On Modes of Economic Governance*

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Abstract

I consider transactions involving asymmetric prisoners' dilemmas between pairs of players selected chosen from two large populations. Games are played repeatedly, but information about cheating is not adequate to sustain cooperation, and there is no official legal system of contract enforcement. I examine how profit-maximizing private intermediation can supply the information and enforcement. I obtain conditions under which private governance can improve upon no governance, and examine why it fails to achieve social optimality.

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1 Introduction

All economic transactions, except spot exchanges of goods or services with objectively known attributes, offer opportunities for one or both or all of the parties to cheat for their own gain at the expense of the others. In turn, the expectation of suffering a loss due to such cheating can make all prospective participants unwilling to enter into a transaction that would benefit them all if the cheating could be checked. Therefore almost all economic transactions need governance.

Much of economic theory assumes that an official legal system provides this service. We used to assume that the law worked perfectly and costlessly. Recent theory has carefully specified the informational requirements of verifiability for contracts to be enforceable, and internal agency problems are recognized when the focus is on the operation of the system as such. But the system is usually assumed to operate in an objective and impartial manner; specifically, it is assumed to have a monopoly over the use of force, and to aim to maximize social welfare.

However, such an objective and official legal system is a rarity, approximated only in a few advanced countries and only in recent times. In most countries and at most times, formal governance has been lacking, corrupt, or too slow to be effective. But economic life has gone on, and societies have developed alternatives modes of governance. Even when the official legal system is generally effective, alternative methods coexist: disputes in labor and financial transactions are often settled by arbitration, and illegal or semi-legal transactions are governed by equally extra-legal methods of justice.

Understanding the operation of these alternative modes of governance is of considerable interest in its own right. It can also lead to a better understanding of the official system, and even more importantly, of the interrelations among the modes – Can alternative governance modes do as well as, or perhaps even better than, the official law? Are different modes mutual substitutes, or can they be complements?

In this paper I will offer a perspective on some general issues of governance and contract enforcement, and some modeling of a particular mode, namely private intermediation. I do not claim to have any big or startling answers, but I do pose many interesting questions, answer a few, and develop approaches that promise more answers. I hope thereby to convince readers that here is a large and rich field of research, ripe for further theoretical exploration.

2 A Classification

The official legal system in modern advanced countries provides a benchmark against which the alternatives are measured. Economic and legal scholars have constructed numerous models where such an institution is designed to maximize social welfare, taking into account various constraints on information and policy and individuals' optimal responses. Polinsky and Shavell (2000) have surveyed this research.

One alternative to the formal legal system that economic theorists have studied most fully is self-governance, modeled as equilibria in repeated interactions. The research most relevant for my purpose is that dealing with the resolution of prisoners' dilemmas played by pairs matched from a large population. If any specific pair is unlikely to meet frequently, the usual tacit cooperation sustained by threats of reversion to non-cooperation may seem implausible. In fact considerable progress has been made, based on Kandori's (1992) model of multilateral punishments that spread in the population by contagion. Ellison's (1994) generalization of this model is probably the definitive statement of the theory today. There is also much empirical evidence on the matter. Greif's (1993, 1994, 1997) case studies and related theoretical models of the control of cheating among spatially separated traders around the mediterranean are well known. Ostrom (1990) reports several case studies of the governance of common resource pools; Ellickson (1991) studies the protection of property rights among cattle ranchers in northern California; McMillan and Woodruff (2000) discuss private governance of contracts in emerging market economies, particularly Vietnam.

The theoretical and empirical literatures alike identify two difficult problems which must be solved by large populations trying to resolve prisoners' dilemmas: collecting and conveying information about previous cheating, and erecting a credible structure of punishments to deter cheating. As usual in economics, these problems also offer profit opportunities for individuals who can solve them. Anyone can, at a cost, collect information about cheating, and sell it to prospective traders in the future. Business associations often collect and provide such information to their members; the case studies cited above provide many examples. Outsiders do this for profit; credit rating agencies, or services that monitor the quality of goods and services provided by firms, are well known examples. This is conceptually similar to solving the problem of double coincidence of wants by introducing money. Such an intermediary must solve two other problems – he must discourage free riding, by making the information unavailable or useless to non-payers, and he must credibly promise not to misuse the information, for example for extortion or double-crossing. But this is simplified by the fact that the intermediary's relationships with all customers are bilateral and non-anonymous: while two traders may meet each other only infrequently, each of them can meet the intermediary every period.

A suitably qualified intermediary can even inflict punishments on behalf of customers. Milgrom, North and Weingast (1990) have a well known study of "law merchants" in medieval France who performed both function. But my most dramatic example of private intermediation comes from Gambetta's (1993) excellent study of the Sicilian mafia. He begins (p. 15) by recounting what a cattle-breeder told him: "When the butcher comes to me to buy an animal, he knows that I want to cheat him [by giving him a low-quality animal]. But I know that he wants to cheat me [by reneging on payment]. Thus we need Peppe [that is, a third party] to make us agree. And we both pay Peppe a percentage of the deal." Gambetta goes on to say (p. 16) that in this context "Peppe was mainly selling information, ... for this service ... he received a 2 percent commission. When in addition he acted as a guarantor of quality and payment, the percentage increased."

Of course the mafia engages in many activities, and Peppe's intermediation may now comprise only a small part of these, but it remains a good example for my purpose. In his information role, Peppe resembles a credit-rating agency or even a restaurant guide, except that he acts for both sides of the deal. In the guarantor or enforcer role, he resembles the official legal system, but has different paths of information and different methods of punishment, and is motivated by private profit rather than by social welfare.

My modeling in this paper will focus on governance by private for-profit intermediaries, but I will relate this mode to self-governance on the one hand and the official legal system on the other. I begin by mentioning a few related issues and some literature on them.

3 Some Related Literature

The official system can cope only imperfectly with information asymmetries and problems of commitment, and forms of self-governance can sometimes do better. This is the theme of the new institutional economics, or transaction cost economics, pioneered by Williamson (1985). These private responses consist of contractual and organizational innovations such as hostage-giving and vertical integration that align the parties' interests closer to the needs of overall efficiency, but the official legal system continues to play an important indirect role in governing exchange. Analysis of corporate governance, whose main concern is with various agency relationships within one firm, is likewise modeled under the umbrella of the official legal system; Tirole (2001) gives an authoritative overview and interpretative survey.

In this paper I focus on the governance of economic transactions, that is, enforcement of *contracts.* Others have examined the enforcement of *property rights.* There, the whole stock of assets of a person or a firm is in principle open to predation and needs to be protected. In my analysis, participation is voluntary, and only the stocks or flows that each side brings into the transaction are at risk due to the other's cheating. Olson's (1993) analysis of private governance by a profit-maximizing "bandit" is well-known. He finds that the efficiency of the bandit's regime depends on the bandit's time-horizon but falls short of that achievable by a democratic government. The intermediary in my model has similar consequences but for somewhat different reasons. Other recent analyses of private enforcement of property rights include Grossman (1995) and Anderson and Bandiera (2000).

Ramey and Watson (1999) study enforcement by a private intermediary, when the same two players meet repeatedly. Transaction cost economics also often deals with situations where only two or a few firms interact. My concern is enforcement in large populations where repeated interactions in identified pairs are infrequent.

The role of intermediaries in search has been studied extensively; some recent papers are Yanelle (1989), Gehrig (1993), and Rust and Hall (2001). Spulber (1999) has a thorough analysis of intermediation between firms, using the transaction cost economics framework.

Private intermediaries often collect and provide information about product quality. This has a moral hazard aspect (one side or the other may deliberately shirk or degrade quality to reduce cost) as well as an adverse selection aspect (quality may be an innate characteristic or type of one side unknown to the other). My model can handle the moral hazard aspect; Lizzeri (1999) analyzes the adverse selection aspect. Rose (1999) considers search and quality intermediation when the transactions are themselves about information, as in the "new economy."

A different but related approach distinguishes between *relation-based* and *rule-based* modes of governance. In essence, the former is self-governance in a community based on ongoing relationships and shared information, whereas the latter is the official legal system operating at arm's length based on public or verifiable information. While the distinction has been known in general terms for a long time, and is sometimes uncritically attributed to exogenous ethnic or cultural differences, the recent work of Li (1999) promises to put it on a sounder economic basis. He recognizes differences between the costs of operating the two systems. Relation-based governance has low fixed costs (each relationship is sui generis and no systemwide investment is necessary to sustain it) but high and rising marginal costs (because each relationship needs a reputational investment, and expansion of a business entails transactions where one has successively weaker relational links with the counterparties, so these require larger initial investment in building the relationship, and they carry a greater risk of collapse). Rule-based governance has high fixed costs (large legislative, judicial, and informational costs are needed to establish the system and give it initial credibility), but low and flat marginal costs (once the system is established, one can deal with strangers). The two systems can and do coexist. In the course of economic growth, and expansion of trade and investment, one should expect the mix to shift away from relation-based and toward rule-based governance. But the transition can be slowed or even stopped by many problems – the difficulty of collective action in making the public investment needed for the rule-based system, the political resistance of incumbents who have reputational capital sunk in the relation-based system, and so on. This perspective, and the analysis of such transition dynamics, seem another very promising avenue of research.

4 The Transaction

The starting point or basic transaction for my analysis is an asymmetric two-sided prisoners' dilemma. The abstract theoretical literature on self-governance has usually considered symmetric dilemmas; Tirole (1996) and Greif (1993, 1994, 1996, 1997) consider one-sided dilemmas where only one party has the temptation to cheat. But most economic transactions are inherently asymmetric, for example that between a buyer and a seller. Spread of information about the other side's cheating, and one's own temptations to cheat, differ greatly for the two. For example, firms that produce durable consumer goods are usually in the market for a long time, and their reputation for good or poor quality can be spread by the media. Each consumer is in the market for such goods only infrequently, and may be tempted to renege on payment unless the firms have a good network for exchanging information about such behavior. I will consider such general asymmetric interactions.

The basic one-shot prisoners' dilemma game involves two generic players, one from each of Side 1 and Side 2, each with two actions, Honest and Cheat. The payoffs are shown in Table 1.

As usual, we assume $W_i > H_i > C_i > L_i$, and

$$H_1 + H_2 > \max (W_1 + L_2, W_2 + L_1), \tag{1}$$

that is, it is jointly better to have both players act honest than to let one of them cheat the other. One further consideration is important in practice. People are not forced to play this game; they may instead take an outside opportunity. Normalize that at 0. It is quite

Table 1: The Basic Prisoners' Dilemma

		Side 2	
		Honest	Cheat
Side	Honest	H_1 , H_2	L_1 , W_2
1	Cheat	W_1 , L_2	C_1 , C_2

possible for one or both of the cheating payoffs C_i to be negative – even a low-quality good costs something to produce, so the seller may be worse off than his outside opportunity if the buyer reneges on payment. Therefore, if in any one period a player is matched with someone who is known (or sufficiently likely) to cheat, he may refuse to play. Or if $C_1 + C_2 > 0$ and credible spot transfer payments can be made, a deal that compensates him may be feasible; for example if $C_1 < 0$, then player 2 may give $-C_1$ to player 1 for playing the game, so player 1 ends up with 0 and player 2 with $C_1 + C_2$. To keep the algebra simple I will ignore these complications and assume $C_i > 0$, but the other possibilities are worth further study.

There is a large population of players on each side. In each period every person from one side is matched with one from the other. Repeat matchings are sufficiently infrequent that I will ignore them; this can be done rigorously as in Townsend (1981) and Milgrom et al (1990), with a countable infinity of people on each side and matching by rotation.

