Optimal M&A Advisory Contracts

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Abstract

Consider a scenario where a firm is in negotiations with a potential buyer. Both the buyer and the seller are uninformed about the value of synergies, but they can hire an M & A Advisor. Suppose, though, that the seller and buyer face a moral hazard problem. If the advisor's effort is not observable, he has the option of not exerting effort and reporting any of the possible values. Should the seller and buyer hire an advisor and what is the optimal contract that they should sign with him? We find that the probabilities with which the buyer and seller hire their advisors and the optimal contracts are determined simultaneously in equilibrium. Both contracts depend on two variables- whether the transaction succeeds or not and, if it does, the value of the transaction. The seller's optimal contract with his advisor is unique, but the buyer's optimal contract can take a variety of forms. The compensation of the seller's advisor is monotonically increasing in the transaction value. Neither advisor is paid if the transaction fails. In equilibrium, both advisors exert effort, report truthfully and do not extract any information rents. However, the first best is not obtained because the transaction can fail even though it is socially optimal.

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1 Introduction

Mergers and acquisitions are a significant mechanism of allocating assets to their most productive users. A merger transaction need not be a zero-sum game; it can leave both the buyer and the seller better off. Mergers can have real effects by increasing the market power of firms and affecting ownership patterns in the economy. A well-functioning market for corporate control can serve as a barometer of the health of the economy and its effectiveness in driving weaker firms out of business

Asymmetric information between the seller and the buyer regarding the synergies of the transaction are pervasive in acquisitions. The buyer and seller often have drastically different assessment of the synergies in the transaction. This can lead to a socially efficient transaction failing or an inefficient transaction going through. A recent example is the failure of Microsoft to acquire Salesforce. Although Microsoft was willing to offer roughly $55 billion for the company, Microsoft's offer was met with counteroffers from Salesforce which were as high as $70 billion.[1]Another example of a possibly momentous merger failing due to disagreements beween the target and bidder over the price occured when negotiations between Uber and Lyft fell through in 2014.[2]

Often, M&A deals feature M&A advisory firms advising the seller, the buyer or both. Servaes and Zenner [1996] compare acquisitions completed with and without investment banks to see why banks are hired and what functions they perform. They argue that investment banks decrease transaction costs by being able to analyze acquistions at a lower cost and thus reduce the asymmetric information inherent in any merger transaction.

Since investment banks decrease the asymmetry of information, their presence may make the difference between the success or failure of the merger, both in terms of the transaction happening and in terms of the later performance of the target firms. However, the presence of an investment bank introduces another friction into the dynamics of the transaction, namely moral hazard. This is because exerting effort to value the synergies is costly for the investment banks.

Since the effort is costly and frequently not observable or contractible, the investment bank has an incentive to report a value of synergies without doing any investigation. The seller and buyer must incentivise their advisors to put in effort by structuring the wage contract with him appropriately. Hunter and Walker [1990] find that gains from a merger are associated with the banks exerting effort.[3]

[1]Kedmey, Dan. "Here's Why Microsoft Didn't Buy Salesforce." *Time Magazine* 22 May 2015. Web. Accessed 23 October 2016.

[2]Shen, Lucinda. "Uber Confirms 2014 Negotiations to Buy Lyft." *Fortune Magazine* 2 September 2016. Web. Accessed 23 October 2016.

[3]However, their proxy for effort is the ease with which the merger negotiations were conducted. It is not clear that this is the best proxy for effort . For instance, a merger can happen if the buyer's advisor reports the highest possible value of synergies without putting in any effort because the buyer will bid the highest possible value.

McLaughlin [1990] points out that making fees contingent on the success of the transaction can lead to conflicts of interest between banks and bidding firms. These kind of contracts are not optimally constructed to solve the moral hazard problem. The bidder's bank may ask the bidder to bid high to ensure the transaction going through and pocket the fees. Even with optimal contracts, it is not obvious that the first best can be realized. McLaughlin [1992] finds evidence from examining tender offers that the effectiveness of fee contracts in solving agency problems in tender offers is mixed.

It is very much possible that an expert is hired to provide a valuation for the target rather than an investment bank. A case in point is PE funds in India, who are hiring industry veterans. An expert mentions that providing information on target valuations is the primary function he performs:

> Sumit Banerjee, a cement hotshot for over a decade, is the go-to man for PE and strategic players whenever a new target comes into the salemarket. Banerjee, in the last two years, has advised at least three potential suitors Apollo, Blackstone and even Piramal Enterprises on as many occasions as they went after Lafarge's India operations and Reliance Cement... "For each of the evaluations, the funds had the bandwidth to do modelling and financial projections. All they needed was someone to validate their assumptions on market growth, prices and people. My desire was to advise them on the fundamental strength and weaknesses of the target which have a direct bearing on valuations."[4]

In practice, M & A advisors may also perform a number of other services like legal services, post-merger integration consulting services, searching for bidders or targets, advice on restructuring the target and helping to raise capital to finance the acquisition. In this paper,we focus only on the valuation services provided by the advisors. As we have argued, this is one of the most important functions of the advisor, if not the most important. In addition, nothing prevents the seller or buyer from offering separate contracts to the advisors for the other functions and the valuation services.

Many of the advisory contracts seen in practice are linearly increasing in transaction value. Two justifications for this both turn out to be false under closer examination. First, a fee increasing in value is reminiscent of Hölmstrom [1979]. The resemblance is superficial. In Hölmstrom [1979], the wage depends on output because effort is not observable, but output, which is increasing in effort, is. However, the value of synergies is completely independent of the advisor's effort. Hence, that is not the mechanism underlying the optimal contract. Second, invesigating the value of a big firm might

[4]Barman, Arijit & Layak, Suman. "Why private equity funds and banks are wooing former head honchos of India Inc to manage their investments". *The Economic Times* 18 September 2016. Web. Accessed 23 October 2016.

involve a higher cost of effort than for a small firm, so one would expect the payment to the advisor to be increasing in value. The fallacy in this argument is that we are comparing the payments across two transactions, one the sale of a small firm and another a large one. This paper is about why the fee paid in a *given* transaction depends on the value of the transaction. It is a comparison among different realizations of value in a given transaction than different expected values *across* transactions.

We model the sale as happening through a take-it-or-leave-it offer made by the seller to the buyer. We also assume that the seller and the buyer choose to hire an advisor or not without knowing whether the other party has a hired an advisor or not. As already mentioned, the friction is that the advisor can report a value of the synergies without having exerted the effort to find out the value.

The research question I address in this paper is the structure of the optimal contract between the acquirer/target and their M&A Advisor to overcome this moral hazard problem. This can be split into a number of sub-questions.

First, what observable parameters does the contract depend on? Does it, for example, depend on the value of the transaction or whether the transaction was a success or not? Is it increasing in the value of the transaction? Or is the contract a flat fee? Are the optimal contracts unique?

Second, if effort is costly for the advisors, for what range of the effort costs are the advisors hired? Intuitively, there must be an upper bound above which the seller or the buyer do not wish to hire the advisor since the cost is greater than the value of knowing the synergies precisely. What is the upper bound, given that neither party knows whether the other is informed or not? Third, do the advisors report truthfully in equilibrium? Do they extract information rents in equilibrium? In other words, will the payment to either advisor higher than their cost of effort?

Fourth, are there pure strategy equilibria where the buyer/seller always hires an advisor or doesn't? Can we have mixed strategy equlibria too (i.e. seller/ buyer mixes between hiring and not hiring the advisor)? If so, what are the probabilities with which the advisors are hired and how do they depend on the effort costs? Fifth, what are the strategies of the seller/buyer when they are informed/ uninformed i.e. when they have hired an advisor or haven't? Does the seller always charge the fair price when he is informed? Does the buyer always accept it?

Sixth, what are the implications of the moral hazard problem on efficiency? How close do we get to first-best? Assuming that the synergies are always greater than zero and it is optimal to sell the firm to the acquirer, how often does the transaction fall through in spite of it being optimal? How does this affect the total surplus in the transaction split between the buyer and the seller?

We solve the problem in three steps, starting with a simple set up and gradually making it more complex. In Part I, we assume that the buyer is always informed and the seller has to minimize the payment to his advisor subject to incentivising the advisor to exert effort. In other words, this part considers the optimal contract under the simpler case where the buyer always hires an advisor. In Part II, we argue that this may not be a realistic assumption and solve for a mixed equilibrium where the buyer and seller mix between hiring their advisor and not hiring him. I treat the payment to the advisor as an exogenous parameter i.e. do not consider any contract. In part III, we combine Parts I and II. We attack the grand question of how the optimal contracts look like when both the buyer and seller optimally choose whether to hire an advisor or not.

The main results I obtain are as follows. First, the optimal contract for both the buyer and the seller depends on two variables- whether the transaction succeeded or not and, if it did, the value of the transaction. There is no payment to the advisor if the transaction failed. The seller's optimal contract with his advisor is unique and the advisor's compensation is monotonically increasing in the transaction value. The buyer's optimal contract with his advisor can take a variety of forms. However, all of these contracts share the feature that the advisor is not paid if he reports the same value to the synergies as the maximum offer the uninformed buyer would have accepted. (Intuitively, the advisor is not paid if it made no difference to the buyer's decision whether to accept the offer).

Second, there is a wide range of effort costs for which the equilibria exist. I make the simplifying assumption that the costs for both the advisors are the same and solve for the equilibrium strategies as a function of the exogenous effort costs. Third, the contract incentivises the advisors to exert effort and report truthfully in equilibrium. The advisors do not extract information rents in equilibrium. Fourth,there a range of values for which we observe mixed equilibria. I fully characterize the strategies of the buyer and seller i.e. their probabilities of hiring their advisor in terms of the exogenous effort costs of the advisor. The buyer's propensity to acquire information increases when the seller doesn't do so. Fifth, There are ranges of the value where the informed seller charges a fair price, but there are ranges where he undercharges and overcharges as well.

Sixth, the first best is never obtained. Even though the advisors do not obtain information rents, there are two other sources of inefficiency. The first is that in equilibria where one party ends up informed and the other uninformed, the asymmetry of information leads to the transaction failing. The probability of the transaction succeeding decreases as the advisor's cost of effort increases. The second source of inefficiency is that even if the transaction is a success, the advisor has to be a paid its cost of effort which destroys some of the surplus in the transaction. The total surplus in the transaction is less than the expected value of the synergies.

The primary contribution I make in this paper is to characterize the optimal contract in a mergers and acquisition setting. Although there have been a few empirical studies onadvisory contracts in mergers, there have not been theoretical justifications of the same.

I solve this contracting problem along with the related problem of costly acquisition of socially inefficient information.The optimal contract with the advisor depends on whether the other party hires the advisor or not. To solve for the contract, one needs to know when the parties involved decide to acquire the information and vice versa.

The rest of the paper is organized as follows. Section 2 reviews relevant related literature. In Section 3, we provide the finer details of the model and discuss the assumptions thoroughly. Sections 4.1, 5 and 6 solve the model in three parts as mentioned above. Section 7 summarizes the results by giving a complete characterization of the Equilibria. Section 8 analyzes the implications of the equilibria for efficiency. Section 9 generates testable empirical hypotheses and validates empirical work already done on the topic. Finally, Section 10 concludes.

2 Related literature

Servaes and Zenner [1996] was among the earliest papers to shed light on the factors affect the hiring of investment banks. They compare 99 transactions from 1981 to 1992 which featured an investment bank, to 198 transactions that didn't. They find that banks are more likely to be hired for complex transactions and if the targets operate in many industries. This leads them to conclude that transaction costs and, in part, contracting costs and information asymmetries affect the decision to hire a bank. Owsley and Kaufman [2005] is a good description of the role of investment banks in bankruptcy. They make the case that handling distressed purchase and sale transactions require more skill than sales involving solvent companies.

Few empirical studies have looked at the actual contract between the advisors and the seller or buyer.[5] McLaughlin [1990] examines 195 tender offers between 1978 and 1985 and describes incentive problems associated with the various kind of contract designs. The contract fees fall into three basic categories: fixed fees, shares-based fees (used by buers), and value-based fees (mostly used by sellers). McLaughlin [1992] finds that fee contracts are used by both firms and bankers to solve agency problems, but they do not eliminate them. There are associations between firm objectives and contract incentives and between incentives and offer outcomes in some tests, but not in others. Hunter and Walker [1990] find that in their sample, the investment bank contracts were mostly fixed fee contracts or were based on the transaction price, contingent on the success.

There have been many studies looking at the association between the decision to hire an investment bank and the outcome of the merger. Hunter and Walker [1990] was one of the earliest studies to find a positive relationship between fees, merger gains and banker effort. They conclude that investment banking merger fee contracts are designed

[5] This may be due to data limitations. Even for public deals, the fees paid to the advisor are not always disclosed since the disclosure is not mandatory

with the aim of incentivizing optimal banker effort. Servaes and Zenner [1996] do not find any difference between the returns earned by acquirers which hired a bank and those that didn't. Daniels and Phillips [2009] show that hiring a financial advisor is associated with increases the transaction value in REIT mergers because advisors reduce the asymmetric information between the target and the bidder. Golubov et al. [2012] argue that the effect of the hiring the advisor may vary depending on the listing status of the target.

In recent years, a host of studies, too numerous to recount exhaustively, have analysed the role of bank's reputation on the gains from the merger. Kale et al. [2003] find evidence that the reputation of the financial advisor affects wealth gain in the transaction and how it is split between the target and the acquirer. Hunter and Jagtiani [2003] document a negative relationship between reputation and merger outcomes. The synergistic gains realized by the acquirers declined when top advisors were used. However, the contingent fees played a significant role in expediting the deal completion. Ismail [2010] point out that in their sample, acquirers advised by tier-one advisors lost more than \$42 billion, but those advised by tier-two advisors gained \$13.5 billion. They attribute this to the large loss deals advised by tier-one advisors, citing the differing incentives of banks in large and small deals as the reason. Rau [2000] finds that the post-acquisition performance of the bidding firm is negatively related to contingent fees in tender offers, porssibly because the banks just try to complete the deal.[6] Golubov et al. [2012] use a sample of U.S. acquisitions of public, private, and subsidiary firms from 1996 to 2009. They find that top-tier advisors are associated with higher bidder returns in public acquisitions because they garner a greater share of synergies for the bidder. The effect is dampened when the target advisor is also top-tier.

Another strand of related literature looks at how information acquisition can destroy efficiency. A recent example is Glode et al. [2012] where two risk-neutral traders exchange an asset. Acquiring expertise is neutralized in equilibrium because the counterparty also acquires it.[7] Shavell [1994] considers a scenario where buyers and sellers can acquire and disclose information prior to sale. He concludes that if disclosure is voluntary rather than mandatory, there are socially excessive incentives to acquire information.

The contribution I make in this paper is to tie together these two strands of research. I argue that the two problems are connected. Incentives to acquire information depend on the other party's cost of acquiring information, which in turn is a function of the optimal contract. So, it is impossible to describe the optimal contract without knowing the probabilities with which the buyer and seller are informed. Similarly, it is impossible

[6]This is exactly the moral hazard problem we model in this paper.

[7]Their model differs from ours in quite a few ways. First, their value is binary, whereas we consider a uniformly distributed value. Second, they give the bargaining power to the buyer and we to the seller. Third, they assume that synergies are known and value unknown; we assume that the value is known and synergies unknown. Lastly and most significantly, they assume an exogenous cost of acquiring information whereas we endogenize the cost through optimal contract design.

to know the probability with which the buyer and seller are informed without knowing the cost of the information if the contract is optimal.

3 Modelling the M&A process

3.1 The framework

The target (seller) and the acquirer (buyer) are both risk-neutral. The synergies are always positive, so it is socially optimal to trade. The stand-alone value of the firm and the distribution of the synergies are common knowledge. However, neither the buyer nor the seller knows the realized value of the synergies V. (From here on, I use "value" to denote the realized value of the synergies). As a result, the transaction may not happen even though it is socially efficient to transfer the asset.

The seller and the buyer have the option of hiring an M&A advisor who can exert effort to find the realized value. (For example, an Investment Bank. In the rest of the paper, we use the terms "bank" and "advisor" interchangeably) The advisor has a cost of exerting effort c. If the advisor exerts effort, he gets to know the value exactly. If he reports this value truthfully to the party which hired him, they get to know the exact value as well. Crucially, the effort exerted by the advisor is not observable and, consequently, not verifiable. In other words, both the seller and the buyer face the problem of moral hazard.

The optimal contract between the seller (or buyer) and his advisor minimizes the expected payment to the advisor conditional on incentivizing the advisor to exert effort. I assume that the wage can only depend on two variables, the value V reported by the advisor and a binary variable b which takes the value 1 when the transaction succeeds and 0 when it did not. The contract specifies a wage schedule $w : \mathbb{R}^+ \times \{0, 1\} \to \mathbb{R}^+$.

The acquisition process can proceed through various mechanisms- by an auction, many rounds of bargaining etc. To simplify the analysis, I assume that the seller has the bargaining power and the sale happens through a take-it-or-leave-it offer made by the seller to the buyer.

Both parties are unaware of whether the other party knows the value or not, that is, whether the other has hired an advisor or not. In other words, the seller, when making the offer, is unaware of whether he is facing an informed buyer or an uninformed one. Similarly, the buyer, when deciding whether to accept the offer, is unaware of whether the offer was made by an uninformed seller or an informed one.

These assumptions are discussed in more detail in section 3.4.

