribe-payer may have an opportunity to cheat by blackmailing the official or cooperating with investigators in exchange for immunity. In other instances, the buyer may have an opportunity to cheat by concealing information that might affect the seller's production cost, or take actions which increase that cost. For example, after an official has accepted a bribe, the bribe-payer may fail to take sufficient care to ensure the transaction remains secret, exposing the official to an increased risk of punishment.

The assumption of simultaneous moves ensures that both parties to a transaction have opportunities to cheat. Of course, in some settings, buyers do not have opportunities to cheat (as in Biglaiser and Friedman 1994). This corresponds to the special case where $g = l = 0$.

The following assumption will enable us to overcome a technical difficulty in constructing equilibria when all actions are private information.

Assumption 2. *At any time, any player can make a hidden side-payment to any other player. Any such payments are observed only by the giver and the recipient.*

2.1. **Multilateral Enforcement with Public Monitoring**

If all actions are publicly observed, or if truthful information about reputations circulates within the community, then cooperation can be sustained by a "social norm" strategy in which cheaters are punished by all community members.

Lemma 2.1. *With perfect public monitoring, honest trade can be sustained in a subgame perfect equilibrium if and only if*

$$\frac{\delta}{1-\delta} \geq \frac{c_P + g}{1 - c_P - c_F} \qquad (1)$$

Proof. Consider a trigger strategy in which all trade ceases following any deviation from honest trade by any player (more realistic, targeted and forgiving punishments are possible, but that is not our concern here. See, for example, Kandori 1992 or Milgrom et al. 1990). Since each party receives payoffs of zero following such a breakdown of trust, this trigger strategy is an optimal penal code (the "worst possible" punishment), so cooperation cannot be sustained by any strategy unless it can be sustained by the trigger strategy (Abreu 1988). A buyer can gain g by cheating a seller; a seller can gain c_P by cheating a buyer. A deviation from the cooperative strategy profile will result in a net per-period loss in all future periods of $(1 - p - c_F)$ for each buyer, and $(p - c_P)$ for each seller. Therefore, cooperation can be sustained if and only if a price p exists such that the following incentive compatibility constraints are both satisfied:

$$g \leq \frac{\delta}{1-\delta}(1 - p - c_F) \qquad (2)$$

$$c_P \leq \frac{\delta}{1-\delta}(p - c_P) \qquad (3)$$

These inequalities reveal lower and upper bounds for p:

$$1 - c_F - \frac{1-\delta}{\delta} g \geq p \geq \frac{c_P}{\delta}$$

A value of p satisfying both of these conditions exists if and only if (1) holds. Conversely, if (1) does not hold, then no price satisfies both these incentive compatibility constraints, so cooperation cannot be sustained.

2.2. **Personal Enforcement with Private Monitoring**

In many situations, the assumption that all players can observe the history of play is unrealistic. Therefore, from this point on we assume that the outcomes of all trades are strictly private information. As usual, if the players are sufficiently patient, then cooperation can be sustained through personal enforcement.

Lemma 2.2. *With perfect private monitoring, honest trade between a buyer and seller can be sustained in a subgame-perfect equilibrium if and only if*

$$\frac{\delta}{1-\delta} \geq \frac{N(c_P + g)}{1 - c_P - c_F} \tag{4}$$

Proof. Whenever the opportunity arises, the buyer can gain g by cheating the seller; the seller can gain c_P by cheating the buyer. If the players adopt a grim trigger strategy, cheating (by either player) will result in a net loss of $1 - p - c_F$ for the buyer whenever these players are matched again, which occurs with probability $1/N$ each period, and a net loss of $p - c_P$ for the seller when the players are matched again. Therefore, cooperation can be sustained if and only if the following both hold:

$$g \leq \frac{\delta}{1-\delta}\left(\frac{1}{N}\right)(1 - p - c_F) \tag{5}$$

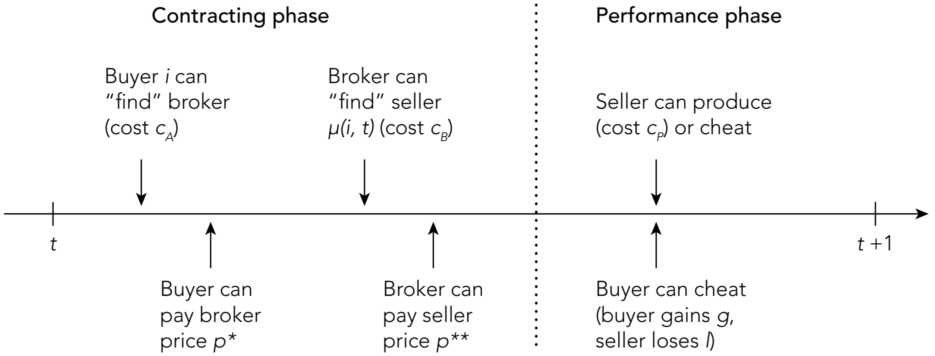
$$c_P \leq \frac{\delta}{1-\delta}\left(\frac{1}{N}\right)(p - c_P) \tag{6}$$

A value of p satisfying both of these conditions exists if and only if (4) holds. Conversely, because the trigger strategy is an optimal penal code, cooperation cannot be sustained if (4) does not hold.

2.3. **Trade through a broker**

We next consider how a broker can facilitate trade, retaining the assumption that the outcomes of all trades are strictly private information. The timeline for broker-intermediated trade is shown in Figure 2.

Figure 2. **TIMELINE FOR BROKER-INTERMEDIATED TRADE**



Each period, buyer i can either find seller $\mu(i, t)$ directly, at cost c_P, or can find the broker, at cost c_A. The broker, in turn, can find any seller at a cost c_B. Let p^* denote the payment made from the buyer to the broker, and let p^{**} denote the payment made from the broker to the seller. As before, we will not tie down the prices; instead, we will ask under what conditions any prices can exist which will enable trade.[2]

A buyer contracts with a broker just as she does with a seller: she pays the broker and promises not to cheat, in exchange for a promise of the delivery of a good or service. The broker *may* then find and contract with the seller, making payment and promising that the buyer will not cheat, in exchange for a promise of delivery. Either party can cheat in either transaction: the buyer can promise the broker that she will not cheat, but then cheat if the opportunity arises (this does not hurt the broker directly, but may have a negative impact on the broker's relationship with the seller, as discussed below); the seller can promise to deliver but fail to do so; the broker can cheat the buyer by failing to ensure that the seller delivers the good or service as promised, and can cheat the seller by failing to ensure that the buyer does not cheat the seller. Note that "cheating" by the broker can therefore occur for two reasons: either because he cheats deliberately, or because one of the trading parties "lets him down", leaving him no choice but to "cheat" the other party. Either way, however, the broker has failed to honor his promise, and since both buyers and sellers deal directly with the broker, it is not *relevant*, from their point of view, whether he cheated them deliberately or not. Thus, the buyer and seller each place their trust in the broker's assurance that they will not be cheated, and the broker, in turn, must trust them by placing his reputation in each of their hands as he vouches for their behavior.

[2] The prices will depend on the bargaining power of the parties. If the broker has all the bargaining power (gets to set prices), his optimal pricing structure may be a combination of fixed membership fees and marginal per-transaction fees. See Rochet and Tirole (2006) for a model that investigates optimal pricing structures in a related setting without moral hazard.

For broker-intermediated trade to work, it is necessary that the broker be able to observe the actions of the buyer and seller during the performance phase. However, unlike Milgrom et al.'s Law Merchant, the broker's essential role is not that of a specialist "monitor" who investigates complaints and transmits information about the identity of players who have cheated. Rather, since it is he who has contracted with both parties, it is he who is the victim of cheating by either party. For example, if the seller does not supply the good contracted for, this hurts the broker by endangering his relationship with the buyer. Indeed, the broker is the *only* one who can tell for sure who cheated, because only he knows the terms of the agreements made with the other parties, having made the agreements himself. In our example of a bribe transaction, for example, the broker - and only the broker - knows what bribes were paid, and what services were promised in return. In some applications, there may be economies of scale in the matching process, so that trading through a broker is more efficient than direct trade – that is, $c_A + c_B < c_F$. That is essentially the case studied by Rubinstein and Wolinsky (1987), who show that in their model, brokers are viable only if they are more efficient than other traders at making contacts. To make clear how this model differs, introduce the following assumption, which supersedes Assumption 1.