Much of the literature assumes that all players on each side are identical and rational economic calculators. In some ways this makes it too easy to sustain an equilibrium in which everyone acts honest. To make the model richer and more realistic I will assume, following Tirole (1996), that the individuals on each side come in one of three behavior types: [1] Honest. These form a fraction α_i of the population on Side i. They do not engage in any unauthorized cheating. Thus they play Honest except when authorized to cheat in a punishment phase that is specified in the equilibrium. Later, when I consider the intermediary, his Honest customers will also Cheat when he instructs them to do so; then "obedient" or "conformist" may be better labels than Honest. [2] Dishonest. These form a fraction β_i of the population on Side i. They live just one period; therefore they have no reason to retain any reputation for good behavior, and they always play Cheat. [3] Opportunist. These form a fraction $\gamma_i = 1 - \alpha_i - \beta_i$ of the population on Side i. They calculate the benefits and costs of cheating using standard dynamic programming and make their privately optimal choices. My presumption is that Opportunists comprise a large proportion of the population, and that Honest and Dishonest types have smaller proportions.

Each period, random pairings are formed from the two populations. (In the case of rotating pairings from a countable double infinity, the types are randomly distributed in the sequence of players on each side). The discount factor is δ. The Honest and Opportunist people on Side i have a probability $(1 - \lambda_i)$ of dying and being replaced by a newborn of the same type. The survival probabilities are λ_i; therefore the effective discount factor of an Opportunist on Side i is $\delta\lambda_i$.

5 Self-Governance

In this section I will consider stochastic stationary state equilibria without any external enforcement. This will serve as an input to the analysis of governance using a private intermediary. The basic structure is simple, I have already made some further simplifying assumptions and will make more; the analysis is also conceptually very simple. Despite this, matters quickly get involved, and the results become taxonomic. Therefore I will examine only a few of the cases that seem especially prominent, interesting, or of expository value, leaving the others for interested readers to construct or for future research.

The focus is on the choices of the Opportunists. Their incentive to take the Honest action comes from the possibility that Cheating will become known. I assume a simple avenue for this: each time an Opportunist on Side i takes a Cheating action that is not authorized as a part of a punishment phase, with probability π_i he will get a publicly observable Bad label starting the following period and lasting as long as he lives. If he gets away with Cheating on one occasion, the probability of getting a Bad label is no different for any subsequent Cheating action. This is a simplified version of the structure in Tirole (1996).

The π_i will depend on the information channels among the players, for example gossip networks as in Ellickson (1991). I will treat them as exogenous, and the pertinent case for a large population is the one where π_i are quite low. In future research the π_i can be explained in terms of the size or the spatial structure of the population, and in turn the group size could be endogenized.

The fundamentals of the game are stationary, and I will consider stationary equilibria with the following equilibrium strategies: When faced with an opponent who has a Bad label, everyone plays Cheat, and players with a Bad label continue to play Cheat. This is a Nash equilibrium of the stage game and therefore satisfies the requirement of subgame perfectness.[1] When faced with an opponent who does not have a Bad label, an Honest type plays Honest and a Dishonest type plays Cheat; these types are not optimizing and their behavior is determined by their type, so questions of subgame perfectness do nor arise. The behavior of Opportunists is of two different kinds corresponding to two different types of stationary states that can arise in different parameter ranges to be determined below. The label Hi (for i = 1 and 2) will signify that in that stationary state the Opportunists on side i play Honest, and Ci will signify that they play Cheat, when meeting someone from the other side without a Bad label. For example, a stationary state labeled (H1,C2) means that the Opportunists on Side 1 play Honest and those on Side 2 play Cheat.[2]

In a stationary state, each player on each side has rational expectations about the be-

[1]Thus any tacitly cooperative outcomes will be sustained by grim trigger strategies. It should be possible to do better using two-phase punishments with a "stick" phase that forces a cheater to take $L_i < 0$, followed by "carrot" phases with positive payoffs, arranged so that the overall two-phase punishment has the present value of 0, the outside opportunity. But grim trigger strategies are simpler and convey adequate intuition for my purpose.

[2]To avoid confusion, note that when used as a label of a stationary state, the letter H or C is roman and the number 1 or 2 is not a subscript, and when used as the symbol for a payoff in the stage game, the letter H or C is in math italics and the number 1 or 2 is a subscript.

havior of his randomly matched opponents on the other side. Let ϕ_i^a denote the probability that a randomly picked Side i player will play Honest, ϕ_i^b the probability that he will play Cheat but does not have a Bad label, and $\phi_i^c = 1 - \phi_i^a - \phi_i^b$ the probability that he has a Bad label.

In an Hi stationary state,

$$\phi_i^a = \alpha_i + \gamma_i, \qquad \phi_i^b = \beta_i, \qquad \phi_i^c = 0\,. \tag{2}$$

The calculation for a Ci stationary state needs care because people with Bad labels may die and their successors are born without a Bad label. But a simple calculation yields

$$\phi_i^a = \alpha_i, \qquad \phi_i^b = \beta_i + \gamma_i\,(1 - p_i), \qquad \phi_i^c = \gamma_i\, p_i\,, \tag{3}$$

where the p_i are the ergodic proportions of Opportunists who have Bad labels. These can be found in terms of the basic parameters of the problem. Since I do not need the precise solutions, I relegate this to Appendix A.

To find when an Opportunist who does not have a Bad label will or will not cheat, let V_1 denote the expected present value payoff for such an Opportunist on Side 1. This satisfies the recursive relation

$$\begin{aligned} V_1 \;\; = \;\; \max \Big\{ & \; \phi_2^a\, H_1 + \phi_2^b\, L_1 + \phi_2^c\, C_1 + \delta\, \lambda_1\, V_1, \\ & \phi_2^a\, W_1 + \phi_2^b\, C_1 + \phi_2^c\, C_1 + \delta\, \lambda_1\, V_1 - \delta\, \lambda_1\, (\phi_2^a + \phi_2^b)\, \pi_1 \left[V_1 - \frac{C_1}{1 - \delta\lambda_1} \right] \Big\} \end{aligned} \tag{4}$$

The first line results when the Side-1 Opportunist follows the candidate equilibrium strategy (play Cheat when matched with someone who has a Bad label and play Honest otherwise), and the second results when he deviates to play Cheat always. In each case the current payoff is the expected value from meeting various types on the other side with various probabilities in the stage game. The continuation payoff from the deviation includes the term with the minus sign which is the expected cost of Cheating. This occurs only if the match does not have a Bad label (probability $\phi_2^a + \phi_2^b$) and in that event the probability that the Side-1 cheater acquires a Bad label is π_1. If this happens, his punishment phase starts next period (effective discounting $\delta\lambda_1$) and the payoff loss equals the difference between the optimum V_1 and the expected value $C_1/(1 - \delta\lambda_1)$ of the mutual Cheating payoff for the rest of his life.

At the boundary where the Side-1 Opportunist is indifferent between Honest and Cheat,

$$\frac{\phi_2^a\,(W_1 - H_1) + \phi_2^b\,(C_1 - L_1)}{\phi_2^a + \phi_2^b} = \delta\, \lambda_1\, \pi_1 \left[V_1 - \frac{C_1}{1 - \delta\lambda_1} \right]\,. \tag{5}$$

This has an obvious interpretation: The left hand side is the expected immediate gain from deviation, conditional on meeting a type without a public Bad label which is the only scenario when deviation is a relevant concept, and the right hand side is the expected future cost of the deviation. Then we can solve for the value at this boundary:

$$V_1 = \frac{\phi_2^a\, H_1 + \phi_2^b\, L_1 + \phi_2^c\, C_1}{1 - \delta\, \lambda_1} \tag{6}$$

If the stationary state is H2 (Opportunists on Side 2 are acting Honest), the fractions ϕ_2^a etc. are defined by (2), and then (5) and (6) define the critical value of π_1 that will make the Side-1 Opportunist indifferent between Honest and Cheat. If the stationary state is C2 (Opportunists on Side 2 are Cheating), the fractions ϕ_2^a etc. are defined by (3) as functions of π_2, and then (5) and (6) define the critical value of π_1, also as a function of π_2.

If the actual π_1 exceeds these critical values, then the Side-1 Opportunist's best response will be to act Honest, in each case when the Side-2 Opportunists have the specified behavior. But we need one further condition: $V_1 > C_1/(1 - \delta\lambda_1)$, or

$$\phi_2^a \, H_1 + \phi_2^b \, L_1 > (\phi_2^a + \phi_2^b) \, C_1 \, . \tag{7}$$

Otherwise the Side-1 Opportunist will do better by voluntarily putting on a Bad label and cheating all the time. I will assume that this holds, and that similar conditions in later analysis are also satisfied.

One further point – if the gain from cheating is large enough, or the survival probability is low enough, then the critical values of π_1 may exceed 1, that is, even the certainty of getting a Bad label may not suffice to deter cheating. Unless otherwise specified in the analysis to follow, I will assume that such is not the case.

In which of the two types of stationary states, H2 or C2, is the critical value of π_1 higher? The answer turns out to depend on whether $C_1 - L_1 > W_1 - H_1$ or the other way round. In the former case, the Side 1 Opportunist's one-time benefit from cheating is higher if the other side is cheating than if it is playing Honest, that is, the prisoner's dilemma is more acute in its "defensive" aspect than in its "offensive" aspect. I will call this the Defensive case, and the opposite the Offensive case. Of course it is possible to have the Defensive case for one side and the Offensive case for the other side.

If the Defensive case prevails on Side 1, the one-time benefits of cheating are larger for a Side-1 Opportunist in a C2 stationary state than in an H2 stationary state, and therefore a higher probability of getting a Bad label is needed to deter his cheating. Therefore the critical value of π_1 is higher in a C2 stationary state than in an H2 stationary state. The opposite applies if the Offensive case prevails on Side 1.

To see this more formally, consider the Defensive case for Side 1. Compare (2) and (3), and note that in an H2 stationary state ϕ_2^a is larger and ϕ_2^b is smaller than in a C2 stationary state. On the left hand side of (5), we have a weighted average of the two advantages of cheating, with the ϕs as weights. The larger term $C_1 - L_1$ (this is the Defensive case) gets the higher weight in the C2 stationary state and is therefore larger. From (6), we see that V_1 is smaller in the C2 than in the H2 stationary state, since $H_1 > L_1$ and the coefficient of the larger term is smaller and that of the smaller term is larger in the C2 than in the H2 stationary state. Therefore the right hand side of (5) is larger for any given π_1 in the C2 than in the H2 stationary state. Putting these two observations together, the critical π_1 defined by (5) is larger in the C2 than in the H2 stationary state.

It can also be shown that for a C2 stationary state, the critical boundary function $\pi_1(\pi_2)$ is downward-sloping in the Side-1-Defensive case, and can be upward-sloping in the Side-1-Offensive case if the offensive benefit of cheating is sufficiently larger than the defensive benefit.

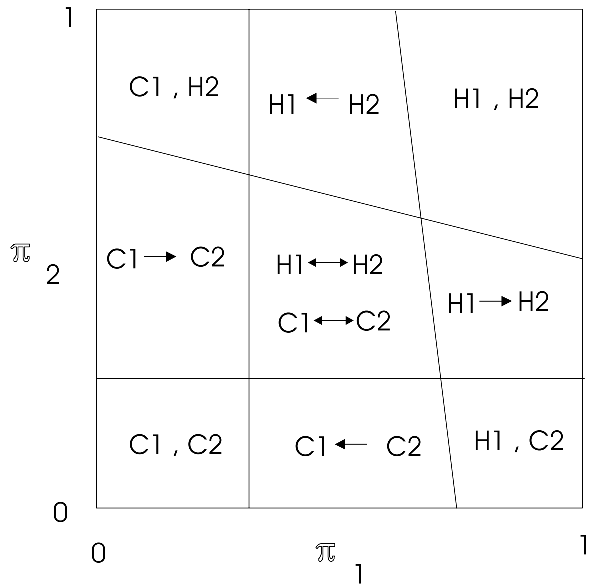

Figure 1: Stationary States in the Defensive Case $C_i - L_i > W_i - H_i$

These calculations were for a Side-1 Opportunist; similar analysis for a Side-2 Opportunist follows by interchanging the labels 1 and 2. Using all this information, Figure 1 shows the full set of possibilities of stationary states when the Defensive case prevails on both sides.