3.2 The timing

The timing of the game is as follows:

1. The value V is realized.
2. The seller (buyer) decides whether to hire an advisor or not.
3. If he hires a advisor, the seller (buyer) offers a wage contract to his advisor.
4. The advisor accepts the contract or rejects it.
5. If the advisor has decided to accept the contract, he chooses whether to exert effort or report a value without exerting effort.
6. The advisor reports a value to the seller (buyer).
7. The seller makes an offer to the buyer.
8. The buyer accepts the offer or rejects it.
9. If the buyer accepts the offer, the sale happens at the offer price. If the buyer rejects the offer, the sale doesn't happen.
10. The seller (buyer) pays his advisor the wage.

3.3 Solution Concept

The solution concept is Perfect Bayesian Equlibrium. Recall that in a PBE, the strategies of the players have to be sequentially rational and the beliefs have to be consistent with the equilibrium strategies whenever possible. The strategy of each party are (a) Seller- The seller startegy comprises of the probability with which he hires the advisor and the offer he makes to the buyer. The offfer depends on the value reported by the advisor, in case he hires one. (b) Buyer- The buyer's startegy

3.4 Discussion of the assumptions

In this section, I provide justifications for some of the assumptions we make about the M&A process.

3.4.1 The bargaining power

Empirical studies of mergers and acquisitions have repeatedly confirmed a puzzling trend- following a merger announcement, the target's stock price increases on an average and the acquirer's stock price falls.[8] For example, when AT&T's acquisition of Time Warner was reported, Time Warner's share price rose 9% on the news while AT&T's dipped close to 3%.[9] This suggests that if there are any synergies in the transaction, the target extracts

[8]One of many such studies is Andrade et al. [2001]

[9]Rushe, Dominic and Thielman, Sam. "AT & T in advanced talks to acquire Time Warner, reports say" *The Guardian* 21 October 2016. Web. Accessed 23 October 2016

most of them. Hence, it seems reasonable to assume that in the negotiation process, the target (or seller) has the bargaining power.

3.4.2 The take-it-or-leave-it offer

In reality, firms can be sold through auctions or negotiations. In recent years, approximately 50% of the transactions are auctions and the other negotiations.[10] Even in a negotiation, the bargaining process can be qute complicated. The assumption that the seller is negotiating only with one buyer and that the sale happens through a take-it-or-leave-it offer is done for tractability.

3.4.3 Neither the seller nor the buyer observes whether the other has hired a bank

This might seem like a strong assumption. However, a bank may be hired for many reasons. As long as both parties are unaware whether a bank has been hired by the other party specifically for valuation rather than something else, this assumption is justified. Second, it is sufficient if neither party observes the other hiring a bank till the sale is completed. Lastly, an alternative interpretation is that even if the bank is hired and exerts effort, it gets to know the value of the firm only with a specified probability. Even if the parties know that the other party hired a bank, they cannot be sure that the bank got to know the value. If the bank doesn't know the value, it is tantamount to the bank not being hired at all.

3.4.4 The wage doesn't depend on the stock market reaction

There are two reasons for assuming this. First, I do not want to exclude the possibility that the target or the acquirer may be private. Second, in practice, contracts usually depend only on whether the transaction succeeded and what the value was, and almost never on the stock market reaction following the announcement or in subsequent years. This may have to do with the complexity of an M& A transaction. It may be the case that the market reaction is not an accurate assessment of a merger transaction, which justifies this assumption.

3.4.5 Both parties don't know the value

Synergies may depend on the information that both parties possess individually, which makes it credible that neither party knows the value of synergies.

[10] For more detailed empirical analysis of the same, see for eg. Boone and Mulherin [2007]. For the theory underlying the choice, see Vasu [2015].

4 Equilibrium Characterization

For low values of the information cost, an equilibrium cannot be characterised by pure strategies of either party being always informed or always uninformed. In equilibrium, the strategies have to be best responses to each other. Consider an equilibrium in which, the seller's strategy is to never hire an advisor. In this case, the buyer will hire an advisor. He would then get to know the realized value of synergies and can reject any seller offer above this value. However, if the buyer always hires the advisor, the seller would also always hire the advisor so as to charge the buyer the fair value. So, the seller never hiring an advisor is not the best response, a contradiction.

Next, consider a possible equilibrium in which the seller strategy is to always hire an advisor. If the buyer also hires the advisor, the seller would offer him the fair value since he knows that they buyer will accept the offer. The buyer would get zero profit from the transaction, but would have to pay the advisor. So, the buyer's best response is to not hire the advisor and accept the seller's offer if it is less than or equal to the expected ex-ante value of the firm. If the buyer is never informed, the seller has no incentive to be informed either since he can just offer the expected value of the firm without hiring the advisor. So, the seller always hiring an advisor is not the best response, a contradiction.

In short, the seller wants to get informed only if the buyer is, but the buyer wants to get informed only if the seller is not. Hence, the only possible equilibria will be mixed equilibria in which the buyer and seller are indifferent between hiring the advisor or not hiring it. The probability of each party hiring the advisor depends on the cost of hiring the advisor. The cost depends on the optimal contract with the advisor. The optimal contract depends on the probability with which the other party hires the advisor. In equilibrium, all of these have to be consistent with each other.

I start by considering a simple case where the buyer is always informed. This is a pure-strategy equilibrium, and cannot be realised for non-zero costs of effort for the buyer's bank. However, the contract developed in this special case gives us valuable intuition for the contract in the actual equilibria.

4.1 Optimal contract when the buyer is always informed

4.2 Three possible values for the synergies

To simplify matters further, we start with the the synergies taking one of three possible values with equal probability of $\frac{1}{3}$. Without loss of generality, let $V \in \{\frac{1}{3}, \frac{2}{3}, 1\}$.

If the advisor reports the realized value truthfully, the the distribution of the reported value is the same as that of the actual value. (I will later impose the constraint that the advisor has no incentive to misreport). Also, the transaction always goes through if the advisor reports truthfully. So, the expected payment made by the seller iif the advisor reports truthfully is $\frac{1}{3}w(\frac{1}{3},1)+\frac{1}{3}w(\frac{2}{3},1)+\frac{1}{3}w(1,1)$

From the advisor's point of view, its payoff is the difference between the expected payment and the cost of effort, c. However, the advisor has the option of not exerting effort and just reporting any one of the three values of synergies. If say the advisor reports the value to be $\frac{2}{3}$ and the seller makes an offer of $\frac{2}{3}$ to the buyer, the transaction would be a success if the realized value is greater than or equal to $\frac{2}{3}$ which happens with probability $\frac{2}{3}$. In this case, the advisor would get the wage $w(\frac{2}{3},1)$. However, if the transaction fails, which happens with probability $\frac{1}{3}$, the bank gets $w(\frac{2}{3},0)$. So, the advisor's payoff from not exerting effort and reporting a value of $\frac{2}{3}$ is $\frac{2}{3}w(\frac{2}{3},1)+\frac{1}{3}w(\frac{2}{3},0)$. To make the advisor exert effort, the seller has to make sure that the payoff is higher than that from not exerting effort, i.e.

$$\frac{1}{3}w(\frac{1}{3},1)+\frac{1}{3}w(\frac{2}{3},1)+\frac{1}{3}w(1,1)-c\geq w(\frac{1}{3},1)$$

Similarly, one can write down two other IC constraints for the other possible values he can report, $\frac{1}{3}$ and 1.

The seller's problem is thus to minimize

$$\frac{1}{3}w(\frac{1}{3},1)+\frac{1}{3}w(\frac{2}{3},1)+\frac{1}{3}w(1,1)$$

subject to the constraints

$$\begin{aligned}
&\frac{1}{3}w(\frac{1}{3},1)+\frac{1}{3}w(\frac{2}{3},1)+\frac{1}{3}w(1,1)-c\geq w(\frac{1}{3},1)\\
&\frac{1}{3}w(\frac{1}{3},1)+\frac{1}{3}w(\frac{2}{3},1)+\frac{1}{3}w(1,1)-c\geq \frac{2}{3}w(\frac{2}{3},1)+\frac{1}{3}w(\frac{2}{3},0)\\
&\frac{1}{3}w(\frac{1}{3},1)+\frac{1}{3}w(\frac{2}{3},1)+\frac{1}{3}w(1,1)-c\geq \frac{1}{3}w(1,1)+\frac{2}{3}w(1,0)
\end{aligned}$$

It is optimal to set $w(V,0)=0$ since the transaction fails only if the bank either did not exert effort or report truthfully, both of which he should be penalised for.

The seller's problem is thus to minimize

$$\frac{1}{3}w(\frac{1}{3},1)+\frac{1}{3}w(\frac{2}{3},1)+\frac{1}{3}w(1,1)$$

subject to the constraints

$$\begin{aligned}
&\frac{1}{3}w(\frac{1}{3},1)+\frac{1}{3}w(\frac{2}{3},1)+\frac{1}{3}w(1,1)-c\geq w(\frac{1}{3},1)\\
&\frac{1}{3}w(\frac{1}{3},1)+\frac{1}{3}w(\frac{2}{3},1)+\frac{1}{3}w(1,1)-c\geq \frac{2}{3}w(\frac{2}{3},1)\\
&\frac{1}{3}w(\frac{1}{3},1)+\frac{1}{3}w(\frac{2}{3},1)+\frac{1}{3}w(1,1)-c\geq \frac{1}{3}w(1,1)
\end{aligned}$$

This is a linear programming problem. The solution is given by

$$w(\frac{1}{3},1) = \frac{6}{5}c$$
$$w(\frac{2}{3},1) = \frac{9}{5}c$$
$$w(1,1) = \frac{18}{5}c$$

The optimal wage schedule is plotted in Figure 1.

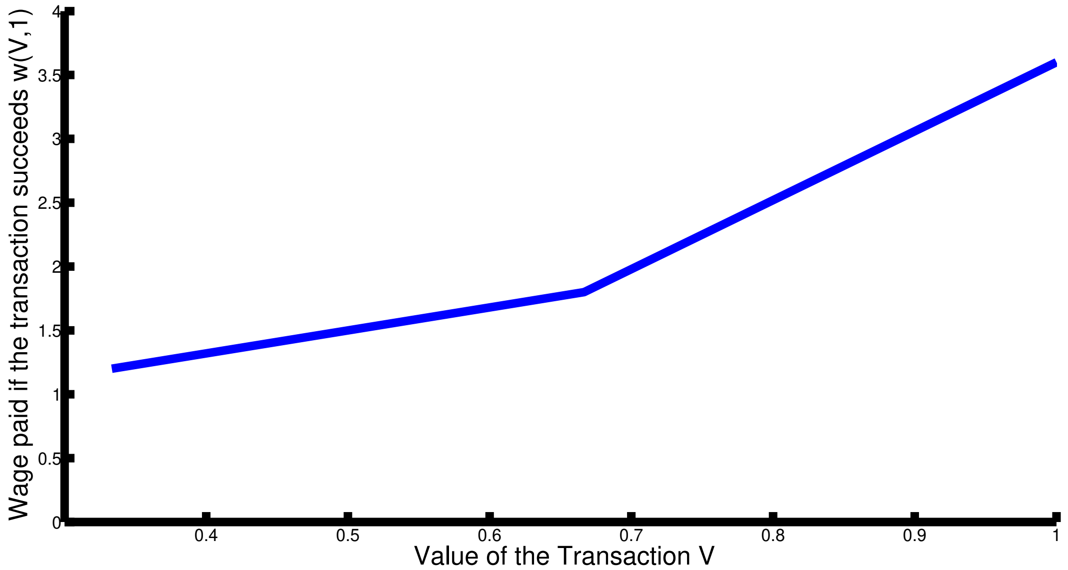

Figure 1: **The wage schedule with 3 possible values of the synergies**

The figure shows the optimal wage schedule when the synergies are $\frac{1}{3}$, $\frac{2}{3}$ or 1 with equal probability. The advisor's cost of effort c is assumed to be 1 (Alternatively, the y axis is scaled by c). The wage is an increasing function of the transaction value.

Several features of the optimal wage schedule are noteworthy.

First, the expected payment to the advisor is given by $\frac{11}{5}c$. Since the bank's cost of effort is c, the advisor makes an expected profit equal to $\frac{6}{5}c$. In other words, the advisor is able to extract information rents from the seller.

For what range of c will the seller hire the advisor? if he doesn't hire the advisor, the seller gets an expected payoff of $\frac{1}{4}$.[11] If he hires the the advisor, the seller can charge a fair price and get an expected payoff equal to the expected value i.e. $\frac{1}{2}$. So, he is willing to hire the advisor as long as the benefits exceed the cost, i.e.

$$\frac{1}{2} - \frac{1}{4} \geq \frac{11}{5}c \implies c \leq \frac{5}{44}$$

[11]The seller offers Q to maximize $Q(1-Q)$, Q being the payoff if the buyer accepts the offer and $1-Q$ being the probability with which the buyer accepts the offer . The expression is maximized at $Q = \frac{1}{2}$ and the maximum value is $\frac{1}{4}$.

Second, not only is the expected profit of the bank greater than 0, but each of the wages is greater than the cost c. In other words, the bank always extracts information rents and not just in expectation.

Third, note that each of the inequalities is satisfied with equality since

$$\frac{1}{3}(w(\frac{1}{3},1)+w(\frac{2}{3},1)+w(1,1))-c=w(\frac{1}{3},1)=\frac{2}{3}w(\frac{2}{3},1)=\frac{1}{3}w(1,1)=\frac{6}{5}c$$

This is a general feature of such contracts, a characteristic we will revisit later.

Fourth, the advisor has no incentive to misreport once it has exerted the effort. Since the wages are increasing in the value reported, misreporting to a lower value would lead to the transaction going through and the bank getting a lower wage than if it had reported truthfully. Misreporting to a higher value would lead to the transaction failing i.e. a wage of 0.

4.3 Discrete uniform distribution of synergies

Now consider the case where the synergies have a discrete uniform distribution taking one of n possible values with equal probability $\frac{1}{n}$. Without loss of generality, let $V \in \{\frac{1}{n}, \frac{2}{n}, ..., 1\}$.

The seller's problem is thus to minimize

$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]$$

subject to the n constraints

$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]-c\geq w(\frac{1}{n},1)$$

....

$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]-c\geq \frac{n-k+1}{n}w(\frac{k}{n},1)$$

....

$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]-c\geq \frac{1}{n}w(1,1)$$

The optimal wage contract satisfies each of the n constraints with equality. The n wages

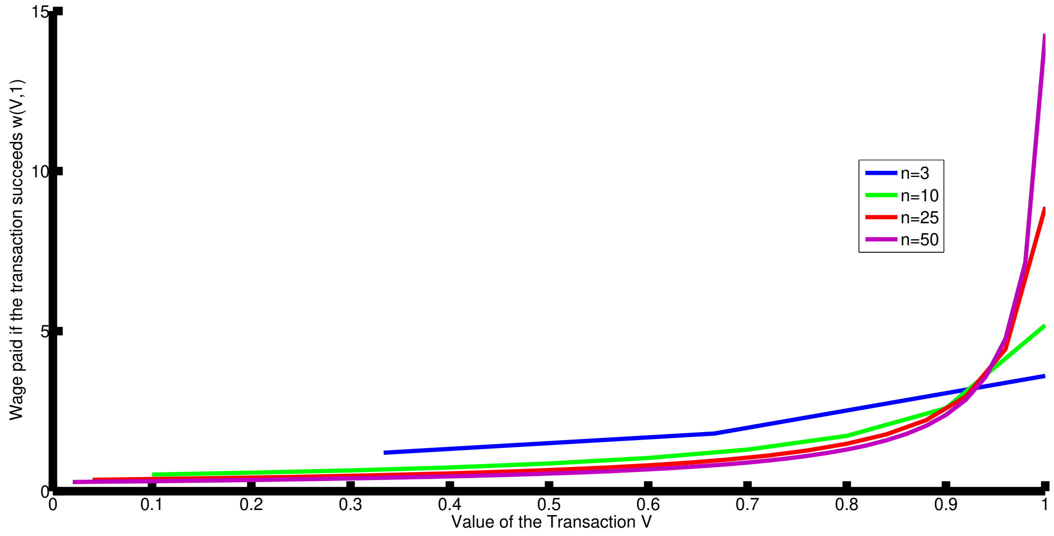

Figure 2: **The optimal wage contract for different values of n**

The figure shows the optimal wage schedule for $n = 3, 10, 25, 50$ and 100. The advisor's cost of effort c is assumed to be 1 (Alternatively, the y axis is scaled by c). The wage is an increasing function of the transaction value. The information rents extracted by the advisor (also equal to the wage on reporting the lowest value) decrease to 0 as n becomes very large. In other words, the expected payment to the advisor approaches the cost of effort. Also, the maximum wage, which corresponds to reporting the maximum possible value, increases as n increases.

in the optimal contract are given by

$$w(\frac{1}{n}, 1) = \left(\frac{1}{\frac{1}{2} + \frac{1}{3} ... + \frac{1}{n}} \right) c$$

....

$$w(\frac{k}{n}, 1) = \left(\frac{1}{\frac{1}{2} + \frac{1}{3} ... + \frac{1}{n}} \right) \frac{n}{n-k+1} c$$

....

$$w(1, 1) = \left(\frac{1}{\frac{1}{2} + \frac{1}{3} ... + \frac{1}{n}} \right) nc$$

For proof, see Appendix A. Figure 2 shows the shape of the contract for different values of n. The wage is monotonically increasing in the transaction value.

A noteworthy feature of the contract is that the expected payment to the advisor converge to c as $n \to \infty$. Thus, the information rents extracted by the advisor (also equal to the wage on reporting the lowest value) decrease to 0 as n becomes very large. This is plotted in Figure 3.