Assumption 3. *Trade through brokers is (weakly) less efficient than direct trade, but sufficiently efficient that there exist potential gains for trade through brokers:*

$$1 - c_P > c_A + c_B \geq c_F$$

Recall that any player can make a hidden side-payment to any other player at any time (Assumption 2). These payments will not be made in equilibrium, but they provide the players with a means of paying a penance in case they have cheated. This will enable us to avoid the complication noted by Kandori (1992): in subgames off the path of play, in which many players have cheated, the value of maintaining a trusting relationship is lowered, so players have an incentive to cheat. Hidden side-payments enable us to get around this difficulty because, even though the status of any relationship at any time is known only to the parties directly involved, as long as all players *expect* all others to try to maintain trusting relationships (by making side-payments if necessary), they all have an incentive to try to maintain trusting relationships themselves. Because the side-payments are visible only to the payer and payee, each player's equilibrium beliefs at the start of each period, even off the path of play, are that all the other players' relationships are trusting and will remain so in the future.

Lemma 2.3. *Honest trade through brokers can be sustained as a perfect Bayesian equilibrium if and only if*

$$\frac{\delta}{1-\delta} \geq \frac{c_P + g + \max(c_B + \frac{c_P}{\delta}, g)}{1 - c_A - c_B - c_P} \tag{7}$$

Proof. Consider an equilibrium in which all buyers and all sellers have relationships with the broker that can be in either *trusting* or *not trusting* status at any particular moment. At the start of the game, all relationships are *trusting*, and they remain *trusting* until either party cheats (simultaneous cheating by both parties is ignored). If a party cheats, the relationship can subsequently be restored to *trusting* status if the cheating party makes a hidden side-payment to the cheated party equivalent to the amount gained by cheating. Thus, a buyer who cheated the broker must pay g. A seller who cheated the broker must pay c_P . A broker who cheated a buyer (in the sense that the seller failed to supply the good or service contracted for) must pay $p^{**} + c_B$. A broker who cheats a seller (in the sense that the buyer cheated the seller despite the broker's assurances that she would not) must pay g. Consider the following strategy profile:

Buyers: If your relationship with the broker is *trusting*, contract with the broker for purchase of the good, and do not cheat. Otherwise, do not attempt to trade. At the end of each period, if the relationship is *not trusting*, and if you cheated the broker the last time you traded with them, then make a side-payment of g to the broker.

Sellers: If a buyer attempts to purchase the good directly, cheat them. If the broker attempts to purchase the good, and your relationship with the broker is *trusting*, accept the contract and deliver the good or service. At the end of each period, if your relationship with the broker is *not trusting*, and if you cheated the broker the last time you traded with him, then make a side-payment of c_P to the broker.

Broker: In period t, if your relationships with both buyer i and seller $\mu(i,t)$ are *trusting*, then contract with buyer i and seller $\mu(i,t)$ for delivery of the good; otherwise, refuse to trade with buyer i in that period. Trade honestly with both buyers and sellers with whom your relationship is *trusting*. At the end of the period, if your relationship with a buyer is *not trusting*, and if you cheated them the last time you traded with them, make a side-payment of $(p^{**} + c_B)$ to the buyer; if your relationship with a seller is *not trusting*, and if you cheated them the last time you traded with them, make a side-payment of g to the seller.

In order for these strategies to constitute an equilibrium strategy profile, the following incentive compatibility constraints must be satisfied:

Buyers: The buyer can gain g by cheating. Since (by assumption) she expects all other players to adhere to the specified strategy profile, she expects the broker to have a *trusting* relationship with all other buyers and sellers in all future periods. Therefore, if she cheats (and does not make the appropriate side- payment as penance), she expects to lose a stream of future utility worth $(1 - p^* - c_A)$ in each future period. Therefore, she will cooperate as long as

$$g \leq \frac{\delta}{1-\delta}(1 - p^* - c_A) \quad (8)$$

Sellers: The seller can gain c_P by cheating the broker (failing to deliver to the buyer). Unless she pays c_P to restore her relationship with the broker, she will lose ($p^{**} - c_P$) in every future period (since all buyers are expected to use the broker in all future periods). She will therefore be willing to cooperate as long as

$$c_P \leq \frac{\delta}{1-\delta}(p^{**} - c_P) \tag{9}$$

Broker: By cheating either party (and not making the appropriate side-payment to restore trust), the broker loses the opportunity to engage in all the future trades in which that player would have played a role. The broker can make a net one-shot gain of ($p^{**} + c_B$) by cheating the buyer (by not bothering to contract with or pay the seller). Therefore, the broker therefore prefers not to cheat the buyer as long as