The sides of the box are the ranges of π_1 and π_2, from 0 to 1 in each case. The vertical line is the critical value of π_1 for an H2 stationary state, and the downward-sloping curve to its right is the critical curve $\pi_1(\pi_2)$ for a C2 stationary state. To the right of this curve, a Side-1 Opportunist will act Honest no matter what Side-2 Opportunists are doing; to the left of the vertical line a Side-1 Opportunist will Cheat no matter what Side-2 Opportunists are doing; between the two, a Side-1 Opportunist will act Honest if and only if Side-2 Opportunists act Honest. Similarly the horizontal line and curve governs the best responses of Side-2 Opportunists.

Putting together these responses, we can identify the possible stationary states. In the four corner regions Opportunists on both sides have dominant strategies and we get corresponding stationary states, for example (H1,H2) in the northeast corner and (C1,C2) in the southwest corner. These are the intuitive outcomes when the detection probabilities are both very high and both very low respectively. In the other two corners, only one side fears detection sufficiently to act Honest even when the other side is Cheating. This may be true in some instances. For example, since the survival probabilities also play a role, firms may be long-lived and have enough reputational reasons for maintaining quality, whereas Opportunist buyers may have shorter lives and renege on payment. In the middle regions on each of the four sides of the box, one side's Opportunists have a dominant strategy and then the other side's Opportunists play their best response; the labels and arrows in these regions show the choices and the direction of causation. On the left side, for example, Side-1 Opportunists have a dominant strategy of Cheating, and this leads Side-2 Opportunists to

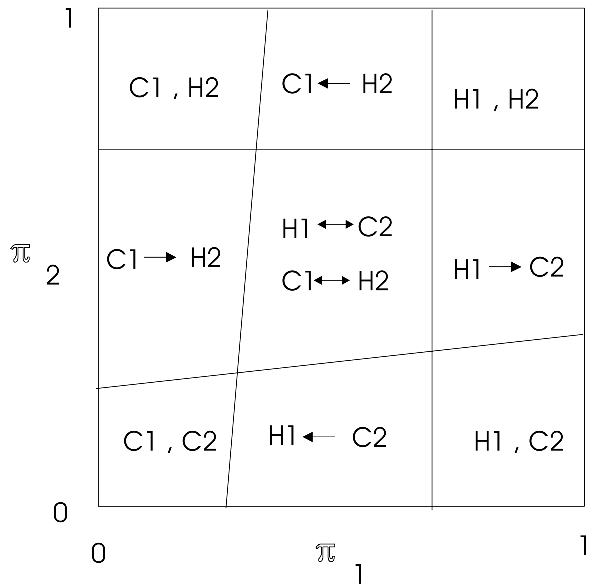

Figure 2: Stationary States in the Offensive Case $W_i - H_i > C_i - L_i$

Cheat too – Cheating spreads like an infection. Similarly, in the middle region along the top edge, Honesty spreads by infection. Finally, in the central region of the box, there are multiple stationary states (H1,H2) and (C1,C2), with either Honesty or Cheating on one side sustained by like behavior on the other. The (H1,H2) state is Pareto preferred, and may get selected by a focal point mechanism, but a lock-in to the (C1,C2) state remains possible. Of course multiple stationary states need not mean multiple equilibria when full dynamics are considered.

Now we can identify the parameter ranges where private intermediation can improve matters for this society. In the three regions to the north-east, the public detection probabilities are high enough for self-governance to work automatically and no intermediation is needed. In the three regions to the south-west, the probabilities are both low, both sides will cheat, and two-sided intermediation (like that of Gambetta's Peppe) can help. In the two regions in the south-east and north-west corners, there is scope for one-sided intermediation. In the inner region, self-governance is possible but not guaranteed; a clever potential intermediary may gain by sowing distrust to keep the group in a (C1,C2) state without him.

Figure 2 is for the case where the offensive aspect of the prisoners' dilemma is the more important on both sides. Now the critical boundary value of π_1 is larger in an H2 stationary state than in a C2 stationary state. This has some strange consequences. For example in the middle region along the top side of the box, Honest is dominant for Side-2 Opportunists, but this draws the response of Cheat from Side-1 Opportunists, yielding a (C1,H2) stationary state. It seems plausible that honesty on one side will produce a dishonest response from the other, but the opposite is less plausible. This makes me think that of the two cases, the defensive case is the one more likely in reality. Also, for the offensive case, the multiple stationary states in the inner central region are (H1,C2) and (C1,H2). These are not Paretoranked, so selection between them is problematic. Once again we can identify the scope for two-sided or one-sided private intermediation in different regions of the figure.

There can be mixed cases, where the offensive aspect prevails on one side and the defensive aspect on the other. I will leave it to interested readers to construct the details of such cases, but will point out that the inner central region will have stationary states with mixed strategies.

This analysis of self-governance, by allowing asymmetry and heterogeneity, has produced a much richer picture, and provided better insight into the possibility of multiple equilibria, than previous literature. In particular, the scope for one-sided versus two-sided intermediation emerges clearly, and the existence of some cheating on the equilibrium path enriches the analysis of intermediation to come. To save space, in what follows I will examine only two-sided intermediation, leaving the one-sided cases for the readers.

6 Information Intermediary

In this section I will consider a private intermediary who tracks information about previous cheating by individuals, and supplies this to his customers each period as their matches on the other side are revealed. I will start by assuming that the intermediary is a monopolist, and consider competition or contest for a monopoly later. I will call this intermediary Info for brevity. Info has an indefinite life, with a probability λ_0 of surviving from one period to the next; this is exogenous for now.

Info has to make individual contracts with each person; he cannot offer an all-or-nothing deal to the whole society and achieve a Coasian outcome. Therefore the equilibrium with Info is not automatically guaranteed to be efficient.

Info cannot observe the type – Honest, Opportunist or Dishonest – of any individual, in particular of any newborns. If Info finds out about an act of unauthorized cheating, and then sees that person around at a later date, he can infer that the person must be an Opportunist; more on this later. Info's detection technology is as follows.

Info's cost in each period of serving one customer on Side i is denoted by I_i. I will assume that if a customer of Info gets cheated, Info finds this out without incurring any further cost. This may be because he provides his service by accompanying his customer (physically or metaphorically) to the trade. This broadly accords with Gambetta's (1993, p.36) description of what Peppe does in his information role. Credit rating agencies, too, are likely to be told by their customer firms or lenders if a buyer or borrower defaults. A customer who has just been cheated probably actually gets a little satisfaction from complaining, but even if he incurs a small cost of complaining, a contract like that in Milgrom et al (1990) will enable Info to induce the customer to report the other party's current cheating. I will subsume this in the cost I_i.

In addition, Info can detect at a further cost any occurences where someone who is not his customer gets cheated; for example he could increase π_i at a cost. However, such detection creates a free-rider problem. Side-2 Opportunists behave honestly even when their current Side-1 match is not Info's customer, because they know that Info will detect and report this cheating to future customers – Info cannot credibly commit not to do so. Knowing this, a

Side-1 trader, even when he is not Info's customer, expects his Side-2 match to act Honest. Thus he would gain nothing by paying Info, and can remain a free rider. Note that this individual is not choosing between an Honest equilibrium and a Dishonest equilibrium; he is merely calculating whether to pay Info given the equilibrium that prevails.

Info can solve this problem very simply – by not doing any direct detection at all, merely relying on reports of his customers. This benefits Info in two ways – it saves cost, and it avoids the free riding by ensuring that people can cheat non-customers with impunity, which also raises the value of being his customer and therefore enables him to charge a higher fee.

Info merely tells a customer either "I know your match has cheated in the past" or "As far as I know, your match has not cheated in the past." If Info says the latter and the other party cheats this time, the customer has no recourse and Info will not inflict any punishment on the other party.[3] The customer has equally no recourse if Info lies about the other party's history (and extracts an additional fee from the other party for allowing him to cheat in this way); we have to find conditions under which the equilibrium is proof against cheating by Info. Similarly, we have to check whether Info has any incentive to extract extortion payments by threatening falsely to attach a bad label on someone with a clean record.

Now we can formally state the structure of the game in each period. (1) Info offers contracts. The contract for a Side-i trader has the following form: "pay me F_i now; then when your match is revealed, I will tell you what I know of that player's history". (2) People decide whether to become his customers. (3) Random pairings are formed; Info tells his customers (not necessarily truthfully) what he knows about their matches' history of actions, and makes any double-crossing side-deals with the other side. (4) People observe whether their matches are Info's customers. Then they decide whether to play the dilemma game at all, and if both want to play, the dilemma game is played. (5) Info keeps a record of any cheating of his customers.

6.1 All-Customer Equilibrium

Info can make a profit by raising the expected payoffs for his customers. To save space and avoid too much taxonomy, I will examine only one case of this, namely one where in his absence the stationary state would be (C1,C2), he deals with both sides, and achieves an (H1,H2) outcome. Even within this, I will focus on an equilibrium where everyone is Info's customer, and only briefly consider cases of selective customership. But other cases are worth future attention. In particular, if under self-governance the stationary state would have been (C1,H2) or (H1,C2), then Info may deal with just one side and observe cheating by the other side; credit rating agencies may be an example of this.

So consider the situation where everyone is Info's customer. When playing against a customer of Info, Honest types and Opportunists act Honest, whereas Dishonest types Cheat. What about off-equilibrium behavior when meeting someone who is a deviant non-customer? Now Opportunists and Dishonests will cheat. Honests may be inclined to give the deviant the benefit of the doubt and act Honest, but Info can tell them that the non-customer is

[3] I will consider enforcement intermediaries in the next section.

sure to be a bad type and authorize or even instruct them to play Cheat. This is in Info's own interest as it lowers the payoff to a non-customer, thereby raising the value of being a customer and so the traders' willingness to pay Info. Therefore I will assume that Info does this.

Info's own temptation to cheat must also be considered. He can extort an extra fee from a trader with a clean record by threatening to label him a cheater. This is a bilateral game between Info and each trader, and can be considered separately from the prisoners' dilemma of the traders; I will do so in a subsection below. Info can also double-cross a trader, by taking an extra fee from the other side to let it cheat. This is considerably harder to analyze, and I have only an imperfect answer in another subsection below. In the meantime I proceed assuming that Info does not double-cross.

To calculate the willingness to pay, we need to know each person's payoffs when a customer, and when not a customer. A Dishonest type who is not a customer will play Cheat. An Honest type who is not a customer will play Honest (cheating is not an authorized action or punishment phase in this situation). But then he is sure to get payoff L_1, which is negative, so he would do better to take the outside option. I will allow Honest traders this much rational calculation – as non-customers, knowing that if they played, their nature would force them to act Honest, they stay out. Finally, consider Opportunists. It is intuitive that an Opportunist non-customer will play Cheat: the reason not to pay the fee and join must be that one wants to cheat. In fact cheating leads to quite complicated possibilities – the cheater may acquire a public Bad label; even if not, Info will observe the cheating, since in the candidate equilibrium being considered, the other party is his customer. But then again Info may not survive to the next period so the cheater may be able to make a clean start. The analysis in the Appendix B (Lemma 1) shows that the simple intuition does survive all this calculation.

Table 2 shows the payoffs of Side-1 players, against all possible matches from Side 2, and when the Side-1 players are Info's customers (in the candidate equilibrium) or deviant non-customers. The payoffs for Side-2 players are analogously constructed.