How is the advisor able to break even? It is because the maximum wage, which corresponds to reporting the maximum possible value, increases as n increases, even as the lowest wage falls. Figure 4, which plots the maximum wage against n, makes this

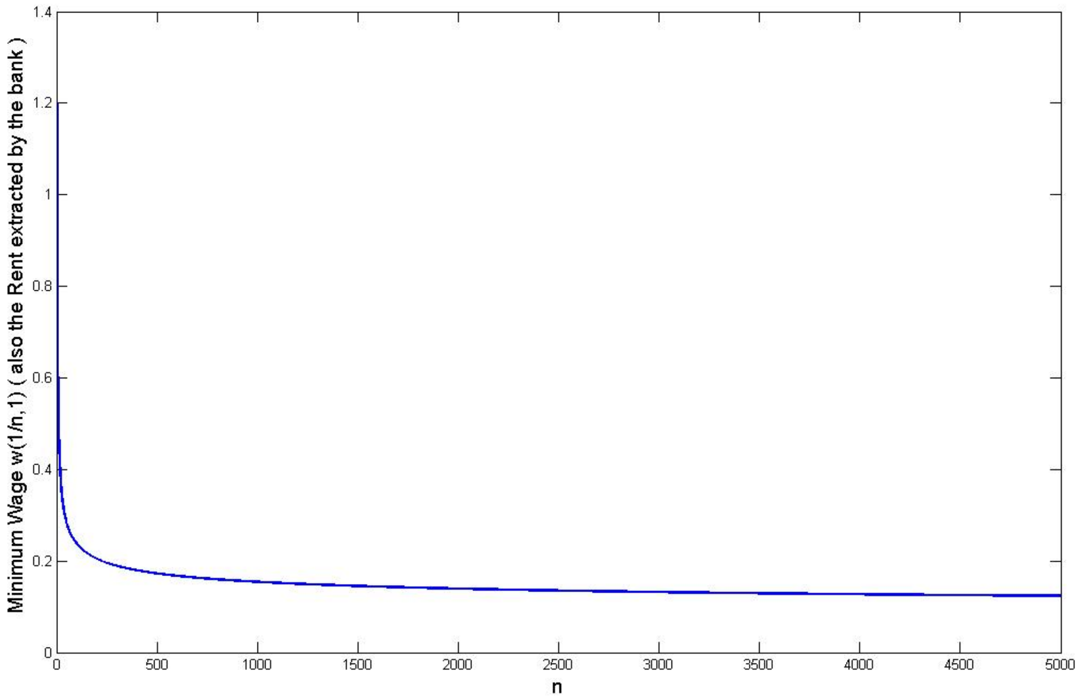

Figure 3: **The minimum wage (information rent extracted by the advisor)**

The figure shows the minimum wage that the advisor can guarantee for itself as a function of n. This corresponds to the wage if the advisor reports the lowest possible value i.e. $w(\frac{1}{n}, 1)$. Since in this case the buyer accepts the offer with probability 1, it is also equal to the information rents extracted by the advisor. It is apparent that the minimum wage decreases as n becomes very large. As $n \to \infty$, the minimum wage approaches 0, though the convergence is very slow as can be seen from the graph. As $n \to \infty$ the support becomes infinite, i.e. the probability distribution becomes a continuous uniform distribution rather than a discrete one. This suggests that if the values are uniformly distributed and continuous, the advisor is unable to extract any rent.

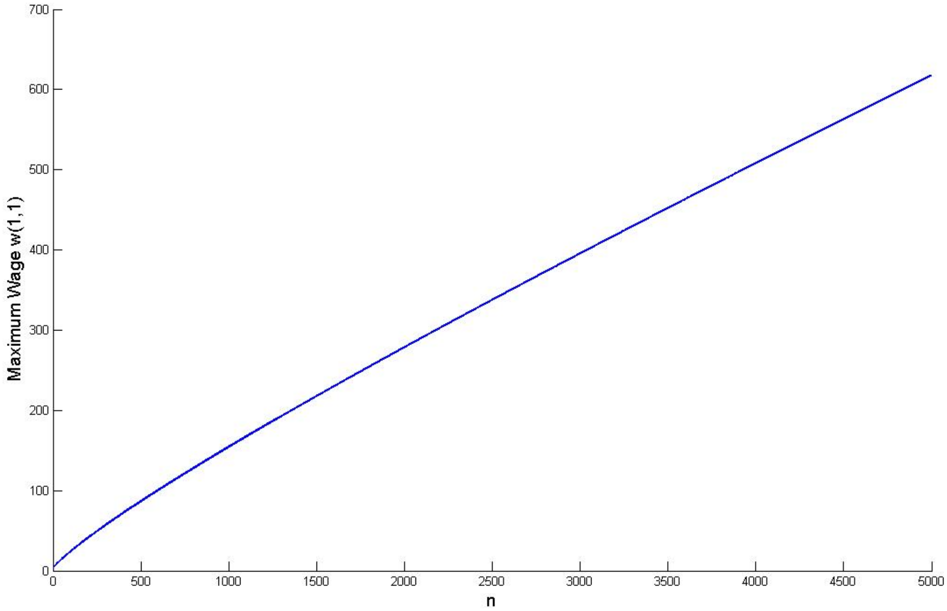

Figure 4: **The maximum wage paid to the advisor**

The figure shows the maximum wage that the advisor can possibly obtain as a function of n. This corresponds to the wage if the advisor reports the highest possible value i.e. $w(1,1)$. As $n \to \infty$, the maximum wage approaches ∞. As $n \to \infty$, the support of the distribution becomes infinite, i.e. the discrete probability distribution approaches a continuous uniform distribution. This suggests that if the values are uniformly distributed and continuous, the maximum wage approaches infinity.

clear.

Another feature of the contract is that it is robust to misreporting once the advisor has exerted the effort. In other words, the advisor has incentive to report the value it discovered rather than misreporting it as another possible value. The misreporting-proofness follows from the monotonicity of the contract. Misreporting to a higher value leads to the transaction failing and the advisor receiving a wage of 0. Misreporting to a lower value results in the transaction succeeding, but the advisor being paid a lower wage than it could have by just reporting truthfully.

4.4 Synergies $\tilde{V} \sim U(0, 1)$

Now consider the case where the synergies are uniformly distributed in $[0, 1]$. Set $w(V, 0)$ to 0. Reasoning as above yields the seller's problem to be

$$\text{Minimise} \int_0^1 w(V, 1)dV - c \text{ s.t}$$

$$\int_0^1 w(V, 1)dV - c \geq (1 - V)w(V, 1) \; \forall V \in [0, 1]$$

To solve this, I consider a probability distribution for $\tilde{V}$, U_ϵ which is obtained by the following transformation of $U[0, 1]$

- Leave the distribution unchanged in the interval $[0, 1 - \epsilon]$.
- Redistribute the probability mass from $[1 - \epsilon, 1]$ to an atom of mass ϵ at $1 - \epsilon$

This distribution can be made arbitrarily close to the uniform distribution by letting $\epsilon \to 0$. The uniform distibution and U_ϵ are plotted in Figure 5. The optimal wage contract

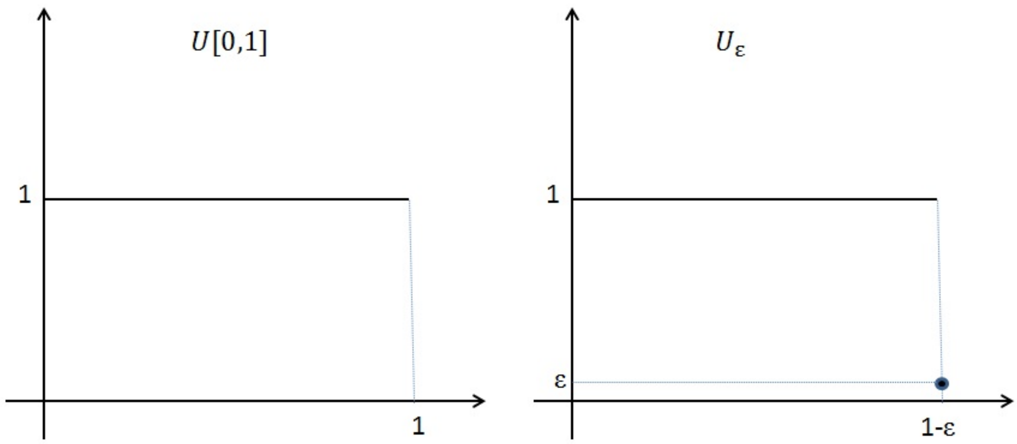

Figure 5: **The uniform distibution and U_ϵ**

The uniform distribution $U[0, 1]$ and the modified uniform distribution which we refer to as U_ϵ. The modification consists of shifting the probability mass from the interval $[1 - \epsilon, 1]$ to the point $1 - \epsilon$, thus creating an atom of mass ϵ at $1 - \epsilon$. As ϵ approaches 0, U_ϵ approaches $U[0, 1]$

satisfies each of the constraints with equality. The contract is given by

$$w(V, 1) = \frac{1}{1 - V} \frac{c}{ln(\frac{1}{\epsilon})}$$

The wage as a function of reported value is plotted in Figure 6. It is convex, increasing sharply as the reported value approaches 1.

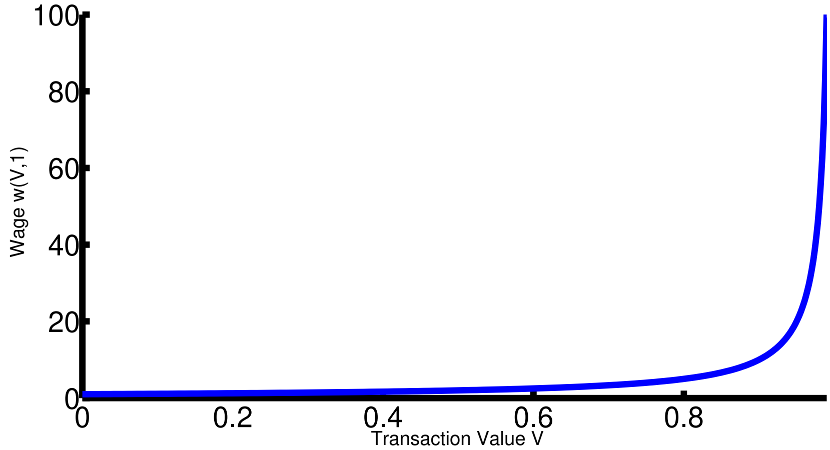

Figure 6: **The wage schedule for a continuous uniform distribution**

The figure shows the wage paid to the bank $w(V,1)$ as a function of the value V reported by it when the values are uniformly distributed in [0,1]. The wage is monotonically increasing in the value reported. The wage increases sharply as the value reported approaches 1. As a result of the optimal wage schedule, the bank is kept to its reservation utility of 0.

The expected payment to the bank is given by

$$c_s = c\left(1 + \frac{1}{ln(\frac{1}{\epsilon})}\right)$$

Just as in the discrete uniform distribution case above where $c_s \to c$ as $n \to \infty$, in this case $c_s \to c$ as $\epsilon \to 0$ In other words, the expected payment to the bank is not greater than the cost of effort. The proof is given in Appendix B.

The seller is willing to hire the advisor as long as the benefits of being fully informed exceed the cost. Following the calculation in 4.2,

$$\frac{1}{2} - \frac{1}{4} \geq c \implies c \leq \frac{1}{4}$$

5 Part II - Equilibria when both the seller and buyer can hire advisors

Clearly, the decision by either party to hire an advisor depends on the probability of the other party being informed. I begin by searching for equilibria where both the seller and the buyer mix between hiring and not hiring an advisor. Let p_s and p_b be the probabilities with which the seller and the buyer hire the sell-side and buy-side advisors respectively. In addition, let c_s and c_b be the expected fees paid to the advisor by the seller and the buyer respectively. These are assumed to be exogenous for now. In the next section, I endogenize these parameters.

5.1 The buyer's strategy

The buyer accepts or rejects the offer made by the seller. If the buyer is uninformed, he will accept any offer less than l where $l \in [0,1]$ is the expected value of the firm conditional on the seller offering l . If the buyer is informed, he will accept any offer less than the value V.

5.2 The uninformed seller's strategy

An offer of Q is accepted if the buyer is uninformed and Q is less than l or the buyer is informed and Q is less than V .

So, the probability of an offer of Q being accepted is

$$(1-p_b)\mathbf{1}(Q \leq l) + p_b \mathbf{1}(Q \leq V)$$

It follows that the expected utility from quoting Q is

$$Q((1-p_b)\mathbf{1}(Q \leq l) + p_b(1-Q))$$

The optimal offer depends both on l and p_b and is given by

$$Q_u = \begin{cases} l & \textit{if } p_b \in [0, \frac{l}{l^2+\frac{1}{4}}] \\ \frac{1}{2} & \textit{if } p_b \in [\frac{l}{l^2+\frac{1}{4}}, 1] \end{cases} \quad \textit{if } l \leq \frac{1}{2} \tag{1}$$

$$Q_u = \begin{cases} l & \textit{if } p_b \in [0, \frac{1}{2l}] \\ \frac{1}{2p_b} & \textit{if } p_b \in [\frac{1}{2l}, 1] \end{cases} \quad \textit{if } l > \frac{1}{2} \tag{2}$$

For proof, see Appendix C. Intuitively, if the buyer hires the advisor with very low probability, the seller is facing an uninformed buyer most of the time. So he offers the the maximum amount the uninformed buyer will accept i.e. l. On the other hand, if there is a high chance that the buyer is informed, the seller's offer offer will not depend on the threshold of the uninformed buyer. The seller will choose an offer which maximizes the expected utility i.e. the product of the payoff from the offer and the probability of it being accepted.

5.3 The informed seller's strategy

The expected utility from quoting Q is

$$Q\left((1-p_b)\mathbf{1}(Q \leq l) + p_b \mathbf{1}(Q \leq V)\right)$$

However, since the informed seller knows V, his optimal offer can also depend on V in addition to l and p_b. It is given by

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, 1] \end{cases} \quad \textit{if } p_b \leq l \tag{3}$$

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, \frac{l}{p_b}] \\ V & \textit{if } V \in [\frac{l}{p_b}, 1] \end{cases} \quad \textit{if } p_b > l \tag{4}$$

The optimal offer by the seller is not always equal to the value reported by the advisor even though the advisor reports truthfully. There are intervals where the seller overcharges, charges a fair price and undercharges. The intuition is that if the advisor reports a very low value, the seller is better off taking a gamble that the buyer is uninformed rather than offering the very low value. As the value increases, the seller charges a fair price because the aforementioned gamble is no longer optimal. Once the value reported by the advisor crosses the threshold of the uninformed buyer, the advisor does not want to risk charging a fair price because the uninformed buyer will reject it. Hence, there is an interval where he undercharges. However, as the value increases further, he is willing to gamble on the fact that the buyer is in fact informed. The optimal offer is graphed in Figue 7 as a function of the value reported by the advisor. For proof, see Appendix D.

5.4 Consistent equilibria after imposing additional constraints

We need to impose subgame perfection of the buyer as an additional constraint. The buyer cannot be left with surplus from any offer he accepts, because the seller, knowing this, could then increase the offer price. Similarly, the buyer should reject anything that gives him a negative payoff.

The informed buyer conditions his strategy on the value of the firm. The uninformed buyer conditions his strategy on the expected value of the firm *given the seller's offer*. He accepts the offer if the expected value is geater than or equal to the offer, and rejects if it is less than or equal to the offer.[12]

[12]In fact, at first glance, it may seem that l should always be $\frac{1}{2}$ in any equilibrium. After all, the expected value is $\frac{1}{2}$, so wouldn't sequential rationality dictate the buyer to set $l = \frac{1}{2}$? Not if we consider the impact of the informed seller's behaviour on the uninformed buyer.

To illustrate this, let us consider an uninformed buyer who does set $l = \frac{1}{2}$. The uninformed seller would offer $\frac{1}{2}$ irrespective of p_b since this is optimal whether the buyer is informed or uninformed (In

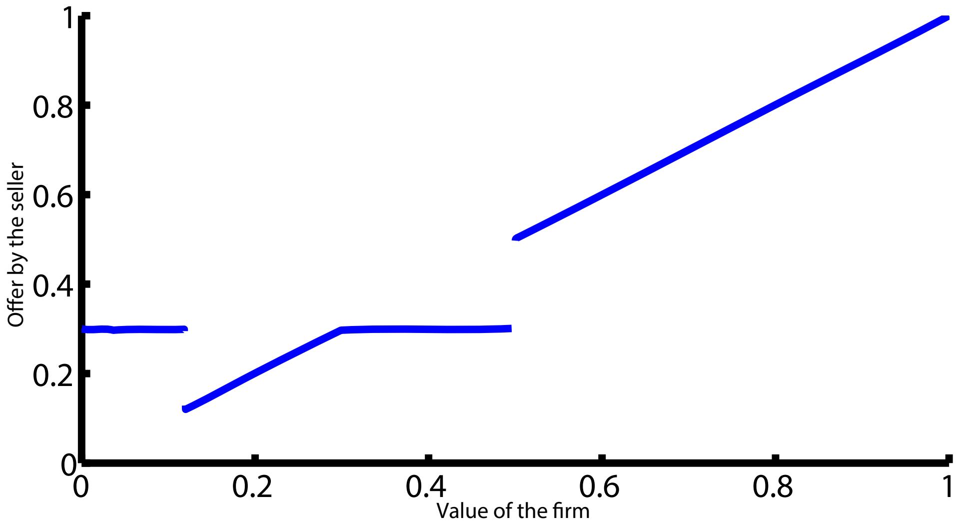

Figure 7: **Informed seller's offers**

The figure shows the offers made by the informed seller. The informed seller's offer depends on the value V that the bank reports, the threshold l of the uninformed buyer and the probability with which the buyer is an informed one p_b. The graph is for $l = 0.3$ and $p_b = 0.6$ The optimal offer by the seller is not always equal to the value reported by the bank even though the bank reports truthfully. There are intervals where the seller overcharges, charges a fair price and undercharges.