$$p^{**} + c_B \leq \frac{\delta}{1-\delta}(p^{*} - p^{**} - c_B) \tag{10}$$

If the broker and a buyer conspire to cheat the seller, the broker can gain at most g (the buyer, in a period in which she has the opportunity to cheat, will be willing to pay the broker a bribe of up to g for the right to cheat the seller with impunity). So, the broker prefers not to cheat the seller as long as

$$g \leq \frac{\delta}{1-\delta}(p^{*} - p^{**} - c_B) \tag{11}$$

Simplifying, the following conditions are necessary to sustain cooperation:

[Buyer] $$\delta(1 - c_A) - g(1-\delta) \geq \delta p^{*} \qquad (8)'$$

[Seller] $$\delta p^{**} \geq c_P \qquad (9)'$$

[Broker] $$\delta p^{*} \geq p^{**} + c_B \qquad (10)'$$

[Broker] $$\delta p^{*} \geq g(1-\delta) + \delta p^{**} + \delta c_B \qquad (11)'$$

Combining these conditions reveals that values of p* and p** which can sustain honest trade through brokers exist if and only if both

$$\delta(1 - c_A) - g(1-\delta) \geq \frac{c_P}{\delta} + c_B$$

and $$\delta(1 - c_A) - g(1-\delta) \geq g(1-\delta) + c_P + \delta c_B$$

which can be rearranged to yield, respectively,

$$\frac{\delta}{1-\delta} \geq \frac{g + c_P + c_B + \frac{c_P}{\delta}}{1 - c_A - c_B - c_P} \quad \text{and} \quad \frac{\delta}{1-\delta} \geq \frac{2g + c_P}{1 - c_A - c_B - c_P}$$

The trigger strategies which would be adopted if players do not pay a penance are optimal penal codes, so if either of these conditions do not hold, then at any combination of prices p* and p**, at least one player has an incentive to cheat, so cooperation cannot be sustained.

Proposition 1. *Denote the minimum discount rate necessary to sustain broker-intermediated trade as* δ_{Broker}*, the minimum discount rate necessary to sustain direct trade through multilateral enforcement with public information as* $\delta_{Community}$*, and the minimum discount rate necessary to sustain direct trade through personal enforcement as* $\delta_{Personal}(N)$*. Then under Assumption 3, there exists N* such that for N ≥ N*,*

$$1 > \delta_{Personal}(N) > \delta_{Broker} > \delta_{Community} = \delta_{Personal}(1) > 0$$

Proof. This follows directly from (1), (4), (7), and Assumption 3.

In the case of public monitoring, community enforcement (for any *N*) is as effective as personal enforcement without random matching. This illustrates Kandori's point that "changing partners itself is unimportant and the crux of the matter is information transmission among the community members" (Kandori 1992, p.64). Note also that even if $c_A + c_B = c_F$, community enforcement can sustain trade for a strictly lower value of δ than that required to sustain trade through brokers. This reflects the need to provide brokers with positive rents to keep them honest.

In the case of private monitoring, however, community enforcement is infeasible, and as N increases, the discount rate required to sustain trade using personal enforcement becomes increasingly close to one. This is where brokers can play a role: trade through brokers poses much less stringent information requirements than community enforcement, yet it may be sustainable even when personal enforcement is not.

Because brokers earn rents, unless brokers are inherently more efficient than direct trade, we might expect buyers and sellers to try to trade directly if personal enforcement is feasible. In particular, if $\delta \geq \delta_{Personal}(N)$, under private information, then an equilibrium with broker-intermediated trade would not be robust to a joint deviation by a buyer-seller pair who agreed to enforce their trade agreements directly. Therefore, although equilibria may exist in which some fraction of the buyers and sellers operate through brokers while others trade directly, such equilibria are unattractively fragile.

If $\delta < \delta_{Personal}(N)$, however, a buyer could not credibly approach a seller and offer to trade honestly, and we should therefore expect sellers to refuse to trade directly, in the expectation that they would be cheated. For example, in the case of the *pyraveekars* who acted as middlemen in bribe transactions in South India, Ram Reddy and Haragopal (1985) found that officials preferred to deal with *pyraveekars* because they felt them to be "trustworthy", and often refused to deal with villagers directly, instructing them to make their requests through a *pyraveekar* instead.