Table 2: Payoffs for Info's All-Customer Equilibrium

Side-1 player		Side 2 match		
Type	Customer?	Honest	Opportunist	Dishonest
Honest	Yes	H_1	H_1	L_1
	No	0	0	0
Opportunist	Yes	H_1	H_1	L_1
	No	C_1	C_1	C_1
Dishonest	Yes	W_1	W_1	C_1
	No	C_1	C_1	C_1

The difference in expected payoffs for each type when a customer and when not a customer can now be calculated using the proportions of the types on Side 2 as probabilities. Thus

$$\begin{aligned} \text{Honest:} \quad & (\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1 \\ \text{Dishonest:} \quad & (\alpha_2 + \gamma_2)\, (W_1 - C_1) \\ \text{Opportunist:} \quad & (\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1 - C_1 = (\alpha_2 + \gamma_2)\, (H_1 - C_1) - \beta_2\, (C_1 - L_1) \end{aligned} \tag{8}$$

Comparing the Honest type's gain to the first expression for the Opportunist type's, and comparing the Dishonest type's gain to the second form of the Opportunist type's, we see at once that the Opportunists have the smallest one-shot gain from being customers, and that is positive by (7).

Honests and Dishonests do not do any intertemporal optimization, so their willingness to pay Info is just the above difference. Opportunists do a more rational intertemporal calculation. If Info extracts their whole one-shot gain as his fee, their present value payoff with Info will be the same as without him, namely $C_1/(1 - \delta\lambda_1)$. Then they will join Info for one period and cheat to get a bigger current payoff, without any future loss. Therefore Info must charge them less, that is, leave them enough current surplus, to induce them to act Honest. The calculation is complex, and done in Appendix B. The result is as follows. Info's fee F_1 must satisfy

$$F_1 \leq [\, (\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1 - C_1\,] - \rho_1\, [\, (\alpha_2 + \gamma_2)\, (W_1 - H_1) + \beta_2\, (C_1 - L_1)\,]\,, \tag{9}$$

where

$$\rho_1 = \frac{\frac{1}{\delta\lambda_1} - \lambda_0\, (1 - \pi_1)}{\frac{\pi_1}{1 - \delta\lambda_1} + \lambda_0\, (1 - \pi_1)} \tag{10}$$

The term in the first square brackets on the right hand side of (9) is the one-shot payoff difference calculated above. The term in the second square brackets is the customer's one-shot gain from cheating; multiplying this by the "effective interest rate" ρ_1 yields the surplus Info must give away. The effective interest rate depends on discounting, the probability of public detection, and the probabilities of the customer's and Info's survival. If $\pi_1 = 0$ (no public detection), then $\rho_1 = 1/(\delta\lambda_0\, \lambda_1) - 1$, while if $\lambda_0 = 1$ (Info has infinite horizon), then $\rho_1 = 1/(\delta\lambda_1) - 1$; these are the usual expressions for the interest rate. If $\lambda_0 < 1$, then ρ_1 is larger, that is, Info must give away more surplus.

As π_1 increases, the factor gets smaller, so Info need give away less surplus. Thus a higher probability of public detection "paradoxically" helps Info; this is because quitting his customership and cheating becomes a less attractive alternative. Of course, if π_1 becomes too large, then the risk of a public Bad label will be enough to keep Side-1 Opportunists acting Honest even without Info's intermediation, and knowing this, Side-2 traders' willingness to pay Info will drop sharply. Thus Info benefits from some but not too much public information about cheating. This mixed result of the model contrasts with Gambetta's (1993, pp. 24-28) unqualified argument that Peppe benefits from creating endogenous distrust in the population.

There is no guarantee that the upper limit on F_1 will exceed I_1, so the equilibrium may not materialize because Info may not be able to make any profit. I will proceed assuming that $F_1 > I_1$, and similarly on the other side.

Since Opportunists have the lowest one-shot payoff gain from becoming Info's customers anyway, and they have to get some rent, the maximum fee Info can charge them is low enough to attract the other two types. Therefore, in the all-customer equilibrium being examined here, Info's fee will equal the upper bound in (9), perhaps minus some small amount which I will ignore. (Info does not know the type of any individual and cannot engage in perfect price discrimination. If someone engages in an act of unauthorized cheating and survives to reappear the next period, Info can identify him then; but such individuals have to be of the Opportunist type who have the smallest willingness to pay, so identifying them does not give Info any ability to extract anything more from them.)

The calculations for the Side-2 customers' willingness to pay are similar. Therefore Info's profit per capita, in the candidate equilibrium where everyone is his customer, is

$$\Pi_I = [\,F_1 - I_1\,] + [\,F_2 - I_2\,] \tag{11}$$

6.2 Extortion

The candidate equilibrium must be tested for Info's incentives to adhere to it. One way Info can cheat is to extort additional amounts at the last minute from a customer by threatening to disown him and falsely asserting that he has a history of cheating.[4] This is a one-sided dilemma problem. Info has a bilateral relationship with each trader. In each period, the game is as follows. The trader decides whether to become Info's customer. If yes, then Info decides whether to extort an extra payment. In a one-shot game, it is ex post optimal for Info to extort, and therefore in the subgame perfect equilibrium the trader would not become his customer. In the repeated game, an equilibrium where the trader becomes Info's customer and Info does not engage in extortion can be sustained by the grim trigger strategy of reversion to the one-shot no-customership equilibrium of the bilateral game between Info and this trader. The condition is that the one-period gain from extortion be less than the expected present value of the subsequent loss. Info does not know any individual customer's behavior type (even though the Dishonests live only one period, any fresh faces could be newborn Honests or Opportunists); therefore he can only charge the smallest willingness to pay as the extra extortion sum. The discount factor is the product of the pure δ and Info's and the customer's survival probabilities. Therefore the condition for non-extortion of a Side-1 customer is

$$F_1 \leq \frac{\delta\,\lambda_0\,\lambda_1}{1-\delta\,\lambda_0\,\lambda_1}\;[F_1 - I_1] \tag{12}$$

If I_1 is small, this is approximately $\delta\,\lambda_0\,\lambda_1 > 1/2$. If I_1 is significant, the test is more stringent. We see that extortion is less of a problem the longer-lived are Info and his customers. Traders on the more transient side have greater reason to fear extortion and should therefore be more hesitant to become Info's customers.

[4] In the equilibrium under consideration, everyone is a customer, and for Nash equilibrium we test only deviations by one player at a time; therefore we need not consider extortion of non-customers.

6.3 Double-Crossing

The other way Info can attempt to gain by dishonoring his agreement with a customer is to accept a payment from the other party in exchange for letting them cheat the first party. If there were no Dishonest types in the population at all ($\beta_i = 0$), then a customer who got cheated could infer with certainty that Info double-crossed him. The game between Info and the customer would be exactly like the one above involving the possibility of extortion, and a good equilibrium would prevail under conditions very like those obtained there, namely a lower bound on $\delta\,\lambda_0\,\lambda_1$.

But when there are Dishonest types in the population (that is, when $\beta_i > 0$, no matter how small), a customer who gets cheated cannot be sure that Info double-crossed him; it could be just the bad luck of having been matched with one of the Dishonests. Thus the game between Info and an Opportunist customer has imperfect monitoring. The Side-1 Opportunist customer gets the low payoff L_1 with probability 1 if Info double-crosses, and with the smaller probability β_2 otherwise. The fact that Info's double-crossing increases the probability of the low payoff enables the use of a grim trigger strategy that is initiated probabilistically in the event of a low payoff. In fact in the particular situation here, that is the best that can be done. Therefore I assume that if the Side-1 Opportunist customer gets the L_1 payoff, then a punishment phase is triggered with probability q_1, and lasts so long as this trader lives. Thus q_1 measures the severity of the punishment. The trigger is a randomization device whose realization is observed with common knowledge by Info and this one trader. In the punishment phase this trader becomes a non-customer and plays Cheat. Since the stage game has an equilibrium where Info would double-cross a customer and therefore the trader does not pay to become a customer, the common-knowledge expectation of the punishment phase is self-fulfilling

An added complication arises if Info is finite-lived ($\lambda_0 < 1$), because all customers in this punishment phase are relased from it when their Info dies, which makes the population proportions non-stationary. Therefore in this section I confine the analysis to the case of an immortal Info ($\lambda_0 = 1$).

Even with the stationary structure and a special simple punishment, the analysis gets intricate, because now in the stationary state there are some Opportunists in the punishment phase who play Cheat. The mathematics in Appendix C yields the following results. Info's fee F_1, as a function of the severity of punishment q_1, must satisfy

$$F_1 \geq \frac{1-\nu_1}{\kappa_1}\,\frac{1-\delta\lambda_1}{\delta\lambda_1}\,(W_2 - H_2)\,. \tag{13}$$

to prevent Info's temptation to double-cross a Side-1 customer. Here κ_1 and ν_1 are the population proportions of Side-1 Opportunists in the customer and punishment phases respectively, and are themselves functions of q_1. The right hand side goes to infinity as q_1 goes to zero, and is a decreasing function at least for a while. The condition to keep the Side-1 Opportunist customer from cheating stipulates the minimum rent that must be given; we have

$$F_1 \leq [\,(\alpha_2+\kappa_2)\,H_1 + \nu_2\,C_1 + \beta_2\,L_1 - C_1\,] - \rho_1\,[\,(\alpha_2+\kappa_2)\,(W_1 - H_1) + \beta_2\,(C_1 - L_1)\,]\,. \tag{14}$$

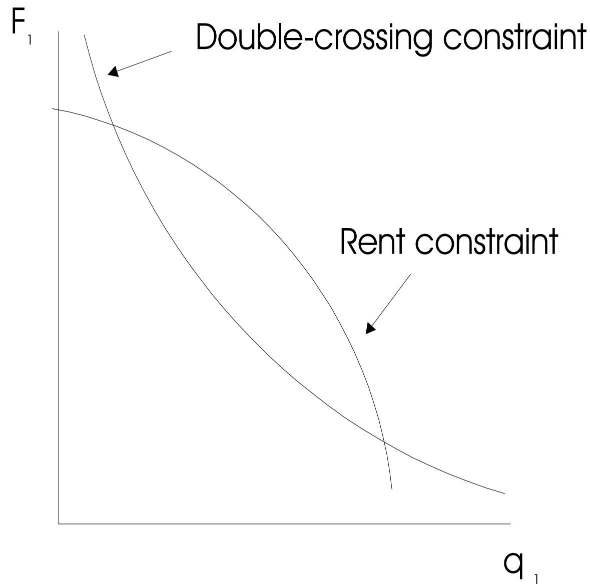

Figure 3: Conditions for Honesty and No Double-Crossing

where

$$\rho_1 = \frac{1 - \delta\,\lambda_1\,(1 - q_1\,\beta_2)}{\delta\,\lambda_1\,(1 - q_1\,\beta_2)} \tag{15}$$

is the effective interest rate. As q_1 increases, ρ_1 increases. Therefore the upper limit on F_1 in (14) is a decreasing function of q_1.

Figure 3 shows the two constraints and the lens-shaped region where both are satisfied. Of course the intersection may be empty for some ranges of the other parameters; then Info's governance becomes infeasible. When the region is non-empty, it makes sense to choose the point with the smallest q_1, since this is the probability with which the punishment is triggered along the equilibrium path even though no double-crossing actually occurs.

6.4 Endogenizing Info

So far I have modeled Info as a monopolist, and there are indeed good reasons to do so; for example, competing Infos would have to exchange information about any cheating against each other's customers, and that can open up the way to collusion and effectively a monopoly. But there can be ex ante competition to attain an ex post monopoly, and continuing struggle to preserve it. Write K_I for the up-front sunk investment to enter the contest to become an Info, P_I for the probability of success, and Π_I for the per-period profit while enjoying the monopoly as the incumbent Info. Then the equilibrium condition (assuming risk neutrality) is

$$K_I = \frac{P_I\,\Pi_I}{1 - \delta\,\lambda_0}\,. \tag{16}$$

We can think of this equation as endogenizing any one of the magnitudes. The per-period profit Π_I might be endogenized by introducing expenditures needed to protect the profit, or continual advertising needed to convince the customers about the quality of one's intermediation. The probability of success could be endogenous depending on the size and abilities of the pool of potential Infos. The sunk investment K_I could be endogenous, for example advertising or acquiring a reputation for toughness, like an entry fee in a no-refund contest.[5] Or an incumbent Info may have to engage in continuing contest with challengers trying to take his place; this would endogenize his survival probability λ_0. Interestingly, Gambetta (1993) finds that if his Peppe "limits himself to selling information without guaranteeing reliability, he will not [show 'mafioso characteristics']" (p. 18), and that "competition among guarantors is perhaps the most common reason" for the use of violence (p. 40).