Once we impose these constraints, the set of equilibria correspond to the following:

The uninformed buyer always accepts any offer $\in [0, l]$ and rejects any other offer. The informed buyer accepts any offer $\in [0, V]$. The uninformed seller offers l. The informed sellers's strategy depends on V, l and p_b and is given by

$l \in [0.15, \frac{1}{2}]$

$$p_b \in [0.54, \frac{l}{l^2 + \frac{1}{4}}]$$

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, \frac{l}{p_b}] \\ V & \textit{if } V \in [\frac{l}{p_b}, 1] \end{cases}$$

$$p_s = \frac{(2l-1)p_b(1+p_b)}{(1-p_b^3)l - (p_b^2 + p_b)(1-l)}$$

$l \in [\frac{1}{2}, 0.54]$

$$p_b \in [\sqrt{\frac{2l-1}{l^2}}, l]$$

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, 1] \end{cases}$$

$$p_s = \frac{(2l-1)(1-p_bl)}{p_bl(p_bl + 1 - 2l)}$$

---

other words, offering $\frac{1}{2}$ is the dominant strategy for the unnformed seller. Remember that $Q(1-Q)$ is maximized at $\frac{1}{2}$). However, we know that the *informed seller* would also quote $\frac{1}{2}$ for some values reported by his bank. To be precise, the informed seller's strategy is

$$Q_i = \begin{cases} \frac{1}{2} & \textit{if } V \in [0, (1-p_b)\frac{1}{2}] \\ V & \textit{if } V \in [(1-p_b)\frac{1}{2}, \frac{1}{2}] \\ \frac{1}{2} & \textit{if } V \in [\frac{1}{2}, \frac{1}{2p_b}] \\ V & \textit{if } V \in [\frac{1}{2p_b}, 1] \end{cases}$$

It should be clear now that the uninformed buyer, when offered $\frac{1}{2}$ must also take into account that it maybe the informed seller offering him $\frac{1}{2}$ after finding out that $V \in [0, (1-p_b)\frac{1}{2}]$ or $V \in [\frac{1}{2}, \frac{1}{2p_b}]$. This is what restricts the value of p_b to be a specific number if $l = \frac{1}{2}$

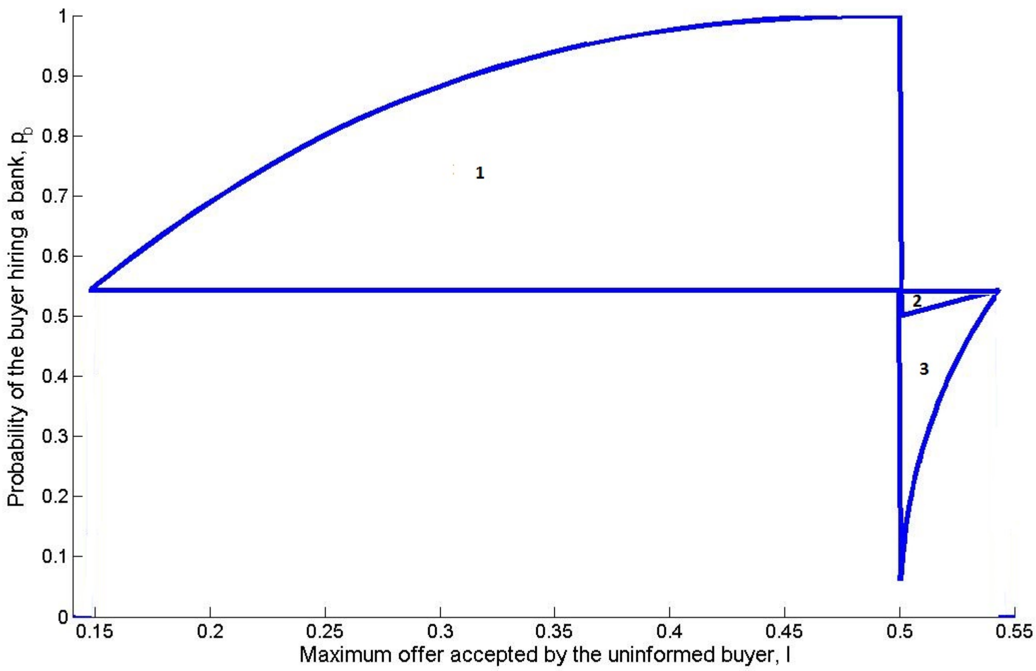

Figure 8: **Range of l and p_b in all equilibria**

The figure shows the ranges of l, the maximum offer accepted by the uninformed seller, and p_b, the probability of the buyer hiring a bank, for all possible equilibria. Areas 1 and 2 correspond to equilibria of the form $lVlV$. Area 3 corresponds to equilibria of the form lVl.

$$p_b \in [l, 0.54]$$

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, \frac{l}{p_b}] \\ V & \textit{if } V \in [\frac{l}{p_b}, 1] \end{cases}$$

$$p_s = \frac{(2l-1)p_b(1+p_b)}{(1-p_b^3)l - (p_b^2+p_b)(1-l)}$$

For proof, see Appendix E. For plots of the possible values of l and p_b in equilibria, see Figure 8.

5.5 The seller's cost of hiring the advisor

For the seller to mix between hiring an advisor and not hiring one, his payoffs from the two have to be equal.

For equilibria of the form

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, \frac{l}{p_b}] \\ V & \textit{if } V \in [\frac{l}{p_b}, 1] \end{cases}$$

the seller's cost of hiring the advisor is given by

$$c_s = \frac{1}{2}l^2 p_b^2 + \frac{1}{2}(\sqrt{p_b} - \frac{l}{\sqrt{p_b}})^2$$

For equilibria of the form

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, 1] \end{cases}$$

the seller's cost of hiring the advisor is given by

$$c_s = \frac{1}{2}l^2 p_b^2$$

For proof, see Appendix F. Note that for any l, c_s is increasing in p_b.

5.6 The buyer's cost of hiring the advisor

For the buyer to mix between hiring an advisor and not hiring one, his payoffs from the two have to be equal. Since he has no bargaining power, both have to be equal to zero. We have already considered the case of the uninformed buyer above. In this section, we focus on the informed buyer to get a condition on the buyer's cost of hiring the advisor.

For equilibria of the form

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, \frac{l}{p_b}] \\ V & \textit{if } V \in [\frac{l}{p_b}, 1] \end{cases}$$

the buyer's cost of hiring the advisor is given by

$$c_b = \frac{1}{2}(1-l)^2 + \frac{1}{2}p_s \left(\frac{l^2}{p_b}(\frac{1}{p_b} - 2) + 2l - 1 \right)$$

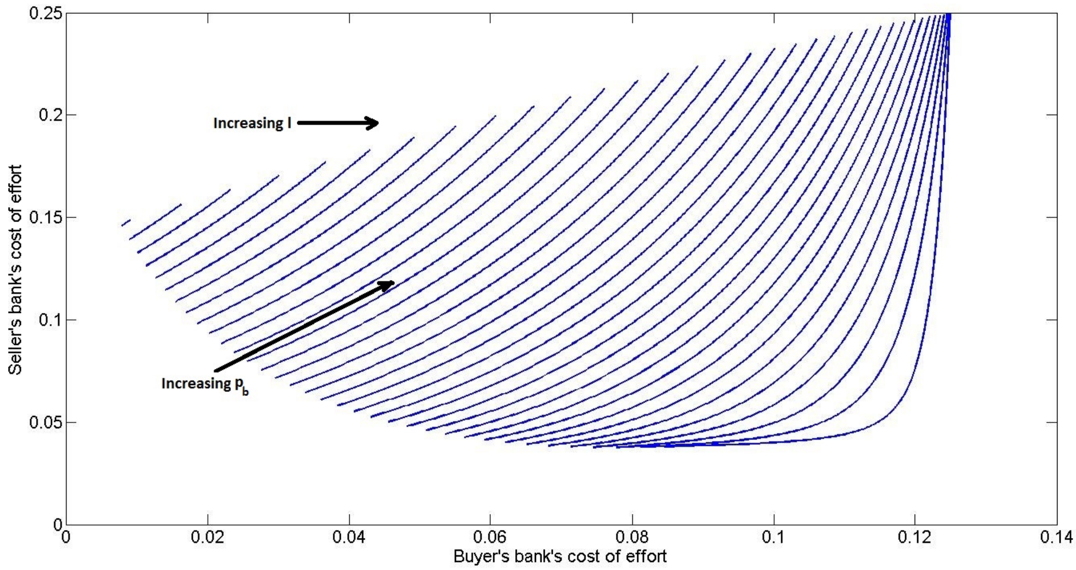

Figure 9: **Existence of a unique mapping from (c_s, c_b) to (l, p_b, p_s).**

The figure shows how the buyer's and seller's cost of hiring an advisor change as l and p_b increase for equilibria corresponding to region 1 in Figure 8. Increasing l leads to a shift of the curve outwards, while increasing p_b leads to a movement upwards *along* the curve. There is a unique mapping between any (c_s, c_b) and (l, p_b, p_s).

For equilibria of the form

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, 1] \end{cases}$$

the buyer's cost of hiring the advisor is given by

$$c_b = \frac{1}{2}(1-l)^2$$

For proof, see Appendix G. What are the range of payments to the advisor we see in equilibrium? Figure 9 plots how increasing l and p_b affects c_s and c_b which support the equilibrium for region 1 in Figure 8. The graphs are reminiscent of indifference curves. Changing l corresponds to a shift of the curve outwards, while changing p_b leads to a movement upwards *along* the curve. Hence, given any pair (c_s, c_b) in this range, there is a unique l and p_b and, by extension, a unique p_s.

Figure 10 plots all values of c_s and c_b for which equilibria exist. Note that at this stage, neither of these are exogenous. Rather, they depend on the true exogenous parameter, the advisor's cost of effort, and the information rents on top of that which

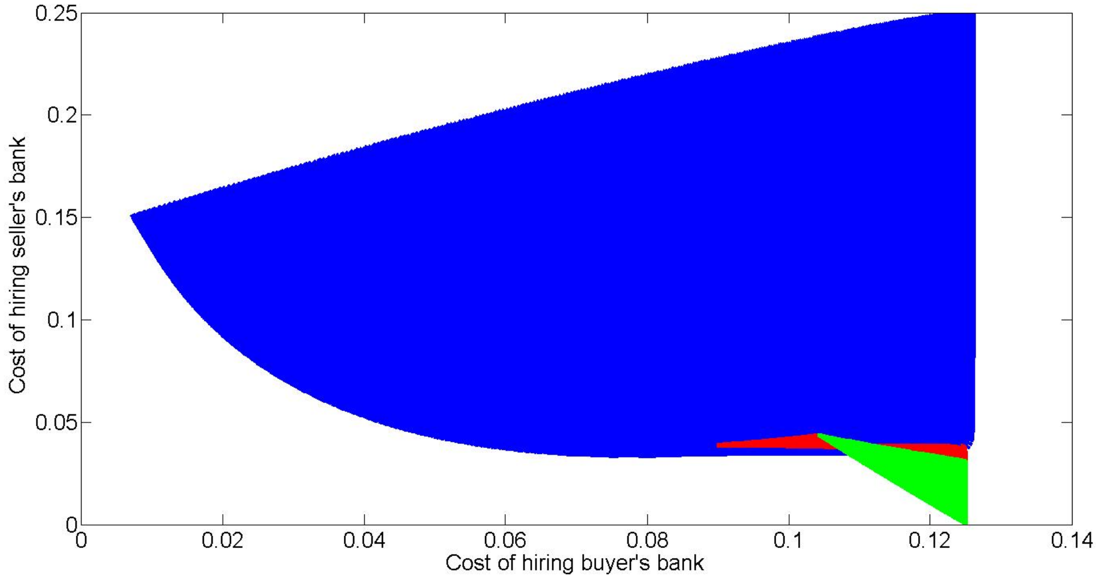

Figure 10: **The seller's and buyer's costs of hiring an advisor for which a mixed equilibrium exists**

The figure shows all possible values of the buyer's and seller's cost of hiring an advisor for which a mixed equilibrium exists. Note that neither of these costs is exogenous. They depend on the advisor' cost of effort , which is the true exogenous parameter, and also on any information rents extracted by the advisors. The blue and red areas correspond to $lVlV$ equilibria and the green to lVl equlibria

the advisors may or may not be able to extract in the optimal contract. I endogenize the payment to the advisors as a function of these exogenous parameters next.

6 Part III - Optimal contracts when both the buyer and seller hire banks

6.1 Seller's contract with the advisor

So far, we have assumed that the cost c_s is exogenous. However, c_s is the outcome of a contract between the seller and the advisor. Now, we turn to the issue of how c_s is related to c, the cost of effort the advisor incurs. It turns out that the the seller's ability to hold the advisor to an information rent of zero depends on which equilibrium is realised.

Start by considering equilbria of the form

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, \frac{l}{p_b}] \\ V & \textit{if } V \in [\frac{l}{p_b}, 1] \end{cases}$$

Let us consider the various options available to the advisor if he decides to report a value without exerting any effort. If the seller's offers are the same for two or more reported values, the corresponding wages have to be the same. If the wages are different, the advisor would always report that value for which the wage is the highest. This doesn't affect the probability of the transaction going through, but increases the wage conditional on it going through.

If the advisor reports a value in either of the intervals $[0, (1-p_b)l]$ or$[l, \frac{l}{p_b}]$ without putting in effort, the seller offers the buyer l. The uninformed seller accepts it and the informed seller accepts it if the realized value $\leq l$, i.e. with probability $1-l$. so the transaction goes through with probability $(1-p_b)+p_b(1-l)$ or $1-lp_b$. So, the intermediary gets an expected payoff of $w(l)(1-lp_b)$ without exerting effort.

If the advisor reports a value V in the interval $[(1-p_b)l, l]$ without putting in effort, the seller offers the value reported. In this range, the value is less than l, so the uninformed seller would accept the offer. The transaction goes through with probability $(1-p_b)+p_b(1-V)$ or $1-Vp_b$. So, the intermediary can secure himself an expected payoff of $w(V)(1-Vp_b)$ without exerting effort for all $V \in [(1-p_b)l, l]$

The option left is to report a value V in the interval $[\frac{l}{p_b}, 1]$ without putting in effort. The seller offers the value reported. In this range, the value is greater than l, so the uninformed seller would reject the offer. The offer will only go through if the buyer is informed and the actual value is less than the value reported, i.e. with probability $p_b(1-V)$. So, the intermediary can secure himself an expected payoff of $p_b(1-V)w(V)$ without exerting effort for all $V \in [\frac{l}{p_b}, 1]$

To motivate the advisor to exert effort, his payoff on exerting effort and reporting the value truthfully must be greater than 0. If he exerts effort and the value $V \in [0, (1-p_b)l]$, the seller offers l. Since the actual value is less than l, the transaction goes through only if the buyer is uninformed i.e. with probability $1-p_b$. So, expected payoff conditional on the value being in this range is $(1-p_b)w(l)$. If he exerts effort and the value $V \in [(1-p_b)l, l]$, the seller offers V. The transaction always goes through since $V \leq l$. If he exerts effort and the value $V \in [l, \frac{l}{p_b}]$, the seller offers l. Since the value is greater than l, the transaction always goes through. So, expected payoff conditional on the value being in this range is $w(l)$. If he exerts effort and the value $V \in [\frac{l}{p_b}, 1]$, the seller offers V. Since $V \geq l$, the transaction only goes through if the seller is informed i.e. with probability p_b.

Hence, the expected payoff if he exerts effort is

$$(1-p_b)l(1-p_b)w(l) + \int\limits_{(1-p_b)l}^{l} w(V)\,dV + \left(\frac{l}{p_b} - l\right) w(l) + p_b \int\limits_{\frac{l}{p_b}}^{1} w(V)\,dV - c$$

Simplifying this expression and equating the payoff from exerting effort to be greater than any payoff from not exerting effort gives the seller's problem and the family of constraints he faces.

Minimise the expected payment to the advisor

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int\limits_{(1-p_b)l}^{l} w(V)\,dV + p_b \int\limits_{\frac{l}{p_b}}^{1} w(V)\,dV - c$$

subject to the constraints

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int\limits_{(1-p_b)l}^{l} w(V)\,dV + p_b \int\limits_{\frac{l}{p_b}}^{1} w(V)\,dV - c \geq (1 - p_b l)w(l)$$

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int\limits_{(1-p_b)l}^{l} w(V)\,dV + p_b \int\limits_{\frac{l}{p_b}}^{1} w(V)\,dV - c \geq (1 - V p_b)w(V) \;\; \textit{if } V \in [(1-p_b)l, l]$$

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int\limits_{(1-p_b)l}^{l} w(V)\,dV + p_b \int\limits_{\frac{l}{p_b}}^{1} w(V)\,dV - c \geq p_b(1 - V)w(V) \;\; \textit{if } V \in [\frac{l}{p_b}, 1]$$

We solve this for the modified uniform distribution U_ϵ introduced in Section 4.4. The optimal contract is given by

$$w(V,1) = \begin{cases} k' c \frac{1}{1-p_b V} & \textit{if } V \in [(1-p_b)l, l] \\ k' c \frac{1}{p_b(1-V)} & \textit{if } V \in [\frac{l}{p_b}, 1-\epsilon] \end{cases}$$

where k' is a constant. The payment made to the advisor is given by $c(1 + k')$. As $\epsilon \to 0$, the payment is just the cost of effort c, so the advisor extracts no information rents. The proof is in Appendix H.