3. MULTIPLE BROKERS

In the previous section, we assumed that there was just one broker, but in many markets, we observe multiple brokers. In this section, we allow for free entry by brokers in order to investigate how the market structure of the brokerage industry is likely to evolve.

Assumption 4. *There is a population of potential brokers who can freely enter or exit the brokerage business. Their reservation utility is zero.*

Suppose there are K brokers indexed by $k \in \{1, \ldots, K\}$. Denote the number of buyers represented by broker k as n_k, where $\sum_1^k n_k \leq N$. Our goal in this section is to endogenize K and n_k: that is, to understand how the number and "size" of brokers is determined in equilibrium.

The timeline for trade is as before (Figure 2). Buyers may trade directly or through a broker. If a buyer could freely choose which broker to employ, and all brokers could trade with any seller, then honest trade would be difficult to sustain (without information flows) because a buyer could simply cheat a broker and employ other brokers in future. However, we can look for equilibria in which brokers avoid this problem by developing regular "channels of trade". This leads to the following assumption.

Assumption 5. *Each broker acts on behalf of a fixed group of buyers.*[3]

Lemma 3.1. *Suppose the broker makes a take-it-or-leave-it (TIOLI) offer (p^{**}) to the seller. Then the minimum incentive compatible value of p^{**} is decreasing in n_k.*

Proof. The probability with which broker k interacts with any particular seller in any particular period is $\frac{n_k}{N}$. To ensure the seller will not cheat, the following incentive compatibility constraint must be satisfied:

$$c_P \leq \frac{\delta}{1-\delta}\left(\frac{n_k}{N}\right)(p^{**} - c_P)$$

Since the broker makes a TIOLI offer, this constraint will hold with equality, so,

$$p^{**} = c_P + \frac{1-\delta}{\delta}\left(\frac{N}{n_k}\right)c_P \tag{12}$$

where the second term can be interpreted as a rent paid to the seller to deter cheating. This rent, and therefore p^{**}, is decreasing in n_k.

[3] None of our results would be qualitatively different if we made the alternative assumption that brokers specialize in dealing with a particular group of sellers.

The intuition for Lemma 3.1 is that a "larger" broker (one with more clients) can offer a seller a lower price, because his expected frequency of repeated interaction with the seller is higher, which reduces the seller's incentive to cheat. Whether these cost savings will be passed on to buyers depends on their bargaining power, which in turn will depend on how difficult it is for buyers to switch between brokers. If the buyers have substantial bargaining power, then a larger broker will pass his cost savings on to the buyer (lowering p^*); buyers will therefore prefer to associate with larger brokers. Alternatively, if the broker has substantial bargaining power (e.g., he gets to set p^* as a TIOLI offer to the buyer), then a larger broker will earn higher per-transaction profits than a smaller broker. The appropriate assumption will depend on the context, but either way, this seems likely to create an impetus for concentration in the brokerage industry.

To keep things simple, let us suppose that with free entry, the brokerage industry is sufficiently competitive that buyers have all the bargaining power, so that the buyer can make TIOLI offers of p^* to brokers (this is analogous to Biglaiser and Friedman (1994) who assume that competition ensures that brokers charge the lowest incentive- compatible prices).

Lemma 3.2. *Suppose buyers can make TIOLI offers to brokers. Then the minimum incentive compatible value of* p^* *is decreasing in* n_k*. That is, the more buyers a broker represents, the lower the TIOLI offer a buyer can make to a broker.*

Proof. The broker's incentive compatibility constraint vis-a-vis the buyer is given by (10)' as before. His incentive compatibility constraint vis-a-vis the seller is

$$g \leq \frac{\delta}{1-\delta}\left(\frac{n_k}{N}\right)(p^* - p^{**} - c_B) \tag{13}$$

or

$$p^* \geq p^{**} + c_B + \left(\frac{1-\delta}{\delta}\right)\left(\frac{N}{n_k}\right)g \tag{14}$$

Whichever constraint ((10)' or (14)) binds, given that p^{**} is decreasing in n_k (Lemma 3.1), the minimum incentive-compatible value of p^* is also decreasing in n_k.