However, an endogenous λ_0 may create other complications. If the intermediation is highly profitable (Π_I/K_I is large), then competition will reduce the equilibrium λ_0, and the resulting Info with a short life-expectancy may be more tempted to engage in extortion or double-crossing. Also (9) shows that a lower λ_0 implies a lower F_1 – a more transient Info has to give his Opportunist customers more surplus to keep them Honest. Then the fee may not cover Info's cost. For all these reasons, it may be impossible to sustain a sufficiently long-lived intermediary precisely in those situations where the benefit of effective intermediation is large and therefore such opportunities are very profitable. There may have been an element of this in Russia during the last decade.

6.5 Selective Equilibria

There cannot be an equilibrium where only the Honest and Opportunist types are Info's customers: the Dishonests will be willing to pay more than the Opportunists, and since Info cannot identify types directly and any separation must be achieved by pricing, any price that attracts Opportunists will also attract Dishonests. But there may be an equilibrium with only Honest customers, if Info charges a fee just less than the Honest types' willingness to pay. This gets him a larger revenue from a subset of the population, so if the proportion of Honest types in the population is sufficiently large, Info may make more profit in such an equilibrium than in the all-customer case. Of course, if only the Honest types on the other side are customers, we must recalculate everyone's willingness to pay. This is done for Side 1 in Table 3.

We see that Side-1 Honest customers are now willing to pay $\alpha_2 H_1 + (\beta_2 + \gamma_2) C_1 = \alpha_2 (H_1 - C_1) + C_1$. Opportunists are willing to pay only $\alpha_2 (H_1 - C_1)$ minus rent, while Dishonests are willing to pay $\alpha_2 (W_1 - C_1)$. If Info charges the Honest customers' full willingness to pay, Opportunists will not sign up, but Dishonests may. The condition to rule this out and make an Side-1-Honest-customer equilibrium possible is

$$\alpha_2 (H_1 - C_1) + C_1 > \alpha_2 (W_1 - C_1), \qquad \text{or} \qquad \alpha_2 (W_1 - H_1) < C_1 \,.$$

This requires that there are not too many Honest customers on Side 2 whom the Side-1 Dishonests can exploit by signing up with Info. Of course, Info can get more profit from the Side-1-Honest equilibrium than the all-customer equilibrium only if α_1 is large enough.

[5] Hirschleifer and Riley (1992, chapter 10) analyze such contests.

Table 3: Payoffs for Info's Honest-Customer Equilibrium

Side-1 player		Side 2 match		
Type	Customer?	Honest	Opportunist	Dishonest
Honest	Yes	H_1	C_1	C_1
	No	0	0	0
Opportunist	Yes	H_1	C_1	C_1
	No	C_1	C_1	C_1
Dishonest	Yes	W_1	C_1	C_1
	No	C_1	C_1	C_1

The fact that the conditions take the form of a lower bound on α_1 and an upper bound on α_2 suggests that there may be selective equilibria that are asymmetric in their composition of customer types on the two sides; I will leave the study of this for future research.

7 Enforcement Intermediary

Now suppose the private intermediary is able to inflict punishment on a trader who cheats one of his customers. I will call such an "enforcement intermediary" Enfo for short. I assume that Enfo's punishments are severe enough to deter any cheating by Opportunists. It is unclear whether Enfo can inflict any effective punishment on Dishonests. They live only for one period, but Enfo might be able to make their deaths far more painful. I will assume that Enfo cannot punish Dishonests. Even then it turns out that Enfo can achieve outcomes that Info could not; an Enfo who can induce Honest action from Dishonests can do even better. Later in this section I will consider another variant, where Enfo can punish cheating only if both parties in a trade are his customers.

Thus the steps of the game in one period are: (1) Enfo offers contracts of the form "pay me F_i now, and if your match cheats you, I will inflict a terrible punishment on him." (2) People decide whether to become his customers. (3) Random pairings are formed. Each player can observe whether his match is Enfo's customer. At this point one of the traders may choose to opt out and take the outside opportunity; the significance of this will become clear soon. But if both want to play, the dilemma game is played. (4) Enfo chooses his punishment actions against anyone who has just cheated one of his customers.

Since Enfo does not provide any information about past actions of traders, there is no question of his extracting an extortion payment from a trader by threatening to assert a bad history. Enfo can still double-cross a customer by letting the other side cheat him without punishment in return for an extra fee. As with Info, for clarity of exposition I will for the moment ignore this possibility, and take it up in a later subsection.

Let Enfo's cost of serving each customer on Side i be E_i. This includes the cost of identifying the person as a customer, basically by "accompanying" him physically or metaphorically, and discovering if he gets cheated. These activities are the same as the ones performed by

Info, so E_i may not too different from I_i. Enfo must definitely incur an up-front cost K_E, which is quite likely to be large, in order to establish the necessary reputation for toughness that makes people fear his punishments. Gambetta (1993, pp.42–43) discusses in detail the nature of this reputation and the costs of acquiring it.[6] If ever Enfo has to inflict an actual punishment on a Side-i trader, he incurs an extra cost Z_i; this represents the real-life risk that the victim fights back effectively, or is protected by someone else.

7.1 All-Customer Equilibrium

Consider when there can be an equilibrium in which everyone is Enfo's customer. We can construct a table of payoffs, and calculate the difference between the expected payoffs when a customer and when not a customer, thereby deriving the willingness to pay, exactly as we did for Info. Table 4 shows the payoffs of Side-1 players, against all possible matches from Side 2, and when the Side-1 players are Enfo's customers (in the candidate equilibrium) or deviant non-customers. The payoffs for Side-2 players are analogously constructed.

If Side-1 Honests and Opportunists engage in trade without being Enfo's customers while their matches on the other side are customers, Enfo would force them to act Honest and get payoff $L_1 < 0$, so Honest and Opportunist non-customers would do better to take the outside opportunity and get 0 payoff.

Table 4: Payoffs for Enfo's All-Customer Equilibrium

Side-1 player		Side 2 match		
Type	Customer?	Honest	Opportunist	Dishonest
Honest	Yes	H_1	H_1	L_1
	No	0	0	0
Opportunist	Yes	H_1	H_1	L_1
	No	0	0	0
Dishonest	Yes	W_1	W_1	C_1
	No	C_1	C_1	C_1

Now the Opportunists do not have any intertemporal decision to make, and they cannot cheat while being Enfo's customers (because their matches are also customers); so Enfo does not have to leave them any rent. Therefore the various types' maximum willingness to pay is

$$\begin{aligned} \text{Honest:} &\quad (\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1 \\ \text{Opportunist:} &\quad (\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1 \end{aligned} \tag{17}$$

[6] A chillingly understated definition of the task is at the end of the crime novel *Cogan's Trade* by George V. Higgins. Dillon, a respected and feared enforcer in the Boston mob, has died (of natural causes), and Cogan, his protege and successor, is paying tribute: "he knew the way things oughta be done ... And when they weren't, he knew what to do."

$$\text{Dishonest:} \qquad (\alpha_2 + \gamma_2)\,(W_1 - C_1)$$

Enfo can get everyone to become a customer by charging fees

$$F_1 = \min\,[\,(\alpha_2 + \gamma_2)\,H_1 + \beta_2\,L_1\,,\;(\alpha_2 + \gamma_2)\,(W_1 - C_1)\,]\,, \tag{18}$$

and similarly for Side 2. It is easy to see that this exceeds the fee in (9) which Info could charge in his all-customer equilibrium, for two reasons. First, the deviation strategy for Info's Opportunist customers was to cheat, when they could get C_1. Enfo's deviant Opportunist customers have to drop out of the market and get 0, so their one-shot payoff difference is larger. Second, Enfo does not have to share any rent to induce the Opportunists to behave honestly, and can extract the full one-shot payoff difference. Thus, when costs are similar, Enfo's profit exceeds Info's. This conforms with, and provides a possible explanation for, Gambetta's observation (1993, p.15, quoted above) that his Peppe received a higher commission when he guaranteed quality and payment than when he merely provided information.

A different kind of all-customer equilibrium can arise if Enfo's power to punish is limited to occurences of cheating *by* a customer. That is, when a customer of Enfo gets cheated, Enfo can mete out the punishment to the cheater only if the cheater is also his customer. Consider a situation where everyone on both sides is a customer. Now everyone is compelled to act Honest by the threat of the punishment. Thus all Side-1 customers get payoff H_1. As deviant non-customers, Side-1 Honest types would stay out (payoff 0); therefore their maximum willingness to pay Enfo is H_1. As deviant non-customers, Side-1 Opportunist and Dishonest types would Cheat and get payoff C_1 because their Side-2 matches, recognizing them as non-customers immune to punishment who are going to cheat, would also cheat. (The Side-2 Honests would be authorized by Enfo to cheat.) Therefore the Side-1 Opportunists' and Dishonests' willingness to pay Enfo is $H_1 - C_1$. Enfo can then charge a fee F_1 just less than $H_1 - C_1$ and attract all traders on Side 1; similarly on Side 2.

Here the traders (particularly the Opportunists and Dishonests) are willing to pay for the privilege of being subject to Enfo's punishment, because that enables them to make a credible commitment to act Honest and get an Honest response from their matches on the other side who are also customers. Schelling (1960, p. 43) made this point in connection with the official legal system: "Among the legal privileges of corporations ... are the right to sue and the 'right' to be sued. Who wants to be sued! But the right to be sued is the power to make a promise ... a prerequisite to doing business." With the private Enfo, this has to be a part of a mutually reinforcing system – this right is valuable to you in deals with others who have also signed up as Enfo's customers and will therefore credibly reciprocate your honesty. Gambetta (1993, p. 20) also recognizes the importance of "purchasing protection against oneself," and Dasgupta (1988) offers a formal analysis.

7.2 Double-Crossing

I consider the same simple stationary strategy for controlling double-crossing by Enfo as I did for Enfo. This reintroduces some intertemporal calculation for Opportunists – they can choose to be non-customers, but in that status they cannot cheat customers. The analysis is in Appendix D. As with Info, it leads to a lower bound on the fee to control double-crossing:

$$F_1 \geq \frac{1-\nu_1}{\kappa_1} \frac{1-\delta\lambda_1}{\delta\lambda_1} (W_2 - H_2 + Z_2), \tag{19}$$

and an upper bound on the fee to control the customer's deviation

$$F_1 \leq (\alpha_2 + \kappa_2) H_1 + \beta_2 L_1, . \tag{20}$$

The lower bound is stiffer for Enfo than for Info, because by double-crossing Enfo saves the direct cost of having to inflict the punishment, something that Info does not have. Thus we have a tradeoff in the matter of using Enfo or Info to achieve cooperation. While Enfo has the advantage over Info that there is no question of his attempting extortion, his no-double-crossing condition is harder to fulfill.

On the customer side, the upper bound on Enfo's fee is higher than that for Info, again because the customer's alternative is worse and because Enfo does not need to share rent. The right hand side of (20) differs from the previous (17) which ignored double-crossing, because now there are customers in the punishment phase so κ_2 replaces γ_2. But that depends on the severity of punishment that controls Enfo's double-crossing of Side-2 customers. Therefore the right hand side of (20) is independent of q_1. In a figure like that for Info (Figure 3), the rent constraint is a horizontal straight line. Otherwise the analysis can proceed similarly.

7.3 Endogenizing Enfo

Enfo can be endogenized using a zero-profit condition similar to that for Info:

$$K_E = \frac{P_E \, \Pi_E}{1 - \delta \, \lambda_0} \, \Pi_E \,, \tag{21}$$

If this determines λ_0, then the relative life-expectancy of Info and Enfo will depend on which has the lower ratio of per-period profits to fixed costs.