Figure 11 shows the wage paid to the seller's advisor as a function of the value reported by the advisor. Remember that in these equilibria, the value at which the transaction takes place is not necessarily the value reported by the advisor because there are intervals in which the seller undercharges or overcharges the buyer. The incentives to the advisor are determined by the seller's offer and not his report since the seller's offer determines the probability of the transaction happening. For reports of low values and values in the interval above l, , the advisor offers l so that the wage corresponds to

$w(l, 1)$. This is why the wage is not monotonically increasing in the value reported by the advisor.

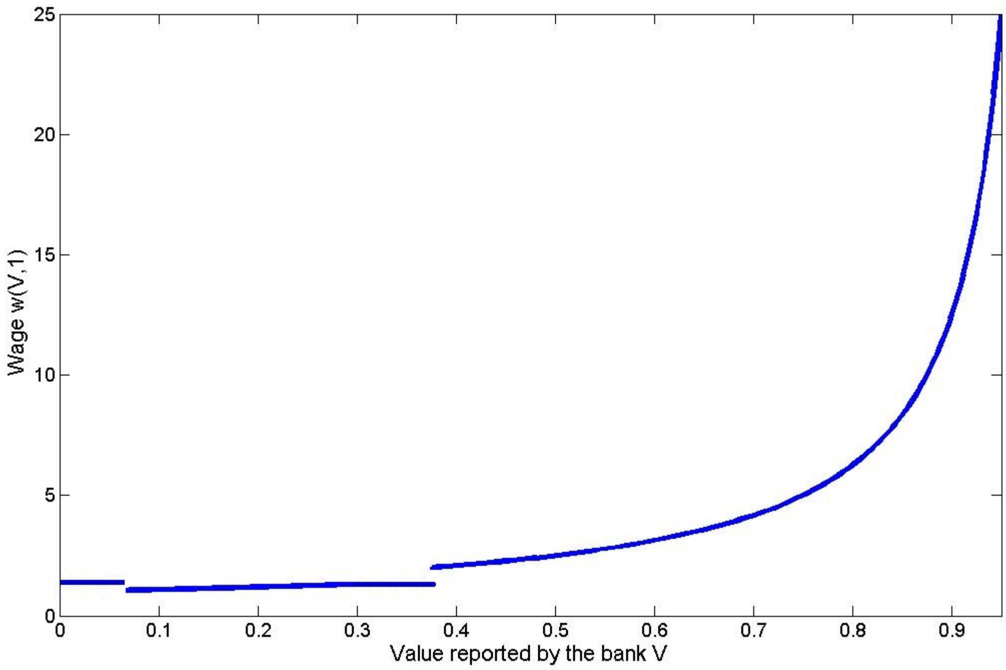

Figure 11: **Optimal contract with the seller's advisor for** $p_b = 0.8$ **and** $l = 0.3$

The figure shows the wage paid to the seller's advisor as a function of the value reported by the advisor. This corresponds to the equilibrium where the buyer hires an advisor with probability $p_b = 0.8$ and accepts any offer less than or equal to $l = 0.3$ if he hasn't hired an advisor. The value reported b the advisor is not the same as the value at which the transaction takes place since there are intervals where the seller undercharges or overcharges. The wage is increasing monotonically in the transaction value. Some of the wages are off the equilibrium path and will not be observed in equilibrium (The wages have been scaled by ck' where c is the advisor's cost of exerting effort and k' is a constant).

We still have to check whether the advisor has an incentive to misreport the value *after* exerting the effort. We need to check this for misreporting from each of the intervals to each of the other 3 intervals. I illustrate this for one interval below.

If the advisor finds that $V \in [0, (1 - p_b)l]$ and reports the value truthfully to the seller, the seller makes the buyer an offer of l. The advisor gets $w(l)$ only if the buyer is uninformed.

- If instead, the advisor misreports the value to $V' \in [(1 - p_b)l, l]$, the seller offers V'. Since $V' < l$, the transaction still goes through only if the buyer is uninformed and the bank gets $w(V) < w(l)$ if it goes through. So, the advisor has no incentive to do this.

- Misreporting to $V^{'} \in [l, \frac{l}{p_b}]$ is pointless since the seller offers l in that range, same as without misreporting, which changes neither the fee nor the probability of the transaction going through.

- Lastly, misreporting to $V^{'} \in [\frac{l}{p_b}, 1]$ leads to the seller offering $V^{'}$. In this case, the transaction fails for sure because both the informed and uninformed seller will reject the offer since $V^{'} > V$ and $V^{'} > l$ respectively. So, there is no incentive to misreport to this range

Hence, there is no incentive to misreport from $V \in [0, (1 - p_b)l]$ to any of the other three intervals. Similarly, it can be shown that the contract is misreporting-proof i.e. the advisor has no incentive to misreport the value after discovering that the true value lies in each of the other three intervals as well. The proof is given in Appendix I. The contract is plotted in Figure 12 for $l = 0.3$ and $p_b = 0.8$

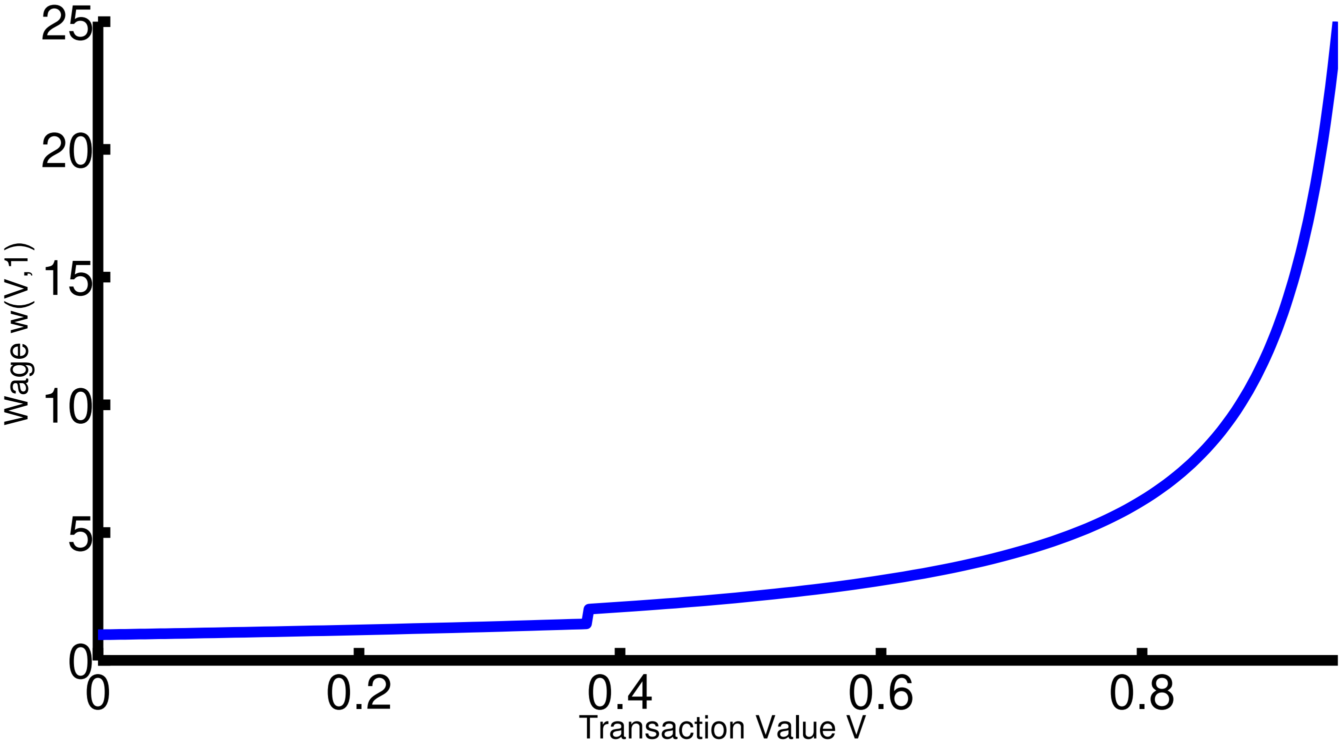

Figure 12: **Optimal contract with the seller's advisor for $p_b = 0.8$ and $l = 0.3$**

The figure shows the wage paid to the seller's bank as a function of the transaction value. This corresponds to the equilibrium where the buyer hires a bank with probability $p_b = 0.8$ and accepts any offer less than or equal to $l = 0.3$ if he hasn't hired a bank. The wage is increasing monotonically in the transaction value. Some of the wages are off the equilibrium path and will not be observed in equilibrium (The wages have been scaled by $ck^{'}$ where c is the bank's cost of exerting effort and $k^{'}$ is a constant).

Now consider equilbria of the form

$$Q_i = \begin{cases} l & \textit{if } V \in [0,(1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l,1] \end{cases}$$

The optimal contract is given by

$$w(V,1) = k^{''} c \frac{1}{1-p_b V} \ \textit{if } V \in [(1-p_b)l, l]$$

where $k^{''}$ is a constant. The payment the intermediary is given by $c(1+k^{''})$. The payment is always greater the cost of effort c, so the advisor extracts information rents in this range. Also, this contract is misreporting-proof. These results are proved in Appendix J

6.2 Buyer's contract with the advisor

The buyer's advisor reports a value to the buyer. His contract can only depend on whether the offer corresponding to the value he reports is equal to the actual offer made by the seller.

First, consider equilibria are of the form

$$Q_i = \begin{cases} l & \textit{if } V \in [0,(1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, \frac{l}{p_b}] \\ V & \textit{if } V \in [\frac{l}{p_b}, 1] \end{cases}$$

It is clear that the buyer has no way of distinguishing between the lower and upper intervals since the seller offers l in both cases. So the wage in these two intervals has to be the same. Else, the buyer's advisor would never report a value in the interval corresponding to the lower wage. Let this wage be $w(l,1)$.

If $V \in [(1-p_b)l, l]$ or $V \in [\frac{l}{p_b}, 1]$, the seller offers V. If the buyer's advisor does not exert any effort, he guesses V right with probability 0. So, not putting effort and reporting a value in either of these intervals gives him zero utility.

The only case in which the buyer's advisor can get an expected utility greater than 0 without exerting effort is if he reports $V \in [0,(1-p_b)l]$ or $V \in [\frac{l}{p_b}, 1]$. In both these cases, he gets paid $w(l)$ if the seller offers l. The seller offers $w(l)$ if he is uninformed or if he is informed and the value falls into those intervals i.e. with probability $\left[1-p_s+p_s(\frac{1}{p_b}-p_b)l\right]$. So, the buyer's advisor can get $(1-p_s+p_s(\frac{1}{p_b}-p_b)l)w(l,1)$ without putting in any effort.

If the advisor does exert effort, he discovers $V \in [0,(1-p_b)l]$ or $V \in [\frac{l}{p_b}, 1]$ with probability $(\frac{1}{p_b}-p_b)l$. The seller offers l whether he is informed or uninformed. So, with probability $(\frac{1}{p_b}-p_b)l$, the bank gets $w(l,1)$. If $V \in [(1-p_b)l, l]$ or $V \in [\frac{l}{p_b}, 1]$, his reported value matches the seller's offer only if the seller is informed.

The buyer tries to minimize the expected payment to the bank

$$(\frac{1}{p_b}-p_b)lw(l,1)+p_s\left[\int\limits_{(1-p_b)l}^{l} w(V,1)dV+\int\limits_{\frac{l}{p_b}}^{1} w(V,1)dV\right]$$

subject to the advisor's IC constraint for exerting effort

$$(\frac{1}{p_b}-p_b)lw(l,1)+p_s\left[\int\limits_{(1-p_b)l}^{l} w(V,1)dV+\int\limits_{\frac{l}{p_b}}^{1} w(V,1)dV\right]-c \geq \left[1-p_s+p_s(\frac{1}{p_b}-p_b)l\right]w(V_l,1)$$

which simplifies to

$$p_s\left[\int\limits_{(1-p_b)l}^{l} w(V,1)dV+\int\limits_{\frac{l}{p_b}}^{1} w(V,1)dV\right]-c \geq [1-p_s]\left[1-(\frac{1}{p_b}-p_b)l\right]w(l,1)$$

Decreasing $w(l,1)$ decreases the objective function and strictly loosens the constraint. So, the optimal contract sets $w(l,1)$ to 0. The constraint thus binds. The expected payment to the advisor is always c. This means that the advisor extracts no informational rents.

In general, the buyer's optimal contract can take various forms. However, all contracts are subject to two restrictions. First, the wage corresponding to a report of l i.e. the threshold that the buyer would have used had he not hired the advisor, must be zero.[13] Second, the advisor makes the cost of effort c in expectation and gets no information rents. Subject to these constraints, the contract can be flat, increasing or decreasing. One way to implement this is through a flat fee $= \frac{c}{p_s(1-\frac{l}{p_b}+lp_b)}$ in $V \in [(1-p_b)l, l]$ or $V \in [\frac{l}{p_b}, 1]$. In general, any wage structure $w(V,1)$ which satisfies

$$\int\limits_{(1-p_b)l}^{l} w(V,1)dV+\int\limits_{\frac{l}{p_b}}^{1} w(V,1)dV=\frac{c}{p_s} \text{ and}$$

$$w(l,1)=0$$

will work.

It is easy to verify that the advisor will not misreport once he has been incentivized to put in the effort. If the advisor misreports from $V \in [0,(1-p_b)l]$ or$V \in [l, \frac{l}{p_b}]$, where

[13]Intuitively, hiring the advisor has not really helped the buyer in this case and so the advisor is paid zero.

the seller offers l, to $V^{'} \in [(1-p_b)l, l]$ or $V^{'} \in [\frac{l}{p_b}, 1]$, where the seller offers V , he has zero probability of getting the value right. Hence, he will not report a value in this range unless he finds the value to be in the range. If instead, the advisor misreports from $V^{'} \in [(1-p_b)l, l]$ or $V^{'} \in [\frac{l}{p_b}, 1]$, where the seller offers V, to $V \in [0, (1-p_b)l]$ or$V \in [l, \frac{l}{p_b}]$, he gets paid $w(l, 1)$ i.e. 0 at best. There is no incentive to do this either. Hence, this contract is misreporting-proof.

Figure 13 shows 3 possible optimal contracts. Since the contract is not uniquely pinned down, there are many others.

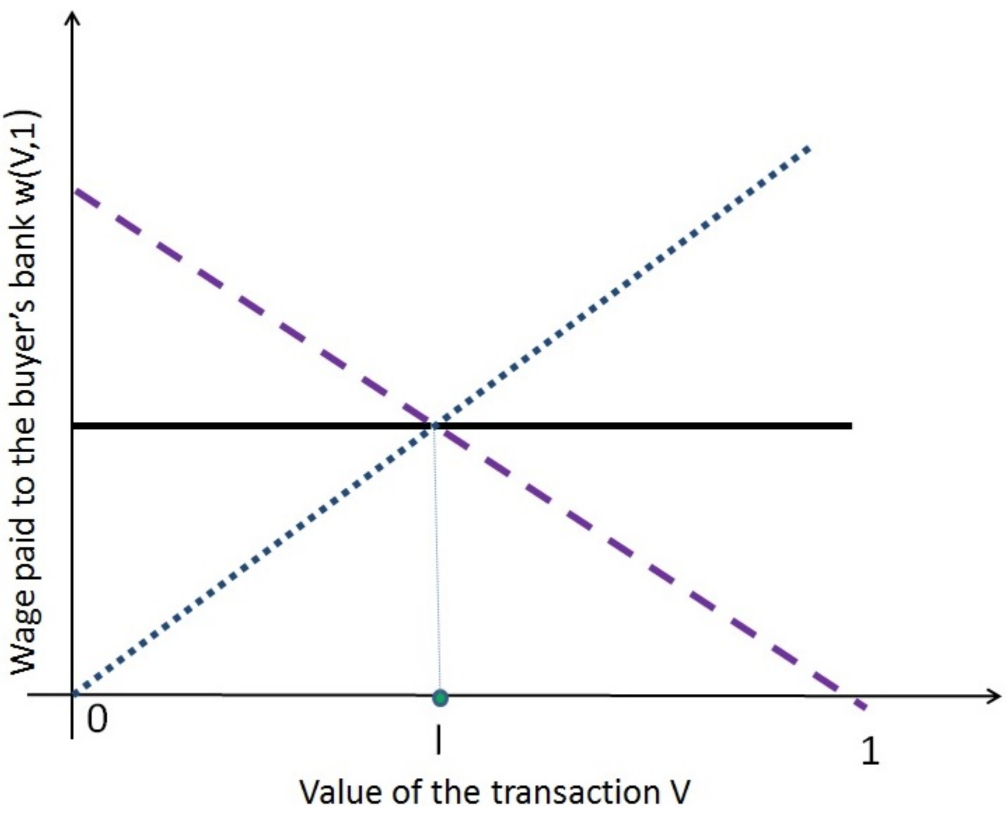

Figure 13: **Optimal contract with the buyer's advisor**

The figure shows the wage paid to the buyer's bank as a function of the transaction value. In general, the buyer's optimal contract can take various forms subject to two restrictions. First, the wage corresponding to a report of l i.e. the threshold that the buyer would have used had he not hired the bank, must be zero. Second, the bank makes the cost of effort c in expectation and gets no information rents. Subject to these, the contract can be flat, increasing or decreasing. Three such contracts- the solid, dotted and dashed lines are given in the figure.