Lemma 3.2 shows that if brokerage markets are competitive, larger brokers can credibly offer to charge buyers lower prices.

Suppose now that buyers can switch brokers in the long run, for example, because buyer-broker links are occasionally broken for exogenous reasons, such as a death, freeing the parties to form new relationships without creating incentive problems within existing relationships. Then a situation with multiple brokers is likely to be unstable in the long run. To give a concrete example: in the bribery case, a "well connected" middleman, who engages in many interactions, will be able to pay lower bribes and therefore to charge his customers lower fees than a middleman who carries out a lower volume of business. As a result, he will be able to "poach" business from brokers with fewer clients. This leads to the following "Proposition", which to avoid unnecessary complexity we will state informally.

Proposition 2. *If there is free entry into the brokerage industry, and buyers can easily switch between brokers in the long run, then in the long run, the only stable situation is one in which there is a single broker.*

Proposition 2 says, in effect, that brokerage may be a natural monopoly. This may seem somewhat counterintuitive (free entry leads to monopoly). The intuition is that brokerage becomes a natural monopoly because of network effects that enable a larger broker to attract more customers by charging lower prices to buyers; but this effect can only kick in if buyers do not face prohibitive costs switching between brokers. Note also that despite free entry and exit, a broker who is in business will earn rents in equilibrium. The explanation is simply that brokers must earn an efficiency wage to keep them honest.

This situation may change if the brokers' bargaining power increases as the brokerage industry becomes concentrated (because buyers do not have an alternative broker to go to). The rents that could be earned by the monopolist broker would then depend on the technology of entry, in particular, by how easy it is for the buyers to credibly threaten to defect en masse to another (entrant) broker. However, if buyers have the ability to coordinate a move to an entrant broker if the entrant is prepared to offer them a lower price p^* than the incumbent, then buyers would retain the bargaining power even as the brokerage industry becomes concentrated.

3.1. **Multiple brokers with capacity constraints**

Despite the implication of Proposition 2, in many applications we observe multiple brokers. This section considers the possibility that brokers face capacity constraints: a single broker simply would not have the time to carry out all trades.

Assumption 6. *Buyers make TIOLI offers to brokers, and brokers make TIOLI offers to sellers.*

Assumption 7. *The broker's cost of "finding" a seller, c_B, is a function of the number of trades carried out by the broker in the current period, n. Furthermore, $c_B'(n)>0$ and $c_B''(n)>0$.*

Assumption 7 alters the analysis in the previous section. On the one hand, a larger broker still has the advantage that he can credibly earn lower rents and can pay lower prices to the seller. However, this advantage is now offset by the increasing cost of carrying out additional trades.

Denote by $p^*(n,N)$ the minimum incentive-compatible TIOLI offer a buyer can make to a broker of size n when the population size is N.

Lemma 3.3. *Under assumptions 2-7, for a given value of N, p*(n,N) is a convex function of n with a minimum at some finite value n*(N) > 0.*

Proof. Broker k, who represents n_k buyers, must offer the seller p^{**} given by (12). The broker's IC constraints vis-a-vis the buyer and seller are (10)' and (14), as before. Substituting (12) into (10)' and (14), the minimum value of p^* that the buyer can offer a broker with n clients while satisfying these constraints is

$$p^*(n,N) = \max\left\{\frac{c_P + c_B(n)}{\delta} + \frac{1-\delta}{\delta^2}\left(\frac{N}{n}\right)c_P, c_P + c_B(n) + \frac{1-\delta}{\delta}\left(\frac{N}{n}\right)(g + c_P)\right\} \qquad (15)$$

Both $\frac{1}{n}$ and $c_B(n)$ are convex functions of n, so it follows that p^* is a convex function of n. Depending on which constraint binds, p^* is minimized either where

$$c_B'(n) = \frac{1-\delta}{\delta}\left(\frac{N}{n^2}\right)c_P \qquad \text{or} \qquad c_B'(n) = \frac{1-\delta}{\delta}\left(\frac{N}{n^2}\right)(g + c_P) \qquad (16)$$

and since $c_B'(\cdot) > 0$ and $\lim_{n\to\infty}\frac{1}{n^2} = 0$, such a minimum exists for finite n.