Although enforcement is more profitable each period than mere information intermediation, becoming an enforcer also requires larger sunk investment. Then there may be specialization by personal characteristics or transaction type. Would-be intermediaries who are better able to make the large investments in reputation for enforcement become Enfos, and those who are not, settle for work as Infos. Large transactions or more severe prisoners' dilemmas, where profits from intermediation are large enough to justify the investment, will be governed by enforcement, leaving smaller transactions for information-based governance.

7.4 Selective Equilibria

Can Enfo make more profit by selling his service to a subset of the population who are willing to pay a higher price? The willingness to pay of each type on one side depends on the customer composition on the other side. Therefore one must examine each combination to see if it can be sustained as an equilibrium, and if so, what profit Enfo gets from it. I examine only a couple of the logical cases.

Table 5: Payoffs for Enfo's Honest-and-Opportunist Equilibrium

Side-1 player		Side 2 match		
Type	Customer?	Honest	Opportunist	Dishonest
Honest	Yes	H_1	H_1	C_1
	No	0	0	0
Opportunist	Yes	H_1	H_1	C_1
	No	0	0	C_1
Dishonest	Yes	W_1	W_1	C_1
	No	C_1	C_1	C_1

Consider first the possibility that only the Honests and the Opportunists on both sides are his customers. The payoffs are shown in Table 5. Therefore the various types' maximum willingness to pay is

$$\begin{array}{rl} \text{Honest:} & (\alpha_2 + \gamma_2)\, H_1 + \beta_2\, C_1 \\ \text{Opportunist:} & (\alpha_2 + \gamma_2)\, H_1 \\ \text{Dishonest:} & (\alpha_2 + \gamma_2)\, (W_1 - C_1) \end{array} \tag{22}$$

Side-1 Honest and Opportunist types are willing to pay Enfo more than in the all-customer case, because Side-2 Dishonests are now identified by the fact of their being non-customers. If Enfo charges $(\alpha_2 + \gamma_2)\, H_1$, Side-1 Honest and Opportunist customers will pay it, and if $W_1 - H_1 < C_1$, then Side-2 Dishonests will not pay it, sustaining the selective equilibrium where Side-1 Honest and Opportunists are Enfo's customers. The condition $W_1 - H_1 < C_1$ is stronger than the inequality $W_1 - H_1 < C_1 - L_1$ that characterized the "defensive" case of the prisoners' dilemma, because $L_1 < 0$. A similar analysis applies for customers on Side 2. Thus, in a subcase of the defensive case, an equilibrium with Honest and Opportunist members can obtain. Info gets more profit from it than from the all-customer equilibrium if

$$\begin{aligned} & (\alpha_1 + \gamma_1)\, [\, (\alpha_2 + \gamma_2)\, H_1 - E_1\,] + (\alpha_2 + \gamma_2)\, [\, (\alpha_1 + \gamma_1)\, H_2 - E_2\,] \\ > \; & [\, (\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1 - E_1\,] + [\, (\alpha_1 + \gamma_1)\, H_2 + \beta_1\, L_2 - E_2\,] \end{aligned}$$

Enfo may go even farther to charge a fee that leaves only the Honest customers. I will omit the details. It can be shown that the situation where Enfo charges $\alpha_2\, H_1 + \beta_2\, C_1$ to Side-1 customers and the corresponding fee for Side 2, and only the Honests join, is an equilibrium provided $\alpha_2\, (W_1 - H_1) < C_1$ and a similar condition on the other side. Since my presumption is that γ_2 is large compared to β_2, it is likely that this fee is less than that for the Honest-and-Opportunist equilibrium. Therefore this more selective equilibrium is unlikely to be profitable for Enfo. However, the analysis points out that for some fees there may be multiple equilibria. How Enfo can bring about a particular one among them is not clear.

8 Social Optimum Comparisons

The private intermediary can bring about an equilibrium with more honest actions than would have been possible in his absence. As a friend (who has asked not to be named) remarked: "Gambetta's Peppe serves a useful purpose in an imperfect world; I wish I could be sure of that for myself." However, the equilibria with Info or Enfo can fall short of social optimality for many reasons.

The most obvious is the discrepancy between the gains of the traders and what the intermediary can extract as his fee. There are numerous cases to consider, and I will sketch only the most prominent ones to make my point. In particular, I will suppose that most of the people are Opportunists, that is, $\gamma_i \approx 1$, and focus on just the gains and fees for these types.

Suppose the equilibrium with self-governance would have been (C1,C2) where the Opportunists on both sides Cheat, but that the intermediary can establish an (H1,H2) equilibrium where they act Honest. Then the expected payoff gain of a Side-1 Opportunist is approximately $(H_1 - C_1)$. To the same approximation, the fee he pays to Info can be found by setting is $\alpha_2 = \beta_2 = 0$ in (14); it is

$$\kappa_2 \, H_1 - C_1 - \rho_1 \, \kappa_2 \, (W_1 - H_1) \, .$$

Recall that κ_2 is the proportion of Info's Opportunist customers who are not in the punishment phase of the bilateral game that controls Info's incentive to double-cross them; even when $\gamma_2 \approx 1$, $\kappa_2 < 1$. Therefore Info's fee is less than the customer's gain $H_1 - C_1$: Info cannot extract all the surplus he creates. Then he may not be able to provide his services profitably even when it is socially desirable to have them, or more generally, will underinvest in intermediation.

If instead the intermediation is done by Enfo, the fee is $\kappa_2 \, H_1$. This could exceed the customer's gain $(H_1 - C_1)$ if κ_2 is large enough: Enfo may be able to extract more than the surplus he creates. There are two reasons: (1) Enfo does not have to leave any rent; (2)in an equilibrium with Enfo, each customer's alternative is not the self-governance equilibrium (where he could cheat and get C_1), but merely dropping out of the game altogether and getting zero. Thus Enfo may become a parasite, who extracts from society more than the benefit he conveys by his governance, but the group is helpless unless it can solve a collective action problem to get rid of Enfo. This seems to describe some situations of mafia rule.

Investment in private intermediation can easily take the form of costly activities that dissipate the rent; this is another reason for social suboptimality. This problem is especially severe with Enfo, because he has the greater profit potential.

Third, in my model double-crossing is controlled by punishments that are triggered along the equilibrium path even when the intermediary has not cheated. While it may be possible to do better than the simple punishment I assumed, in this game of incomplete information about type and imperfect information about action, any punishment that controls double-crossing is likely to entail some cost. If an official legal system can credibly commit itself to honorable behavior in this regard, it can avoid this cost.

I have compared private intermediation with an ideal social optimum having the same information technology. A real-life official legal system may have its own problems. Its internal agency problems may reduce its information capabilities. Its officials may be biased or corrupt. And the prospect of attaining a position where one can earn bribes may set off a rent-seeking competition that dissipates resources, just like the ex ante contest to become the private intermediary. A better comparison of private and public enforcement needs a better model of the public law system.

9 Conclusions and Ideas for Further Research

I have explored a model of contract governance in large-group interactions by profit-motivated private intermediation, and its links to self-enforcement on the one hand, and an ideal social optimum on the other hand. I hope some results of this simple exercise are interesting. In particular I would like to point out the following: [1] Under self-governance, the choice between Honesty and Cheating for each side interacts with the similar choice on the other side, producing different possible and multiple stationary states, and scope for one-sided or two-sided private for-profit governance. [2] A better public information system can locally increase rather than lower the intermediary's profit. [3] Intermediation by provision of information differs from that by punishment of cheaters in many ways. The latter can give the intermediary more profit than the social benefits from his presence by worsening the alternatives of his customers. [4] Private intermediation may be infeasible just when it is most valuable, because the prospect of a large profit creates a fierce contest, which shortens the horizon of the intermediary and threatens the conditions needed to sustain good behavior in repeated interactions.

However, this simple exploration is far from being an end in itself. I intend it to be a mere first step in what promises to be an interesting and potentially valuable area of research.

To keep this initial exploration as simple as possible, I made several simplifying assumptions and examined only a few of the possible cases. For a better account of reality, these need to be altered or relaxed. First, the case where one side or the other gets a worse payoff in the cheating outcome of the prisoners' dilemma than its outside opportunity, that is, where C_1 or C_2 is negative, should be analyzed. Second, good outcomes of the repeated interactions may be achievable for a bigger range of parameters, and at a smaller cost of coping with imperfect information, than the simple trigger strategies I have used; this needs to be studied. Third, other technologies for gathering and spreading information should be explored – can Info carry out explicit detection without running into free riding, and will the public Bad label process help or hurt Info's profit from explicit detection?

Even more important are the larger questions this framework suggests. The members of any large group are engaged in many different kinds of economic interactions, with different payoffs, different possibilities of cheating, and different forms of repetition, than the simple prisoners' dilemma that I modeled. Will a common system of governance cope with them all, or will different modes have different comparative or absolute advantages for governing different transactions? Can there be multiple equilibria, where either mode can persist once it gets established, even though another may have better properties? Should one expect a shift from one mode to another during the process of economic growth or expansion of trade, as Li (1999) suggests? Can the existence of multiple equilibria give rise to lock-in?

Governance of transactions is a very basic issue in economics. Much progress has been made in understanding it, but much more remains to be done. I hope this small contribution will draw greater interest and attention from theorists and spur more rapid and sustained progress.

Appendix

A: Ergodic Proportions of Bad Labels

Consider the stochastic stationary state where Opportunists cheat. On Side 1, let p_1 denote the proportion of Opportunists who have a Bad label in the stochastic stationary state. Of those with a Bad label, a fraction λ_1 survive to the next period. Of the other $(1 - p_1)$, a fraction $(1 - \gamma_2\, p_2)$ meet Side-2 players without a Bad label.[7] The act of cheating in this interaction will earn the Side-1 cheaters a Bad label with probability π_1, and a fraction λ_1 of them will survive to the next period. In the stochastic stationary state, therefore

$$p_1 = p_1\, \lambda_1 + (1 - p_1)\, (1 - \gamma_2\, p_2)\, \pi_1\, \lambda_1\,,$$

or

$$\frac{p_1}{1 - p_1}\, \frac{1 - \lambda_1}{\lambda_1\, \pi_1} = 1 - \gamma_2\, p_2\,. \tag{A.1}$$

There is a similar equation for the proportions on the other side.

$$\frac{p_2}{1 - p_2}\, \frac{1 - \lambda_2}{\lambda_2\, \pi_2} = 1 - \gamma_1\, p_1\,. \tag{A.2}$$

Then (p_1, p_2) are found by simultaneous solution of these equations.

Figure 4 shows this geometrically. The points labeled E_1 and E_2 are

$$E_1 = \left(\frac{\lambda_1\, \pi_1}{1 - \lambda_1 + \lambda_1\, \pi_1}\,, 0 \right)\,, \qquad E_2 = \left(0\,, \frac{\lambda_2\, \pi_2}{1 - \lambda_2 + \lambda_2\, \pi_2} \right)\,.$$

As λ_1 or π_1 increases, the curve (A.1) shifts to the right, so p_1 increases and p_2 decreases. As γ_1 increases, the curve (A.2) shifts downward so p_1 increases and p_2 decreases. The effects of shifts in λ_2, π_2 and γ_2 can be found similarly.

B: The Opportunist As Info's Customer

Suppose all groups on Side 2 are Info's customers. Consider a Side-1 Opportunist. He takes as given the strategies of the other players:

Info: (1) Will let his Side-2 customers cheat a Side-1 non-customer; in fact he will instruct and authorize his Side-2 Honest customers to do so. (2) Will record any instance where a customer gets cheated, and report the cheater's history to future customers, and allow or instruct them to play Cheat against the previous cheater, even though the cheater may offer to sign up as a customer later.