For equilibria of of the form

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, 1] \end{cases}$$

it is apparent by arguments almost exactly the same as above that the optimal contract sets

$$\int_{(1-p_b)l}^{l} w(V,1)dV = \frac{c}{p_s} \text{ and}$$

$$w(l,1) = 0$$

Once again, the advisor is paid c in expectation, i.e. extracts no information rents, and the contract is misreporting-proof.

6.3 The range of c for which the mixing equilibria exist

We have demonstrated that the buyer's advisor never gets information rents and the seller's advisor doesn't for the $lVlV$ equilibria. For the rest of the paper, I consider only equilibria where the cost of effort c is the same for both the buyer's advisor and the seller's advisor. Figure 10 makes it clear that the lVl equilibria cannot have both the advisors' costs of effort equal to c. This is because for these equilibria, $c_b = c$ and $c_s > c$ since the seller's advisor extracts information rents. However, from the graph, we see that this is not possible. By the same logic, the $lVlV$ corresponding to the areas shaded red can also be ignored. We are left only with the blue area of the graph.This is shown in Figure 14

7 Complete characterization of the Equilibria

I fully characterise the buyer's and seller's strategies in equilibria given the cost of effort c of their advisors. A strategy is described below in terms of the ordered triple (l, p_b, p_s) given c . In keeping with the requirements of a Perfect Bayesian Equilibrium, the beliefs of either party are consistent with the strategy of the other. I also describe the contracts between both parties and their advisors. The advisors exert effort and report truthfully in all the equilibria.

Buyer's strategy

If uninformed, the buyer accepts any offer less than or equal to a threshold l. If informed, the buyer accepts any offer less than or equal to the value V. The buyer becomes informed

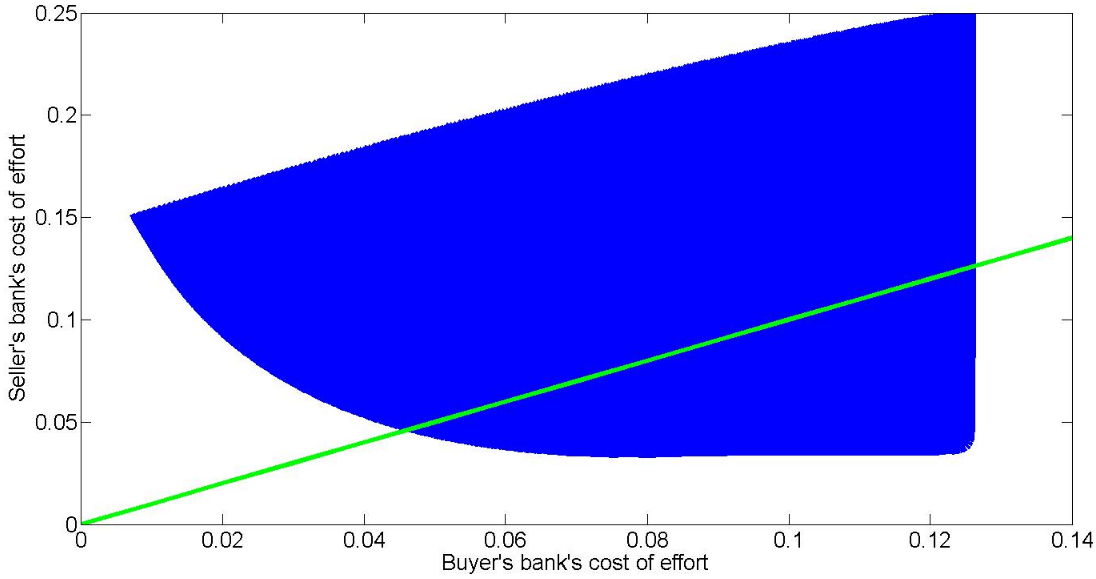

Figure 14: **Equilibria and the advisor' cost of effort**

The figure shows the ranges of the advisors' cost of effort for which mixed equilibria exist under the assumptions that both the advisors have the same cost of effort c. The set of equilbria correspond to the intresection of the region in Figure 10 with the $x = y$ line. We only need to consider the blue region in Figure 10 because the line doesn't intersect the green or red regions. In the equilibria, both advisors get paid the effort cost. As can be seen from the figure, equilibria exist for a wide range of c.

i.e. hires an advisor with probability p_b. The buyer's contract with his bank is given by, for eg,

A flat fee $= \frac{c}{p_s(1-\frac{l}{p_b}+lp_b)}$ in $V \in [(1-p_b)l, l]$ or $V \in [\frac{l}{p_b}, 1]$ and $w(l, 1) = 0$

Seller's strategy

If uninformed, the seller offers l.

If informed, the seller offers

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, \frac{l}{p_b}] \\ V & \textit{if } V \in [\frac{l}{p_b}, 1] \end{cases}$$

The 3 unknowns l, p_s and p_b are determined from the three equations

$$p_s = \frac{(2l-1)p_b(1+p_b)}{(1-p_b^3)l-(p_b^2+p_b)(1-l)}$$
$$c = \frac{1}{2}l^2p_b^2 + \frac{1}{2}(\sqrt{p_b} - \frac{l}{\sqrt{p_b}})^2$$
$$c = \frac{1}{2}(1-l)^2 + \frac{1}{2}p_s\left(\frac{l^2}{p_b}(\frac{1}{p_b}-2)+2l-1\right)$$

The seller's contract with his bank is given by

$$w(V,1) = \begin{cases} k'c\frac{1}{1-p_bV} & \textit{if } V \in [(1-p_b)l, l] \\ k'c\frac{1}{p_b(1-V)} & \textit{if } V \in [\frac{l}{p_b}, 1-\epsilon] \end{cases}$$

8 Analysis of the equilibria

Numerical solutions of the above equations for various values of c show that the solution (l, p_b, p_s) is unique for each value of c. I now turn to the question of how each of these parameters depend on c and how these affect the efficiency and the probability of the transaction going through. Figure 15 shows how l, p_s and p_b vary with c As the cost of effort increases, the buyer hires an advisor more often. He also accepts more offers if uninformed because his threshold of accepting is higher. However, the seller hires the advisor less often.

The transaction goes through with probability

$$p_{success} = p_sp_b + (1-p_s)(1-p_b) + p_s(1-p_b)(\frac{l}{p_b}) + (1-p_s)(p_b)(1-l)$$

The proof is in Appendix K. As the cost of effort increases, the probability of sale decreases. The graph is shown in Figure 16. With no advisors, the seller offers $\frac{1}{2}$ and the buyer always accepts it. With advisors, the transaction happens less frequently, which affects the efficiency.

How does this affect the expected utility of the seller? Since the seller is indifferent between hiring and not hiring the advisor, the expected utility of the seller is calculated easily as the expected utility of the uninformed seller, which we derived in Appendix to be equal to $l(1-lp_b)$. The graph is shown in Figure 17. With no advisors in the picture, the seller offers $\frac{1}{2}$ and the buyer always accepts it. So, the seller would have got a payoff of $\frac{1}{2}$. As can be seen, the payoff with the possibility of hiring advisors is always less than $\frac{1}{2}$. Remember that the buyer is held to his reservation utility of 0 in all equilibria since the seller has the bargaining power. So, this is also the total surplus.

The possibility of information acquisition thus has two effects. First, it destroys the total surplus in the transaction when the transaction happens. Second, the transaction happens less frequently. So, we see that the efficiency is destroyed in two ways- the

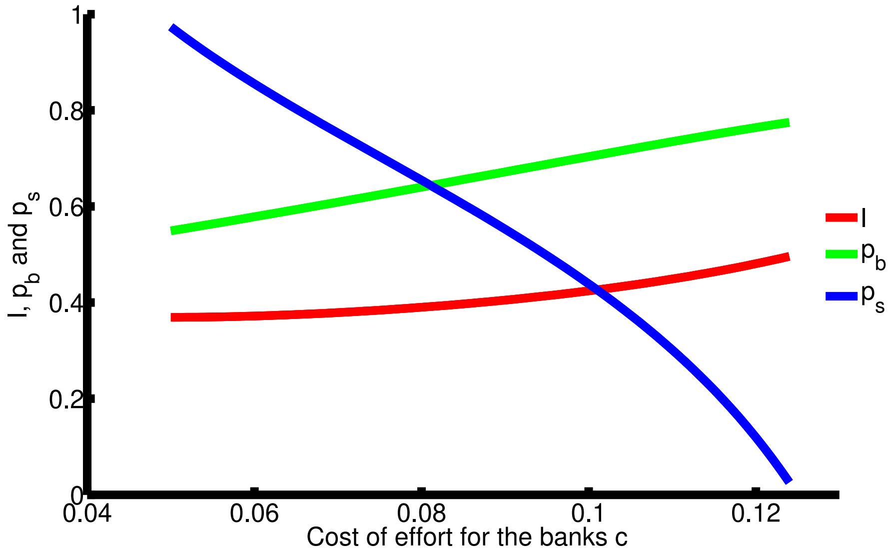

Figure 15: l, p_s **and** p_b **as a function of** c

The figure shows the probabilities of the seller and the buyer hiring their advisors and the maximum offer accepted by the uninformed buyer as a function of the advisors' cost of effort. As the cost of effort increases, the buyer hires an advisor more often. He also accepts more offers if uninformed (because his threshold of l increases). However, the seller hires the advisor less often.

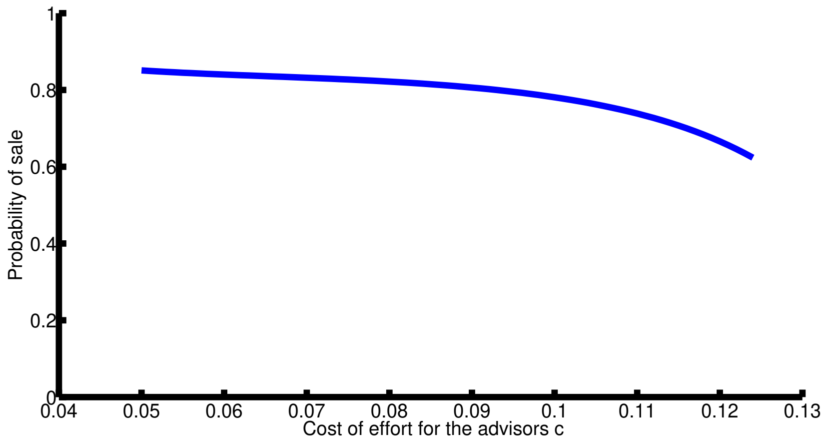

Figure 16: **Probability of the sale as a function of** c

The figure shows the probability of the transaction going through as a function of the advisors' cost of effort. The transaction happens less frequently than the benchmark case with no advisors where it always goes through

transaction not always going through, and the bank exerting costly effort to acquire the information. Interestingly, the banks do not extract rents, which would have decreased the efficiency even further.

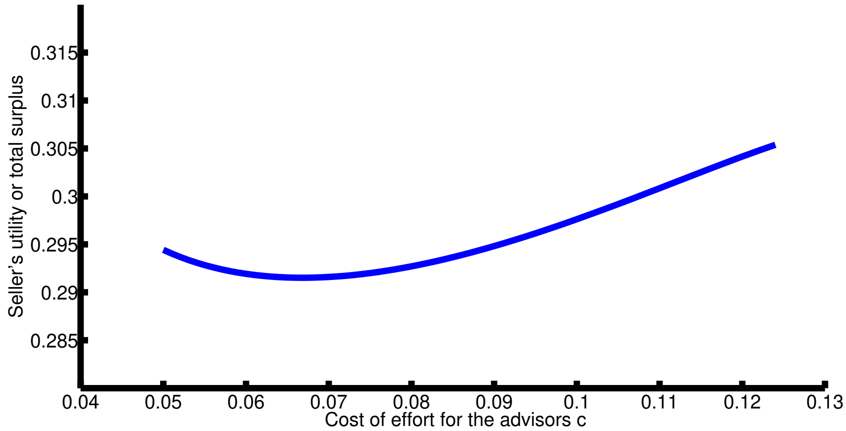

Figure 17: **The seller's payoff (or total surplus) as a function of** c

The figure shows the seller's payoff (or total surplus) as a function of as a function of the advisors' cost of effort. The seller's surplus is always lesser than the benchmark value of 0.5 with no advisors.

9 Empirical implications

In this section, we reconcile the predictions from the model with some of the empirical studies.

We have shown that equilibria exist for a wide range of effort costs. McLaughlin [1990] finds that on an average, the fees paid to the banks were 0.77% of acquisition value for target firms and 0.55% for bidder firms. Servaes and Zenner [1996] report a value of 1% . In the model, we find the range to be from about 4% to 12.5% of the synergies. Synergies themselves can be anywhere from 2% to 10% of the transaction value. So the estimates are well within our predictions.

A more straightforward prediction of the model can be crosschecked with the estimate provided by Hunter and Walker [1990] who state that that on average, only about 6 percent of the merger gains were captured by the investment bankers in the form of fees. Once again, 6% falls well within our permitted range of c in equilibrium.

Another empirical implication is the difference in fees charged between high quality and low quality banks. Golubov et al. [2012] find that top-tier advisors charge a mean advisory fee of 0.55% of the transaction value and non-top-tier advisors charge 0.72%.[14]

On the returns to the acquirer, Servaes and Zenner [1996] find that the returns earned by acquirers are independent of whether the bank is hired or not. Our model predicts this almost by construction since the buyer always gets a payoff of 0. Regarding returns to the target, Asquith [1983] provide evidence that increases in the probability

[14] They also find differences in the characteristics of firms who hire top-tier advisors and non-top-tier advisors. The former are public firms. Public firms have more information and financial statements publicly available, so they are less costly to investigate.

of merger benefit the stockholders of target firms. This is true for some ranges of c, the low values to be precise.

On the likelihood of the transaction going through, Hunter and Jagtiani [2003] suggest that the payment of larger advisory fees do not play an important role in determining the likelihood of completing the deal. Our model in fact predicts a negative relation between the two.

10 Concluding remarks

In this paper, we solve for the optimal contract that a seller or buyer should offer an information intermediary who can precisely know the value of the asset if he exerts effort. Using a simple model, we first solve for an equilibrium choice of firms to get informed as a function of the intermediary's cost of effort. We then characterize the features of the optimal contract, comment on the impact on efficient allocation of assets and generate empirically testable hypotheses.

In light of the recent merger wave, mergers and acquisitions conjure up images of high value transactions (upwards of even \$100 billion in many cases) between two big, public firms. However, it would be a mistake to focus only on such deals in any discussion of asymmetric information problems.[15] There is an active market for the sale of smaller firms, which account for a large proportion of mergers in many industries.[16] If the target is a smaller private firm, the buyer and the target face even more uncertainty regarding the synergies in the transaction since there is less publicly available information about the target.[17] In addition, innovative start ups with intangible assets which are difficult to value are inevitably private firms. For these reasons, the analysis in the paper is particularly relevant for the sale of small, private targets.

In conclusion, it is worth noting that although we have specialized the discussion to an M&A setting, the paper can be applied to most other settings involving the sale of an asset of unknown value.The model suits any context where advisors can be hired to provide information on the value of the asset, as long as their effort is costly and not verifiable. It is applicable, for example, to the sale of a real estate property or the negotiation between a seller of a rare painting and an art collector. The optimal contract

[15] It is also well-documented that the stock market reaction to acquirers of private firms is on an average positive while that to acquisitions of public targets is zero or even negative. This suggests that acquisitions of private firms are value enhancing for the shareholders of both the acquirer and the target. Empirical studies investigating this are many, Capron and Shen [2007], Faccio et al. [2006] or Officer [2007] to name just three

[16] See for example Ho, Catherine. *"Law firm mergers continue to target small firms"*. The Washington Post. 6 July 2014. Web. Accessed 24 October 2016.

[17] For more on the costs and benefits of acquiring small firms, see for example Shen and Reuer [2005] or Moeller et al. [2004].

in all these settings is of the form described above.

Appendices

A The optimal wage contract when synergies have a discrete uniform distribution

The seller's problem is to minimize

$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]$$

subject to the constraints

$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]-c\geq w(\frac{1}{n},1)$$
$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]-c\geq \frac{n-1}{n}w(\frac{2}{n},1)$$
$$..................................$$
$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]-c\geq \frac{n-k+1}{n}w(\frac{k}{n},1)$$
$$..................................$$
$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]-c\geq \frac{2}{n}w(\frac{n-1}{n},1)$$
$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]-c\geq \frac{1}{n}w(1,1)$$

Divide both sides of k^{th} equation by $n-k+1$ and add all the equations up .

The seller's problem is to minimize

$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]$$

subject to

$$\left(\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]-c\right)\left(\frac{1}{n}+\frac{1}{n-1}+...+\frac{1}{2}+1\right)\geq \frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]$$

Simplifying the constraint, the problem becomes to minimize

$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]$$

s.t.

$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]-c\geq \frac{1}{\frac{1}{n}+\frac{1}{n-1}+...+\frac{1}{2}}c$$

The optimal solution would just set

$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]-c= \frac{1}{\frac{1}{n}+\frac{1}{n-1}+...+\frac{1}{2}}c$$

The expected payment to the bank decreases to c as $n \to \infty$.