Lemma 3.3 shows that there is some scale of operations, $n^*(N)$, which minimizes the cost a broker must charge his customers. If $n^*(N) > N$, then a single monopolist broker remains the likely outcome. If $n^*(N) < N$, however, then, assuming some kind of competition among brokers over the long run, brokers closer to this scale of operations would be able to out-compete those which were either larger or smaller, and (ignoring integer problems) an equilibrium with approximately $\frac{N}{n^*(N)}$ brokers should emerge.

Note that, as in the previous subsection, the brokers would earn positive rents despite free entry and exit.

Proposition 3. *Under assumptions 2-7, there exists* $\hat{N}$ *such that broker-intermediated trade is viable only for population size* $N < \hat{N}$.

Proof. Consider either of the conditions in equation (16). One of these equations implicitly defines the optimal value of n, $n^*(N)$. The left side of each of these equations is increasing in n, and the right side is decreasing in n. An increase in N will cause each of these equations to be satisfied at a higher value of n. Therefore, both $n^*(N)$ and $\frac{N}{n^*(N)^2}$ are increasing in N. Therefore, $\frac{N}{n^*(N)}$ is also increasing in N. Because of this, and because $c_B'(n) > 0$, it follows from (15) that $\frac{dp^*(n^*(N),N)}{dN} > 0$. If broker-intermediated trade is to be viable, however, the value of p^* is bounded above by the buyer's incentive compatibility constraint (8)', which does not depend on N.

The intuition for Proposition 3 is as follows. As N rises, interactions between brokers and particular sellers become less frequent, so the rents that brokers and sellers must receive to keep them honest increase. Eventually, they become so great that the buyers are no longer willing to pay a high enough price, even if brokers operate at the rent-minimizing scale, $n^*(N)$. At this point, broker-intermediated trade breaks down.

Consider now what these results imply regarding the potential role for brokers in a community of traders as the market expands. When N is small, individuals can engage in frequent face-to-face interactions, achieving trust without the need for brokers. As N grows, however, trades between particular pairs of players become less frequent, personal enforcement breaks down, and brokers may emerge. Both the volume of transactions handled by an individual broker, and the number of brokers, will tend to grow as the market expands. If the population grows too large, however, brokers will no longer be able to enforce transactions, and some kind of alternative governance institution must develop, for example, to share information about players reputations (like Milgrom et al.'s "Law Merchant"), or to punish cheaters directly, like Dixit's *Enfo*. That is, while brokered markets are viable up to a certain population size, the extent of the market is limited without formal enforcement institutions.

4. **CONCLUSION**

This paper reveals a role for brokers that has not been discussed by the existing literature on market intermediation. In situations in which both parties to a transaction have opportunities to cheat, the broker removes the need for the parties to trust each other by, in effect, splitting each transaction between a buyer and seller into two sub–transactions between the buyer and broker, and broker and seller, respectively. The key to the broker's role is his cultivation of trusting relationships with participants on both sides of the market, and his ability to create trust is simply a product of the volume of transactions he undertakes. Without capacity constraints, and with free entry, brokerage becomes a natural monopoly due to network effects. With capacity constraints, broker-intermediated trade may be viable only for intermediate levels of specialization; as the market expands, broker-intermediated trade ultimately breaks down and more formal enforcement mechanisms ultimately become necessary.

While we have used the example of bribe transactions, brokers play a role in many different kinds of economic exchanges, including insurance, real–estate, and labor markets (eg., temp agencies). The nature of the brokers role varies depending on the context. In a real–estate market, for example, the low frequency of transactions and the reliance on formal contracts means that brokers are used primarily to reduce search costs rather than to ensure "trust". In an insurance market, however, in which insurers can cheat by attempting to avoid payment of losses and insureds can cheat by failing to take adequate care to avoid losses, brokers often play an important role in helping to ensure both parties to trust that the other will act in "utmost good faith" (Doherty and Muermann; Kingston 2007).

In many real-world applications, brokers appear to fulfill several roles simultaneously. An interesting avenue for future research would be to study how the broker's role modeled in this paper, as a direct intermediary involved in trade itself, complements or substitutes for other possible roles of intermediaries such as reducing search costs or transmitting reputational information. Trade through brokers, as modeled here, is inefficient (relative to the first-best) because the brokers incur the costs of engaging in unnecessary trades and must be paid a rent to ensure their honest behavior. Another interesting issue would be to compare the efficiency of broker-intermediated trade with that of more formal enforcement mechanisms.

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