Side-2 Honests will act Honest unless authorized by Info to play cheat. **Dishonests** will play Cheat no matter what. **Opportunists** will play Honest against Info's customers with no known history of cheating; they will play Cheat against non-customers.

[7] Remember that Opportunists form a proportion γ_2 of the population on Side 2, and of these a fraction p_2 have Bad labels, so the fraction $\gamma_2\, p_2$ of the Side-2 *population* have bad labels, and the other $(1 - \gamma_2\, p_2)$ do not.

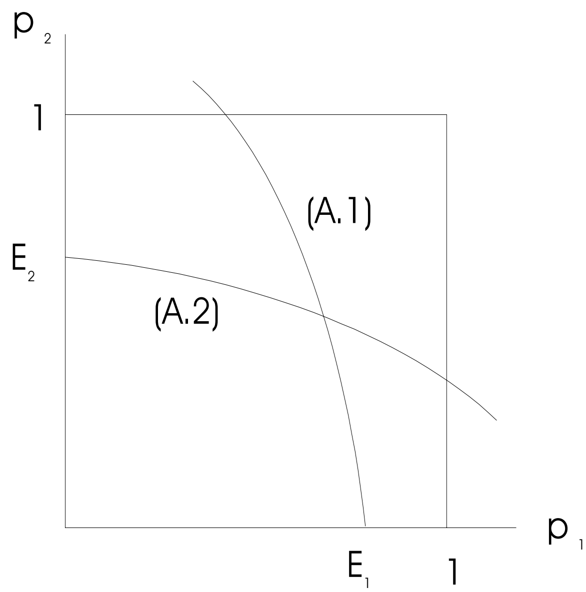

Figure 4: Stationary State Proportions of Bad Labels

Of course these other strategies must also be checked for best response properties. The strategy of Side-2 Opportunists is checked in the same way as the analysis for Side 1 below; Info's incentives to deviate (by extortion or double-crossing) are discussed in the text.

Let V_1 denote the present value payoff to a Side-1 Opportunist with a clean history. He can take any of four actions this period: [1] He can become Info's customer by paying F_1, and act Honest. Then the one-shot game will give him a payoff $(\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1$, and the continuation value V_1 starting next period. [2] He can become a customer by paying F_1, but Cheat. The one-period payoff is higher, $(\alpha_2 + \gamma_2)\, W_1 + \beta_2\, C_1$; let $\widehat{V}_1$ be the continuation value starting next period. [3] He can stay a non-customer but act Honest. All of his Side-2 matches will Cheat, so he will get a current-period payoff L_1, but his record will stay clean and the continuation payoff will be V_1. [3] He can stay a non-customer and play Cheat. This will get him a current-period payoff C_1, and the continuation payoff $\widehat{V}_1$. The effective discount factor taking into account the probability of this player's survival is $\delta\lambda_1$.

Therefore his dynamic programming problem is

$$\begin{aligned} V_1 \;=\; \max \{ \; & (\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1 - F_1 + \delta\lambda_1\, V_1 \\ & (\alpha_2 + \gamma_2)\, W_1 + \beta_2\, C_1 - F_1 + \delta\lambda_1\, \widehat{V}_1 \,, \\ & L_1 + \delta\lambda\, V_1 \,,\; C_1 + \delta\lambda_1\, \widehat{V}_1 \; \} \end{aligned} \tag{B.1}$$

The continuation value $\widehat{V}_1$ after a Cheating action can be decomposed as follows. With probability π_1 this will earn a public Bad label, and all future matches will play Cheat, so this player will also play Cheat and get C_1 every period; the present value is $C_1/(1 - \delta\lambda_1)$. With probability $(1 - \pi_1)$ there will be no public bad label, but since all players on Side 2 are Info's customers in the stationary state we are testing, Info will find out. If Info survives until the next period (probability λ_0), he will instruct all his Side-2 customers to Cheat, and the Side-1 customer will get the one-shot payoff C_1 and the continuation value $\widehat{V}_1$ again. With probability $(1-\lambda_0)$, Info will not survive, when the Side-1 Opportunist can make a fresh start, value V_1. Thus

$$\widehat{V}_1 = \pi_1 \, \frac{C_1}{1-\delta\lambda_1} + (1-\pi_1)\lambda_0 \, [\, C_1 + \delta\lambda_1 \, \widehat{V}_1 \,] + +(1-\pi_1)(1-\lambda_0) \, V_1 \; . \tag{B.2}$$

I begin by proving a preliminary result that is used in the text:

Lemma 1: Being a non-customer but playing Honest cannot be optimal.
Proof: Suppose it is optimal. Then

$$V_1 = L_1 + \delta\lambda_1 \, V_1 \qquad \text{or} \qquad V_1 = L_1 \, / \, (1-\delta\lambda_1) \, ,$$

and

$$V_1 \geq C_1 + \delta\lambda_1 \, \widehat{V}_1 \, .$$

Using this in (B.2),

$$\widehat{V}_1 \geq \pi_1 \, \frac{C_1}{1-\delta\lambda_1} + (1-\pi_1, \lambda_0 \, [\, C_1 + \delta\lambda_1 \, \widehat{V}_1 \,] + (1-\pi_1)(1-\lambda_0) \, [C_1 + \delta\lambda_1 \, \widehat{V}_1] \; .$$

Collecting terms and simplifying, this becomes

$$V_1 \geq C_1 \, / \, (1-\delta\lambda_1) \, .$$

Combining this with the above expression for V_1, we have $L_1 \geq C_1$, which is inconsistent with the payoffs of the one-shot game. QED

Now turn to the conditions for the strategy of becoming a customer and playing Honest to be optimal. The dynamic programming relation yields the following:
Since the first choice is (by assumption) optimal:

$$V_1 = (\alpha_2 + \gamma_2) \, H_1 + \beta_2 \, L_1 - F_1 + \delta\lambda_1 \, V_1 \, , \tag{B.3}$$

or

$$V_1 = \frac{(\alpha_2 + \gamma_2) \, H_1 + \beta_2 \, L_1 - F_1}{1-\delta\lambda_1} \, . \tag{B.4}$$

Comparing the first and the second choices:

$$V_1 \geq (\alpha_2 + \gamma_2) \, W_1 + \beta_2 \, C_1 - F_1 + \delta\lambda_1 \, \widehat{V}_1 \, , \tag{B.5}$$

or combining this with (B.3),

$$(\alpha_2 + \gamma_2) \, (W_1 - H_1) + \beta_2 \, (C_1 - L_1) \leq \delta\lambda_1 \; [\, V_1 - \widehat{V}_1 \,] \, . \tag{B.6}$$

Comparing the first and the third choices:

$$V_1 \geq L_1 + \delta\lambda_1 \, V_1 \, , \tag{B.7}$$

or combining this with (B.3),

$$F_1 \leq (\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1 - L_1 = (\alpha_2 + \gamma_2)\,(H_1 - L_1)\,. \tag{B.8}$$

Comparing the first and the fourth choices:

$$V_1 \geq C_1 + \delta\lambda_1\, \widehat{V}_1\,, \tag{B.9}$$

or, combining this with (B.3),

$$F_1 \leq (\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1 - C_1 + \delta\lambda_1\, [\, V_1 - \widehat{V}_1\,]\,. \tag{B.10}$$

A preliminary result makes some of these inequalities redundant.

Lemma 2: $F_1 < (\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1 - C_1\,.$
Proof: Suppose otherwise, that is,

$$(\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1 - F_1 \leq C_1\,.$$

Using this in (B.3),

$$V_1 \leq C_1 + \delta\lambda_1\, V_1, \qquad \text{or} \qquad V_1 \leq \frac{C_1}{1-\delta\lambda_1}\,.$$

Next, using (B.9) in (B.2),

$$\widehat{V}_1 \geq \pi_1\, \frac{C_1}{1-\delta\lambda_1} + (1-\pi_1, \lambda_0\, [\, C_1 + \delta\lambda_1\, \widehat{V}_1\,] + +(1-\pi_1)(1-\lambda_0)\, [C_1 + \delta\lambda_1\, \widehat{V}_1\,]\,,$$

which simplifies to

$$\widehat{V}_1 \geq C_1/(1-\delta\lambda_1)\,.$$

Therefore (B.9) becomes

$$V_1 \geq C_1 + \delta\lambda_1\, \frac{C_1}{1-\delta\lambda_1} = \frac{C_1}{1-\delta\lambda_1}\,.$$

But we proved the opposite weak inequality above from the contradiction hypothesis, therefore $V_1 = C_1/(1-\delta\lambda_1)$. Using this back in (B.9),

$$\widehat{V}_1 \leq \frac{1}{\delta\lambda_1}\, [\, V_1 - C_1\,] = \frac{1}{\delta\lambda_1}\, \left[\frac{C_1}{1-\delta\lambda_1} - C_1\right] = \frac{C_1}{1-\delta\lambda_1}\,.$$

We proved the opposite weak inequality just above, so $\widehat{V}_1 = C_1/(1-\delta\lambda_1)$ also.
Finally, using $V_1 = \widehat{V}_1$ in (B.6),

$$(\alpha_2 + \gamma_2)\,(W_1 - H_1) + \beta_2\,(C_1 - L_1) \leq 0\,,$$

which is incompatible with the payoffs of the one-shot game. QED

Now we can proceed to find the conditions for the specified stationary state to be an equilibrium. First, (B.6) implies $V_1 \geq \widehat{V}_1$, and then Lemma 2 implies that the inequality (B.10) is slack. Moreover, since $C_1 > L_1$,

$$(\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1 - L_1 > (\alpha_2 + \gamma_2)\, H_1 + \beta_2\, L_1 - C_1\,;$$

then by Lemma 2 the inequality (B.8) is also slack. This leaves us to consider (B.3) and (B.6).

Observe that

$$\begin{aligned} V_1 &= \pi_1\, V_1 + (1-\pi_1)\lambda_0\, V_1 + (1-\pi_1)(1-\lambda_0)\, V_1 \\ &= \pi_1\, V_1 + (1-\pi_1)\lambda_0\, [(\alpha_2+\gamma_2)\, H_1 + \beta_2\, L_1 - F_1 + \delta\lambda_1\, V_1] + (1-\pi_1)(1-\lambda_0)\, V_1\,, \end{aligned}$$

where the first line is an identity since the probabilities that are used as coefficients sum to 1, and the second line uses (B.3). Subtract (B.2) from this, to obtain

$$V_1 - \widehat{V}_1 = \pi_1 \left[V_1 - \frac{C_1}{1-\delta\lambda_1} \right] + (1-\pi_1)\lambda_0\, [\, (\alpha_2+\gamma_2)\, H_1 + \beta_2\, L_1 - F_1 - C_1\,] + (1-\pi_1)\lambda_0\, \delta\lambda_1\, [\, V_1 - \widehat{V}_1\,]\,.$$

Using (B.3), this “simplifies” to

$$V_1 - \widehat{V}_1 = \frac{(\alpha_2+\gamma_2)\, H_1 + \beta_2\, L_1 - F_1 - C_1}{1-\delta\lambda_1}\; \frac{\pi_1 + (1-\pi_1)\,\lambda_0\,(1-\delta\lambda_1)}{1-\delta\lambda_1\,\lambda_0\,(1-\pi_1)}\,.$$

Substituting in (B.6) and rearranging terms, we have

$$\begin{aligned} F_1 \;\leq\;& [\,(\alpha_2+\gamma_2)\, H_1 + \beta_2\, L_1 - C_1\,] \\ &- [\,(\alpha_2+\gamma_2)\,(W_1 - H_1) + \beta_2\,(C_1 - L_1)\,]\; \frac{\frac{1}{\delta\lambda_1} - \lambda_0\,(1-\pi_1)}{\frac{\pi_1}{1-\delta\lambda_1} + \lambda_0\,(1-\pi_1)} \end{aligned} \tag{B.11}$$

The intuition for this was explained in the text. Info's fee F_1 must not be so large as to extract the Opportunist's entire one-shot benefit from being his customer. If it were, the customer would cheat for an immediate gain, and get the same future payoffs as if he had not cheated. Info must give the customer enough surplus to induce him to stay honest. This is a product of (i) the one-period gain from cheating (the term in the square brackets on the second line on the right hand side), and (ii) an effective discount rate that depends on pure discounting, the probability of public detection, and the probabilities of the customer's and Info's survival. The higher the probability of Info's survival (λ_0), and the higher the probability of public detection (π_1), the smaller is the effective discount rate, and therefore Info needs to give away less surplus.