If we can find a wage schedule which gives this value for the objective and is feasible under the original constraints, it will be the optimal contract under the original constraints. Since the aggregate constraint is satisfied with equality. a natural candidate is to look for a solution which satisfies each of the original constraints with equality and is feasible. Thus, the k^{th} equation gives

$$\frac{1}{n}\left[w(\frac{1}{n},1)+w(\frac{2}{n},1)+...+w(1,1)\right]-c=\frac{n-k+1}{n}w(\frac{k}{n},1)$$

B The optimal wage contract when synergies are uniformly distributed

The seller's problem is to minimize

$$\int_0^{1-\epsilon} w(V,1)dV+\epsilon w(1-\epsilon,1)$$

subject to

$$\int_0^{1-\epsilon} w(V,1)dV+\epsilon w(1-\epsilon,1)-c\geq(1-V)w(V,1) \text{ for } V\in[0,1-\epsilon)$$

$$\int_0^{1-\epsilon} w(V,1)dV+\epsilon w(1-\epsilon,1)-c\geq\epsilon w(1-\epsilon,1)$$

Denote the objective function $\int_0^{1-\epsilon} w(V,1)dV+\epsilon w(1-\epsilon)$ by k

Divide first equation by $1-V$, integrate from 0 to $1-\epsilon$ and add the second equation to get an aggregate constraint, a weaker one

$$(k-c)\left[\int_0^{1-\epsilon}\frac{1}{1-V}dV+1\right]\geq\int_0^{1-\epsilon} w(V,1)dV+\epsilon w(1-\epsilon)$$

Recognizing that the right hand side of the equation is k, the aggregate constraint can be rewitten as

$$(k-c)\left[\int_0^{1-\epsilon}\frac{1}{1-V}dV+1\right]\geq k$$

which simplifies to

$$k\geq c+\frac{c}{ln(\frac{1}{\epsilon})}$$

The seller's problem is to minimize k subject to the aggregate weaker constraint

$$k\geq c+\frac{c}{ln(\frac{1}{\epsilon})}$$

The solution to this is simply to set

$$k=c+\frac{c}{ln(\frac{1}{\epsilon})}$$

which gives the minimum value of the objective function as $c + \frac{c}{ln(\frac{1}{\epsilon})}$

The solution under the stronger family of constraints cannot be higher than under this weaker constraint. If we can find a wage schedule which gives this value for the objective and is feasible under the original constraints, it will be the optimal contract under the original constraints. Since the aggregate constraint is satisfied with equality. a natural candidate is to look for a solution which satisfies each of the original constraints with equality and is feasible. So, set

$$w(V,1) = \frac{1}{1-V}\frac{c}{ln(\frac{1}{\epsilon})}$$

which is a feasible wage schedule, satisfies each of the original constraints with equality and leads to the same minimum value of the objective function

$$k = c + \frac{c}{ln(\frac{1}{\epsilon})}$$

as under the weaker constraint. Hence, this is the optimal contract.

C The uninformed seller's strategy

The maximand is $Q((1-p_b)\mathbf{1}(Q \leq l) + p_b(1-Q))$

First, consider $l \leq \frac{1}{2}$

If $Q \leq l$, this is equal to $Q\,(1 - Qp_b)$ which is increasing in $[0, \frac{1}{2p_b}]$ (First derivative $1 - 2Qp_b$ is greater than 0 in this interval) and hence maximised at $Q = l$. The maximum is equal to $l(1 - lp_b)$

If $Q > l$, this is equal to $Q\,(p_b(1-Q))$ which is decreasing in the interval $(\frac{1}{2}, 1]$.(First derivative $p_b(1-2Q)$ is negative in this interval). Quoting $\frac{1}{2}$ gives $\frac{1}{4}p_b$

Hence he quotes l if $l(1 - lp_b) > \frac{1}{4}p_b$ i.e. $p_b < \frac{l}{l^2 + \frac{1}{4}}$ and gets utility $l(1 - lp_b)$ He quotes $\frac{1}{2}$ if $l(1 - lp_b) < \frac{1}{4}p_b$ i.e. $p_b > \frac{l}{l^2+\frac{1}{4}}$ and gets utility $\frac{1}{4}p_b$

Now, consider $l \geq \frac{1}{2}$.

If $Q \leq l$, this is equal to $Q\,(1 - Qp_b)$ which is increasing in $[0, \frac{1}{2p_b}]$ and decreasing after that (First derivative $(1 - 2Qp_b)$ is greater than 0 in this interval and less than 0 after that).

Quote $Q = l$ if $l \leq \frac{1}{2p_b}$ i.e. $p_b \in [0, \frac{1}{2l}]$. The maximum is equal to $l(1-lp_b)$ and $Q = \frac{1}{2p_b}$ if $l \geq \frac{1}{2p_b}$ i.e. $p_b \in [\frac{1}{2l}, 1]$ The maximum is equal to $\frac{1}{4p_b}$.

If $Q > l$, this is equal to $Q\,(p_b(1-Q))$ which is decreasing in the interval $(l, 1]$.(First derivative $p_b(1-2Q)$ is negative in this interval). Quoting l is optimal irrespective of p_b

D The informed seller's strategy

The seller quotes Q to maximize $Q\,((1-p_b)\mathbf{1}(Q \leq l) + p_b\mathbf{1}(Q \leq V))$

If $V \leq l$, then this function is increasing in Q in $[0, V]$ and $(V, l]$. This means that the optimal quote has to be either l or $V.l$ is accepted with probability $1 - p_b$ and V is always accepted.

So, quote l if $(1-p_b)l \geq V$ i.e. $V \in [0, (1-p_b)l]$ and quote V if $V \in [(1-p_b)l, l]$.

If $V \geq l$, then this function is increasing in Q in $[0, l]$ and increasing from $(l, V]$.

Again, the optimal quote has to be either l or V. l is always accepted whereas V is accepted with probability p_b. So, quote l if $l \geq p_bV$ i.e. $V \in [l, \frac{l}{p_b}]$ and quote V if $V \in [\frac{l}{p_b}, 1]$.

If $p_b \leq l$, $l \geq p_bV$ can never be satisfied. So quote l if $V \in [l, 1]$

E Additional constraints

Subgame perfection implies that the payoff for the buyer has to be 0 if he is uninformed and if the offer is l. Also, the payoff must be greater than 0 if the offer is less than l First, consider the following case for the uninformed seller

$$Q_u = \begin{cases} l & \textit{if } p_b \in [0, \frac{1}{2l}] \\ \frac{1}{2p_b} & \textit{if } p_b \in [\frac{1}{2l}, 1] \end{cases} \textit{if } l > \frac{1}{2}$$

The case where theuninformed seller quotes $\frac{1}{2p_b}$ *if* $p_b \in [\frac{1}{2l}, 1]$ is impossible. The buyer would know that only an uninformed seller would quote $\frac{1}{2p_b}$ and would be paying $\frac{1}{2p_b}$ for something worth $\frac{1}{2}$ in expectation. He would thus refuse to accept the offer, even though it is less than l in this range of p_b, which is inconsitent with his strategy of accepting anything less than l. So, we eliminate this interval and only need to consider

$$Q_u = l \textit{ if } p_b \in [0, \frac{1}{2l}] \textit{ if } l > \frac{1}{2}$$

"lVl" Equilibria

Consider equilibria of the form

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, 1] \end{cases}$$

which occur when $p_b \leq l$

Probability of being offered l by informed seller is $(1-p_b)l + 1 - l$ i.e. $1 - p_b l$

Expected value conditional on being offered l by informed seller is

$$\frac{(1-p_b)l}{1-p_b l}\frac{(1-p_b)l}{2} + \frac{1-l}{1-p_b l}\frac{1+l}{2} = \frac{1}{2(1-p_b l)}\left(l^2 p_b(p_b-2)+1\right)$$

Expected payoff conditional on being offered l by the informed seller is

$$\frac{1}{2(1-p_b l)}\left(l^2 p_b(p_b-2)+1\right) - l = \frac{1}{2(1-p_b l)}\left(l^2 p_b^2 + 1 - 2l\right)$$

If $l \leq \frac{1}{2}$

In this case, the uninformed seller offering l leads to a payoff greater than 0 since the buyer pays $l \leq \frac{1}{2}$ for something worth $\frac{1}{2}$ in expectation.

The payoff from the informed seller offering l, i.e. $\frac{1}{2(1-p_b l)}\left(l^2 p_b^2 + 1 - 2l\right)$, is greater than 0.

So there is no way in which the expected payoff conditional on an offer of l can be zero. Hence, there is no such equilibrium for $l \leq \frac{1}{2}$ whether the uninformed seller offers l or not.

If $l \geq \frac{1}{2}$

In this case, the uninformed seller offering l leads to a payoff less than 0 since the buyer pays $l \geq \frac{1}{2}$ for something worth $\frac{1}{2}$ in expectation.

The payoff from the informed seller offering l, i.e. $\frac{1}{2(1-p_b l)}\left(l^2 p_b^2 + 1 - 2l\right)$, has to be greater than 0.

Since this payoff is increasing in p_b, we need $l^2 p_b^2 + 1 - 2l > 0$, which gives $p_b^2 > \frac{2l-1}{l^2}$, so there is a p_b above which this expression is > 0.
However, remember that $p_b \leq l$, so we must also have $\frac{2l-1}{l^2} \leq l^2$. This gives $l \leq 0.54$. (Also, note that $p_b \leq \frac{1}{2l}$ is redundant since $p_b \leq l$ and $l \leq \frac{1}{2l}$ in this range)
p_s can be obtained by solving $(1-p_s)(\frac{1}{2} - l) + p_s \frac{1}{2(1-p_b l)} \left(l^2 p_b^2 + 1 - 2l\right) = 0$
p_s always exists since it is the weight that makes the average of a positive and negative number equal to zero. Also, p_s is decreasing in p_b since the second term is increasing in p_b and less weight is required on the second term for the average to be 0.

Putting it all together, there is an"lVl" equilibrium if

$$l \in [\frac{1}{2}, 0.54]$$
$$p_b \in [\sqrt{\frac{2l-1}{l^2}}, l] \ \mathit{and}$$
$$p_s = \frac{(2l-1)(1-p_b l)}{p_b l(p_b l + 1 - 2l)}$$

"lVlV" Equilibria

Consider equilibria of the form

$$Q_i = \begin{cases} l & \mathit{if}\ V \in [0, (1-p_b)l] \\ V & \mathit{if}\ V \in [(1-p_b)l, l] \\ l & \mathit{if}\ V \in [l, \frac{l}{p_b}] \\ V & \mathit{if}\ V \in [\frac{l}{p_b}, 1] \end{cases}$$

which occur when $p_b > l$

Probability of being offered l by informed seller is $l(1-p_b) + \frac{l}{p_b} - l$ i.e. $(\frac{1-p_b^2}{p_b})l$

Probability that $V \in [0, (1-p_b)l]$ conditional on being offered l by the informed seller is

$$\frac{(1-p_b)l}{(\frac{1-p_b^2}{p_b})l} = \frac{p_b}{1+p_b}$$

Probability that $V \in [l, \frac{l}{p_b}]$ conditional on being offered l by the informed seller is

$$\frac{\frac{l}{p_b} - l}{(\frac{1-p_b^2}{p_b})l} = \frac{1}{1+p_b}$$

Expected value conditional on being offered l by informed seller is

$$\left(\frac{p_b}{1+p_b}\frac{(1-p_b)l}{2} + \frac{1}{1+p_b}\frac{l+\frac{l}{p_b}}{2}\right) - l = \frac{1}{2}l\left(\frac{p_b(1-p_b)}{1+p_b} + \frac{1}{p_b} - 2\right)$$

The function $\left(\frac{p_b(1-p_b)}{1+p_b} + \frac{1}{p_b} - 2\right)$ is decreasing in p_b since its derivative $-\frac{p(b)^4+2p(b)^3+2p(b)+1}{p(b)^2((1+p(b))^2}$ is less than 0. The function itself is less than 0 if $p_b \geq 0.54$

If $l \leq \frac{1}{2}$

In this case, the uninformed seller offering l leads to a payoff greater than 0 since the buyer pays $l \leq \frac{1}{2}$ for something worth $\frac{1}{2}$ in expectation.

The payoff from the informed seller offering l, i.e. $\frac{1}{2}l\left(\frac{p_b(1-p_b)}{1+p_b}+\frac{1}{p_b}-2\right)$, has to be less than 0 or $p_b \geq 0.54$
But note that for this kind of an equilibrium, $p_b \geq l$ which is automatically satisfied since $l \leq \frac{1}{2}$ and $p_b \geq 0.54$.
Also, for the uninformed seller to be offering l, we need $p_b < \frac{l}{l^2+\frac{1}{4}}$.
So really, we will have such an equlibrium for any $p_b \in [0.54, \frac{l}{l^2+\frac{1}{4}}]$
If $0.54 > \frac{l}{l^2+\frac{1}{4}}$, then there is no solution. This corresponds to $l \in [0, 0.15]$
p_s can be obtained by solving $(1-p_s)(\frac{1}{2}-l)+p_s\frac{1}{2}l\left(\frac{p_b(1-p_b)}{1+p_b}+\frac{1}{p_b}-2\right)=0$
p_s always exists since it is the weight that makes the average of a positive and negative number equal to zero.
Also, p_s is decreasing in p_b since the second term is decreasing in p_b and hence less weight is required on the second term for the average to be 0.

If $l \geq \frac{1}{2}$

In this case, the uninformed seller offering l leads to a payoff less than 0 since the buyer pays $l \geq \frac{1}{2}$ for something worth $\frac{1}{2}$ in expectation.
The payoff from the informed seller offering l, i.e. $\frac{1}{2}l\left(\frac{p_b(1-p_b)}{1+p_b}+\frac{1}{p_b}-2\right)$, has to be greater than 0 or $p_b \leq 0.54$
However, $p_b \geq l$, so then $l \in [0.5, 0.54]$ and $p_b \in [l, 0.54]$. Note that $p_b \leq \frac{1}{2l}$, a condition for the uninformed seller to offer l, is automatically satisfied in this range.
p_s can be obtained by solving $(1-p_s)(\frac{1}{2}-l)+p_s\frac{1}{2}l\left(\frac{p_b(1-p_b)}{1+p_b}+\frac{1}{p_b}-2\right)=0$
p_s always exists since it is the weight that makes the average of a positive and negative number equal to zero.
Also, p_s is increasing in p_b since the second term is decreasing in p_b and hence less weight is required on thesecond term for the average to be 0.
Note that ranges of p_b for which $Q=\frac{1}{2p_b}$ need not be considered. The uninformed buyer will know that only the uninformed seller will make this offer, and will not accept it since he is paying more than $\frac{1}{2}$ for something worth $\frac{1}{2}$. (even though it satisfies the condition that the quote is less than l). This is inconsistent with his strategy.

Putting it all together, there is an"lVlV" equilibrium if

$$l \in [0.15, \frac{1}{2}]$$
$$p_b \in [0.54, \frac{l}{l^2+\frac{1}{4}}]$$
$$p_s = \frac{(2l-1)p_b(1+p_b)}{(1-p_b^3)l-(p_b^2+p_b)(1-l)}$$

or if

$$l \in [\frac{1}{2}, 0.54]$$
$$p_b \in [l, 0.54]$$
$$p_s = \frac{(2l-1)p_b(1+p_b)}{(1-p_b^3)l-(p_b^2+p_b)(1-l)}$$

F The seller's cost of hiring the bank

If the seller doesn't hire the bank, he quotes l. This offer is accepted either if the buyer is uninformed or if he is his informed and V is less than l. So, the probability of the offer being accepted is $1-p_b+p_b(1-l)$ i.e. $1-lp_b$ and the utility of the uninformed seller is $l(1-lp_b)$

Since the seller mixes, this has to be equal to the utility of the informed seller. The latter depends on the form of the equlibria.

Consider equilibria of the form

$$Q_i = \begin{cases} l & \textit{if } V \in [0,(1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, 1] \end{cases}$$

If $V \in [0,(1-p_b)l]$, which happens with probability $(1-p_b)l$, the seller quotes l. This is accepted only if the buyer is uninformed. So, the utility conditional on the value being in this range is $(1-p_b)l$

If $V \in [(1-p_b)l, l]$, which happens with probability $p_b l$, the seller quotes V, which is always accepted. So, the utility conditional on the value being in this range is the expected value in this range, $\frac{l(2-p_b)}{2}$

If $V \in [l, l]$, which happens with probability $1-l$, the seller quotes l. This is always accepted. So, the utility conditional on the value being in this range is l

So, the expected utility of the informed seller is

$$(1-p_b)l(1-p_b)l + \frac{l(2-p_b)}{2}p_b l + l\,(1-l) - c_s$$

Equating this with the utility of the uninformed seller $l(1-lp_b)$ gives

$$l(1-lp_b) = (1-p_b)l(1-p_b)l + \frac{l(2-p_b)}{2}p_b l + l\,(1-l) - c_s$$

which simplifies to

$$c_s = \frac{1}{2}l^2 p_b^2$$

If the equilibria are of the form

$$Q_i = \begin{cases} l & \textit{if } V \in [0,(1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, \frac{l}{p_b}] \\ V & \textit{if } V \in [\frac{l}{p_b}, 1] \end{cases}$$

we have two new ranges of value $V \in [l, \frac{l}{p_b}]$ and $V \in [\frac{l}{p_b}, 1]$

If $V \in [l, \frac{l}{p_b}]$, which happens with probability $\frac{l}{p_b} - l$, the seller quotes l. This is always accepted. So, the utility conditional on the value being in this range is l

If $V \in [\frac{l}{p_b}, 1]$, which happens with probability $1-\frac{l}{p_b}$, the seller quotes V, which is accepted only if the buyer is informed. The expected value in this range is $\frac{l+p_b}{2p_b}$. So, the utility conditional on the value being in this range is $p_b\frac{l+p_b}{2p_b}$

So, the expected utility of the informed seller is

$$(1-p_b)l(1-p_b)l + \frac{l(2-p_b)}{2}p_b l + l\left(\frac{l}{p_b} - l\right) + p_b\frac{l+p_b}{2p_b}\left(1-\frac{l}{p_b}\right) - c_s$$

Equating this with the utility of the uninformed seller $l(1-lp_b)$ gives

$$l(1-lp_b) = (1-p_b)l(1-p_b)l + \frac{l(2-p_b)}{2}p_b l + l\left(\frac{l}{p_b} - l\right) + p_b\frac{l+p_b}{2p_b}\left(1-\frac{l}{p_b}\right) - c_s$$

which simplifies to

$$c_s = \frac{1}{2}l^2p_b^2 + \frac{1}{2}(\sqrt{p_b} - \frac{l}{\sqrt{p_b}})^2$$

G The buyer's cost of hiring the bank

The expected payoff of the informed buyer from hiring the bank or not hiring the bank must be zero.