C: Info's Double-Crossing

Here I allow the possibility that Info can take an extra fee from a customer on one side to let him cheat the customer on the other side. However, I restrict the analysis to the case where

Info lives for ever ($\lambda_0 = 1$). The punishment strategy that controls Info's temptation to double-cross is as follows. If a Side-1 Opportunist customer gets payoff L_1, then with probability q_1 the relationship between him and Info switches to a punishment phase. Starting the next period (if the trader is still alive), he becomes a non-customer and starts to play Cheat. Every period thereafter (so long as the customer is still alive), the punishment phase continues. The probability is generated by an iid device whose realizations are observed (with common knowledge) by Info and this customer. Since the stage game has an equilibrium where Info would double-cross a customer and therefore the trader does not become a customer, the common-knowledge expectation of the punishment process is self-fulfilling.

The customer's cheating during the punishment phase is regarded as authorized and therefore does not result in a public Bad label. But Info may try to extort an extra fee later by threatening to say that it was unauthorized. The condition to rule this out is the same no-extortion condition as in the text.

I will look for an equilibrium where Info does not double-cross. Since there are Side-2 Dishonests who are customers of Info but Cheat, in equilibrium play a Side-1 Opportunist will get the payoff L_1 with probability β_2. In that event, with probability $\lambda_1 q_1$ the punishment phase will be triggered – he will survive and become a non-customer next period. And someone in this situation will stay in it the following period with probability λ_1. (With probability $1 - \lambda_1$ he will die, and his replacement will start afresh in the customer phase.) Therefore Side-1 Opportunists switch between the customer and punishment categories according to the transition matrix shown in Table 6:

Table 6: Transition Matrix for Opportunists

		To category	
		Customer	Punishment
From category	Customer	$1 - \beta_2 \lambda_1 q_1$	$\beta_2 \lambda_1 q_1$
	Punishment	$1 - \lambda_1$	λ_1

Then the ergodic proportion of the non-customer category, say x, is defined by the equation

$$x = (1 - x)\ \beta_2 \lambda_1 q_1 + x\ \lambda_1\,.$$

Solving for x, the population proportions of Side-1 Opportunist customers and non-customers, denoted by κ_1 and ν_1 (with $\kappa_1 + \nu_1 = \gamma_1$), are

$$\kappa_1 = (1 - x)\,\gamma_1 = \frac{1 - \lambda_1}{1 - \lambda_1 + \beta_2 \lambda_1 q_1}\ \gamma_1, \qquad \nu_1 = x\gamma_1 = \frac{\beta_2 \lambda_1 q_1}{1 - \lambda_1 + \beta_2 \lambda_1 q_1}\ \gamma_1\,. \tag{C.1}$$

Now we can obtain the condition for Info not to double-cross a customer on Side 1. If he does so, the match on Side 2 gains an extra $W_2 - H_2$, and this is the maximum Info can extract from him. The probability that the Side 1 customer is an Opportunist is $\kappa_1/(1-\nu_1) = \kappa_1/(\alpha_1+\beta_1+\kappa_1)$. In that event, the punishment phase will kick in, and while it lasts, Info will lose the fee he charges, say F_1. The expected present value of this is calculated using the effective discount factor $\delta\lambda_1$. Therefore the no-double-crossing condition is

$$W_2 - H_2 \le \frac{\kappa_1}{1-\nu_1}\,\frac{\delta\lambda_1}{1-\delta\lambda_1}\,F_1\,,$$

or

$$F_1 \ge \frac{1-\nu_1}{\kappa_1}\,\frac{1-\delta\lambda_1}{\delta\lambda_1}\,(W_2 - H_2)\,. \tag{C.2}$$

Next consider the Side 1 Opportunist customer's decision. His match on Side 2 may be a customer who is Honest, Opportunist, or Dishonest with respective probabilities α_2, κ_2 and β_2, or with probability ν_2 a non-customer in the punishment phase. He himself may choose to be a customer and act Honest (in the candidate equilibrium), or deviate to be a non-customer and/or cheat. So his dynamic programming problem is

$$\begin{aligned} V_1 \;=\; \max\Big\{ & (\alpha_2+\kappa_2)\,H_1 + \nu_2\,C_1 + \beta_2\,L_1 - F_1 + \delta\lambda_1\,V_1 - q_1\,\beta_2\,\delta\lambda_1\,(V_1 - \overline{V}_1)\,, \\ & (\alpha_2+\kappa_2)\,W_1 + \nu_2\,C_1 + \beta_2\,C_1 - F_1 + \delta\lambda_1\,\widehat{V}_1\,, \\ & L_1 + \delta\lambda_1\,V_1\,, C_1 + \delta\lambda_1\,\widehat{V}_1 \Big\}\,, \end{aligned} \tag{C.3}$$

Here $\overline{V}_1$ is the continuation payoff when the probabilistic punishment phase intended to control Info's double-crossing is triggered by a chance meeting with a Side-2 Dishonest, and $\widehat{V}_1$ is the continuation payoff in the punishment phase triggered by the Side-1 Opportunist's own cheating.

From the rules of the probabilistic punishment phase, we have the recursion formula for its continuation payoff:

$$\overline{V}_1 = C_1 + \delta\,\lambda_1\,\overline{V}_1, \text{ therefore } \overline{V}_1 = C_1\,/\,(1-\delta\lambda_1)\,,$$

and

$$V_1 - \overline{V}_1 = \frac{(1-\delta\lambda_1)\,V_1 - C_1}{1-\delta\,\lambda_1}\,. \tag{C.4}$$

Next, as in Lemma 1 of Appendix B, it cannot be optimal to take the third action on the right hand side of the dynamic programming recursion (being a non-customer but choosing Honest). Then we can write recursion equations for the continuation payoff when the customer cheats:

$$\widehat{V}_1 = \pi_1\,\frac{C_1}{1-\delta\,\lambda_1} + (1-\pi_1)\,(C_1 + \delta\,\lambda_1\,\widehat{V}_1)\,.$$

The first term on the right hand side is what happens if the cheating gets a public bad label; the second term is when only Info finds out. This simplifies to

$$\widehat{V}_1 = \frac{C_1}{1-\delta\,\lambda_1}\,. \tag{C.5}$$

Now the analysis proceeds as in Appendix B. The important condition is that for the first choice in the dynamic programming problem (C.3) to be better than the second. After some algebra, this can be written as

$$(\alpha_2 + \kappa_2)\,(W_1 - H_1) + \beta_2\,(C_1 - L_1) \le \frac{1}{\rho_1}\,[\,(\alpha_2 + \kappa_2)\,H_1 + \nu_2\,C_1 + \beta_2\,L_1 - C_1 - F_1\,]\,,$$

where

$$\rho_1 = \frac{1 - \delta\,\lambda_1\,(1 - q_1\,\beta_2)}{\delta\,\lambda_1\,(1 - q_1\,\beta_2)}\,. \tag{C.6}$$

As usual, the condition says that the one-time gain should not exceed the capitalized expected value of the subsequent stream of losses during the punishment. The effective discount rate is given by (C.6). If the punishment phase to control Info's double-crossing did not have to be triggered with positive probability along the equilibrium path, that is, if $\beta_2 = 0$ or $q_1 = 0$, then the discount rate would be just the familiar $\rho_1 = 1/(\delta\,\lambda_1) - 1$. But because of the additional need to control Info's double-crossing, the effective discount rate is larger. Then the condition can be written as

$$F_1 \le [\,(\alpha_2 + \kappa_2)\,H_1 + \nu_2\,C_1 + \beta_2\,L_1 - C_1\,] - \rho_1\,[\,(\alpha_2 + \kappa_2)\,(W_1 - H_1) + \beta_2\,(C_1 - L_1)\,]\,. \tag{C.7}$$

Thus, to control the Side-1 Opportunist's cheating as well as Info's double-crossing, we need F_1 and q_1 to satisfy both (C.2) and (C.7). In particular, to control Info's double-crossing in this situation of imperfect information, we need a punishment that is sometimes triggered even when Info has remained faithful. This lowers the customer's payoff from staying Honest. To retain his incentive, Info has to give him more rent.

D: The Opportunist and Enfo

The analysis is similar to that in Appendix C, and the same notation is used without redefinition. The one crucial difference is that a trader who chooses not to be a customer does not have the possibility of cheating any of Enfo's customers. I will assume that the customers who are temporarily in a punishment phase can cheat others of the same kind and be cheated by anyone; the results are unaffected if no cheating can occur at either of these.

The Side-1 Opportunist's dynamic programming problem is now

$$\begin{aligned} V_1 \;\; = \;\; \max \Big\{ \; & (\alpha_2 + \kappa_2)\,H_1 + \nu_2\,C_1 + \beta_2\,L_1 - F_1 + \delta\lambda_1\,V_1 - q_1\,\beta_2\,\delta\lambda_1\,(V_1 - \overline{V}_1)\,, \\ & \nu_2\,C_1 + \delta\lambda_1\,V_1 \Big\}\;, \end{aligned} \tag{D.1}$$

where

$$\overline{V}_1 = \nu_2\,C_1 + \delta\,\lambda_1\,\overline{V}_1\,,$$

and then

$$V_1 - \overline{V}_1 = \frac{(1 - \delta\lambda_1)\,V_1 - \nu_2\,C_1}{1 - \delta\,\lambda_1}\,. \tag{D.2}$$

For the first choice on the right hand side in (D.1) to be optimal, we need

$$\begin{aligned} V_1 &= (\alpha_2 + \kappa_2)\, H_1 + \nu_2\, C_1 + \beta_2\, L_1 - F_1 + \delta\lambda_1\, V_1 - q_1\, \beta_2\, \delta\lambda_1\, (V_1 - \overline{V}_1) \\ &\geq \nu_2\, C_1 + \delta\lambda_1\, V_1\,. \end{aligned}$$

Using (D.2), the equation yields

$$(1 - \delta\lambda_1)\, V_1 - \nu_2\, C_1 = \frac{1 - \delta\lambda_1}{1 - \delta\,\lambda_1 + \beta_2\,\delta\,\lambda_1\, q_1}\, [\,(\alpha_2 + \kappa_2)\, H_1 + \beta_2\, L_1 - F_1\,]\,. \tag{D.3}$$

Then the inequality can be written as

$$\begin{aligned} (\alpha_2 + \kappa_2)\, H_1 + \beta_2\, L_1 - F_1 &\geq \beta_2\, \delta\lambda_1\, q_1\, (V_1 - \overline{V}_1) \\ &= \frac{\beta_2\, \delta\lambda_1\, q_1}{1 - \delta\,\lambda_1 + \beta_2\,\delta\,\lambda_1\, q_1}\, [\,(\alpha_2 + \kappa_2)\, H_1 + \beta_2\, L_1 - F_1\,]\,. \end{aligned}$$

This simplifies to

$$F_1 \leq (\alpha_2 + \kappa_2)\, H_1 + \beta_2\, L_1,\,. \tag{D.4}$$

The analysis and the condition to rule out Enfo's double-crossing is similar to that in Appendix C except that if Enfo double-crosses a Side-1 customer, he saves the extra cost Z_2 of actually inflicting the punishment on the Side-2 cheater. Therefore the condition is

$$F_1 \geq \frac{1 - \nu_1}{\kappa_1}\, \frac{1 - \delta\lambda_1}{\delta\lambda_1}\, (W_2 - H_2 + Z_2)\,. \tag{D.5}$$

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