The informed buyer may face either the uninformed seller, with probability $1-p_s$, or the informed seller with probability p_s.

If the seller is uninformed, he quotes l. The informed buyer accepts it only if $V > l$, which happens with probability $1-l$. His expected utility conditional on accepting the offer is the expected difference between the value V and the payment l conditional on $V \in [l, 1]$, $\frac{1-l}{2}$. So, his ex ante expected utility conditional on the seller being uninformed is $(1-l)\frac{1-l}{2}$.

What if the seller is informed? First consider equilibria of the form

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, 1] \end{cases}$$

If $V \in [0, (1-p_b)l]$, which happens with probability $(1-p_b)l$, the seller quotes l. The informed buyer does not accept this offer. So, the utility conditional on the value being in this range is 0

If $V \in [(1-p_b)l, l]$, which happens with probability $p_b l$, the seller quotes V. The informed buyer accepts this offer, but gets no utility from it since he pays V for an object worth V. So, the utility conditional on the value being in this range is again 0.

If $V \in [l, l]$, which happens with probability $1-l$, the seller quotes l. The informed buyer accepts this offer. So, the utility conditional on the value being in this range is the difference between the expected value in this range and the payment l, $\frac{1-l}{2}$

So, the expected utility of the informed buyer is

$$(1-p_s)(1-l)\frac{1-l}{2} + p_s(1-l)\frac{1-l}{2} - c_b$$

Equating this to 0 yields

$$c_b = \frac{1}{2}(1-l)^2$$

If the equilibria are of the form

$$Q_i = \begin{cases} l & \textit{if } V \in [0, (1-p_b)l] \\ V & \textit{if } V \in [(1-p_b)l, l] \\ l & \textit{if } V \in [l, \frac{l}{p_b}] \\ V & \textit{if } V \in [\frac{l}{p_b}, 1] \end{cases}$$

We have two new ranges of value $V \in [l, \frac{l}{p_b}]$ and $V \in [\frac{l}{p_b}, 1]$

If $V \in [l, \frac{l}{p_b}]$, which happens with probability $\frac{l}{p_b} - l$, the seller quotes l. The informed buyer accepts this offer. So, the utility conditional on the value being in this range is the difference between the expected value in this range and the payment l, $\frac{l}{2}(\frac{1}{p_b} - 1)$

If $V \in [\frac{l}{p_b}, 1]$, which happens with probability $1 - \frac{l}{p_b}$, the seller quotes V. The informed buyer accepts this offer, but gets no utility from it since he pays V for an object worth V. So, the utility conditional on the value being in this range is again 0.

So, the expected utility of the informed buyer is

$$(1-p_s)(1-l)\frac{1-l}{2} + p_s\left(\frac{l}{2}(\frac{1}{p_b} - 1)(\frac{l}{p_b} - l)\right) - c_b$$

Equating this to 0 yields

$$c_b = \frac{1}{2}(1-l)^2 + \frac{1}{2}p_s\left(\frac{l^2}{p_b}(\frac{1}{p_b} - 2) + 2l - 1\right)$$

H Seller's contract with the advisory

Minimise the expected payment to the bank

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int_{(1-p_b)l}^{l} w(V)\,dV + \int_{\frac{l}{p_b}}^{1} w(V)\,dV - c$$

subject to the constraints

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int_{(1-p_b)l}^{l} w(V)\,dV + \int_{\frac{l}{p_b}}^{1} w(V)\,dV - c \geq (1-p_b l)w(l)$$

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int_{(1-p_b)l}^{l} w(V)\,dV + \int_{\frac{l}{p_b}}^{1} w(V)\,dV - c \geq (1-Vp_b)w(V) \ \textit{if}\ V \in [(1-p_b)l, l]$$

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int_{(1-p_b)l}^{l} w(V)\,dV + \int_{\frac{l}{p_b}}^{1} w(V)\,dV - c \geq p_b(1-V)w(V) \ \textit{if}\ V \in [\frac{l}{p_b}, 1]$$

We solve this for the modified uniform distribution U_ϵ introduced in Section 4.4. Under this distribution, the problem is modified to

Minimise the expected payment to the bank

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int\limits_{(1-p_b)l}^{l} w(V)\,dV + p_b \int\limits_{\frac{l}{p_b}}^{1-\epsilon} w(V)\,dV + p_b\epsilon w(1-\epsilon) - c$$

subject to the constraints

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int\limits_{(1-p_b)l}^{l} w(V)\,dV + p_b \int\limits_{\frac{l}{p_b}}^{1-\epsilon} w(V)\,dV + p_b\epsilon w(1-\epsilon) - c \geq (1-p_b l)w(l)$$

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int\limits_{(1-p_b)l}^{l} w(V)\,dV + p_b \int\limits_{\frac{l}{p_b}}^{1-\epsilon} w(V)\,dV + p_b\epsilon w(1-\epsilon) - c \geq (1-Vp_b)w(V) \;\; \mathit{if}\; V \in [(1-p_b)l, l]$$

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int\limits_{(1-p_b)l}^{l} w(V)\,dV + p_b \int\limits_{\frac{l}{p_b}}^{1-\epsilon} w(V)\,dV + p_b\epsilon w(1-\epsilon) - c \geq p_b(1-V)w(V) \;\; \mathit{if}\; V \in [\frac{l}{p_b}, 1]$$

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int\limits_{(1-p_b)l}^{l} w(V)\,dV + p_b \int\limits_{\frac{l}{p_b}}^{1-\epsilon} w(V)\,dV + p_b\epsilon w(1-\epsilon) - c \geq p_b\epsilon w(1-\epsilon)$$

The proof is similar to Appendix B. Denote the objective function

$$\left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l) + \int\limits_{(1-p_b)l}^{l} w(V)\,dV + p_b \int\limits_{\frac{l}{p_b}}^{1-\epsilon} w(V)\,dV + p_b\epsilon w(1-\epsilon)$$

by k

The problem reduces to minimizing k subject to the constraints

$$\begin{aligned}
&k - c \geq (1-p_b l)w(l)\\
&k - c \geq (1-Vp_b)w(V) \;\; \mathit{if}\; V \in [(1-p_b)l, l]\\
&k - c \geq p_b(1-V)w(V) \;\; \mathit{if}\; V \in [\frac{l}{p_b}, 1-\epsilon]\\
&k - c \geq p_b\epsilon w(1-\epsilon)
\end{aligned}$$

We now consider minimizing k subject to the weaker constraints

$$\left(\frac{p_b^2 - 2p_b + \frac{1}{p_b}}{1-p_b l}\right) l(k-c) \geq \left(p_b^2 - 2p_b + \frac{1}{p_b}\right) lw(l)$$

$$\int\limits_{(1-p_b)l}^{l} \frac{1}{1-Vp_b}(k-c)\,dV \geq \int\limits_{(1-p_b)l}^{l} w(V)\,dV$$

$$\int\limits_{\frac{l}{p_b}}^{1-\epsilon} \frac{1}{1-V}(k-c)\,dV \geq p_b \int\limits_{\frac{l}{p_b}}^{1-\epsilon} w(V)\,dV$$

$$k - c \geq p_b\epsilon w(1-\epsilon)$$

Now make the constraint even weaker by replacing it with an aggregate constraint which is the sum of all these constraints. If these constraints are added up, the right hand side of the aggregate constraint reduces to k. The aggregate constraint is

$$\left(\frac{p_b^2 - 2p_b + \frac{1}{p_b}}{1 - p_b l} l + \int_{(1-p_b)l}^{l} \frac{1}{1 - V p_b}\, dV + \int_{\frac{l}{p_b}}^{1-\epsilon} \frac{1}{1 - V}\, dV + 1 \right) (k - c) \geq k$$

which simplifies to

$$k \geq c + \frac{1}{\left(\frac{p_b^2 - 2p_b + \frac{1}{p_b}}{1 - p_b l} l + \int_{(1-p_b)l}^{l} \frac{1}{1 - V p_b}\, dV + \int_{\frac{l}{p_b}}^{1-\epsilon} \frac{1}{1 - V}\, dV \right)} c$$

The original problem is thus to minimize k subject to this constraint, which is accomplished by setting

$$k = c + \frac{1}{\left(\frac{p_b^2 - 2p_b + \frac{1}{p_b}}{1 - p_b l} l + \int_{(1-p_b)l}^{l} \frac{1}{1 - V p_b}\, dV + \int_{\frac{l}{p_b}}^{1-\epsilon} \frac{1}{1 - V}\, dV \right)} c$$

The solution to the weaker constraint must be the solution to the stronger constraint if this value is feasible. It is easy to see that the way to make this feasible is to satisfy each of the constraints with equality, thus giving us the contract as

$$w(V) = \begin{cases} k^{'} c \frac{1}{1 - p_b V} & \textit{if } V \in [0, (1 - p_b)l] \\ k^{'} c \frac{1}{p_b(1 - V)} & \textit{if } V \in [\frac{l}{p_b}, 1 - \epsilon] \end{cases}$$

where

$$k^{'} = \frac{1}{\left(\frac{p_b^2 - 2p_b + \frac{1}{p_b}}{1 - p_b l} l + \int_{(1-p_b)l}^{l} \frac{1}{1 - V p_b}\, dV + \int_{\frac{l}{p_b}}^{1-\epsilon} \frac{1}{1 - V}\, dV \right)}$$

$k^{'}$ vanishes as $\epsilon \to 0$ since the denominator contains the term

$$\int_{\frac{l}{p_b}}^{1-\epsilon} \frac{1}{1 - V}\, dV = log(1 - \frac{l}{p_b}) + log(\frac{1}{\epsilon})$$

which $\to infty$ as $\epsilon \to 0$

The expected payment to the bank is given by $k = c(1 + k^{'})$ which $\to c$ as $\epsilon \to 0$

I Misreporting-proofness

Each row in the table below corresponds to the value discovered by the bank falling in the interval in column 1. The second column is the offer made by the seller. The third column gives the bank's utility if he reports truthfully and the following columns the utility if he misreports to any of the other intervals.

Value lies in	Offer	Bank's Utility	$[0,(1-p_b)l]$	$[(1-p_b)l,l]$	$[l,\frac{l}{p_b}]$	$[\frac{l}{p_b},1]$
$V\in[(1-p_b)l,l]$	V	$w(V)$	$(1-p_b)w(l)$	$-$	$(1-p_b)w(l)$	0
$V\in[l,\frac{l}{p_b}]$	l	$w(l)$	$w(l)$	$w(V^{'})$	$-$	0
$V\in[\frac{l}{p_b},1]$	V	$p_bw(V)$	$w(l)$	$w(V^{'})$	$w(l)$	$-$

From row 1, to avoid misrpeorting, $w(V)\geq(1-p_b)w(l)$ has to hold whenever $V\in[(1-p_b)l,l]$.

$$\begin{aligned}(1-p_b)w(l) &= (1-p_b)\frac{w(V)(1-p_bV)}{1-p_bl} \textit{ since, in this range, } w(V)(1-p_bV)=w(l)(1-p_bl)\\ &= w(V)(1-p_bV)\frac{(1-p_b)}{1-p_bl}\end{aligned}$$

which is $< w(V)$ since other terms are less than 1.

From row 2, to avoid misrpeorting, $w(l)\geq w(V^{'})$ which is satisfied for $V^{'}\in[(1-p_b)l,l]$ since $w(V)=k^{'}c\frac{1}{1-p_bV}$ if $V\in[0,(1-p_b)l]$

From row 3, which is the last interval to be checked, misreporting is avoided if $p_bw(V)\geq w(l)$. But

$$\begin{aligned}p_bw(V) &= \frac{k^{'}c}{1-V} \text{ if } V\in[\frac{l}{p_b},1]\\ &\geq \frac{k^{'}c}{1-p_bV}\\ &\geq \frac{k^{'}c}{1-p_bl}\end{aligned}$$

Hence, misreporting is avoided in all intervals.

J Seller's contract with the advisory for "lVl" equilibria

The proof is similar to that in Appendix H above.

The significant difference is that there are only 3 intervals to consider now. If the intermediary reports l without putting in effort, the transaction goes through with probability $(1-p_b)(1-p_b)l+(1-l)$ or $1+lp_b(p_b-2)$

Denote the objective function

$$(1+p_bl(p_b-2))\,w(l)+\int\limits_{(1-p_b)l}^{l} w(V)dV$$

by k

The problem reduces to minimizing k subject to the constraints

$$k - c \geq (1 - p_b l) w(l)$$
$$k - c \geq (1 - V p_b) w(V) \;\; if \; V \in [(1 - p_b) l, l]$$

We now consider minimizing k subject to the weaker constraints

$$\frac{1 + p_b l(p_b - 2)}{1 - p_b l}(k - c) \geq (1 + p_b l(p_b - 2))\, w(l)$$
$$\int_{(1-p_b)l}^{l} \frac{1}{1 - V p_b}(k - c)\, dV \geq \int_{(1-p_b)l}^{l} w(V)\, dV$$

Now make the constraint even weaker by replacing it with an aggregate constraint which is the sum of all these constraints. If these constraints are added up, the right hand side of the aggregate constraint reduces to k. The aggregate constraint is

$$\left(\frac{1 + p_b l(p_b - 2)}{(1 - p_b l)} + \int_{(1-p_b)l}^{l} \frac{1}{1 - V p_b} dV \right) (k - c) \geq k$$

which simplifies to

$$k \geq c + \frac{1}{\left(\frac{1 + p_b l(p_b - 2)}{(1 - p_b l)} + \int_{(1-p_b)l}^{l} \frac{1}{1 - V p_b} dV - 1 \right)} c$$

The original problem is thus to minimize k subject to this constraint, which is accomplished by setting

$$k = c + \frac{1}{\left(\frac{1 + p_b l(p_b - 2)}{(1 - p_b l)} + \int_{(1-p_b)l}^{l} \frac{1}{1 - V p_b} dV - 1 \right)} c$$

Note that

$$\begin{aligned}
\frac{1 + p_b l(p_b - 2)}{(1 - p_b l)} + \int_{(1-p_b)l}^{l} \frac{1}{1 - V p_b} dV &\geq \frac{1 + p_b l(p_b - 2)}{(1 - p_b l)} + \int_{(1-p_b)l}^{l} \frac{1}{1 - l p_b} dV \\
&= \frac{1 + p_b l(p_b - 2)}{(1 - p_b l)} + \frac{p_b l}{(1 - l p_b)} \\
&= \frac{1 - p_b l(1 - p_b)}{1 - p_b l} \\
&\geq 1
\end{aligned}$$

so that the denominator is ≥ 0

Simplifying the integral yields

$$k = c + \frac{1}{\left(\frac{1+p_b l(p_b-2)}{(1-p_b l)} + \frac{1}{p_b} log\left(\frac{1-p_b l(1-p_b)}{1-lp_b}\right) - 1\right)} c$$

The solution to the weaker constraint must be the solution to the stronger constraint if this value is feasible. It is easy to see that the way to make this feasible is to satisfy each of the constraints with equality, thus giving us the contract as

$$w(V) = k^{''} c \frac{1}{1 - p_b V} \ \ \textit{if}\ V \in [0, (1-p_b)l]$$

where $k^{''}$ is the constant

$$\frac{1}{\left(\frac{1+p_b l(p_b-2)}{(1-p_b l)} + \frac{1}{p_b} log\left(\frac{1-p_b l(1-p_b)}{1-lp_b}\right) - 1\right)}$$

The expected payment to the bank is $c(1 + k^{''})$ Is this increasing in p_b for any given l?

The misreporting-proofness obtains as a simpler case of Appendix I above with one less interval to check for misreporting.

K Probability of the transaction being a success

Informed seller and informed buyer

Seller offers V, buyer accepts V, so the transaction always goes through.

Uninformed seller and uninformed buyer

Seller offers l, buyer accepts l, so the transaction always goes through.

Informed seller and uninformed buyer

Seller offers

$$Q_i = \begin{cases} l & \textit{if}\ V \in [0, (1-p_b)l] \\ V & \textit{if}\ V \in [(1-p_b)l, l] \\ l & \textit{if}\ V \in [l, \frac{l}{p_b}] \\ V & \textit{if}\ V \in [\frac{l}{p_b}, 1] \end{cases}$$

Buyer accepts upto l

The transaction goes through in all cases except $V \in [\frac{l}{p_b}, 1]$ i.e. with probability $1 - (1 - \frac{l}{p_b})$ or $\frac{l}{p_b}$

Unformed seller and uninformed buyer

Seller offers l, buyer accepts till V

Transaction goes through if $V \geq l$ i.e. with probability $1 - l$

So, considering all the cases, the transaction goes through with probability

$$p_s p_b(1) + (1-p_s)(1-p_b)(1) + p_s(1-p_b)(\frac{l}{p_b}) + (1-p_s)(p_b)(1-l)$$

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