Reputation Effects of Disclosure[*, **]

Radhika Lunawat[†]

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[†]Department of Accounting, Opus College of Business, University of St Thomas, 1000 LaSalle Avenue, Mail# TMH 443, Minneapolis, MN 55403; e-mail: rlunawat@stthomas.edu.

Abstract

This paper analyzes the role of disclosure in building reputation for being trustworthy. I allow for information asymmetry in a finitely repeated sender-receiver game and solve for sequential equilibrium to show that if there are some trustworthy managers who always disclose their private information (or there is simply a belief that there are some trustworthy managers), then a rational manager will choose to disclose her private information in an attempt to earn a reputation for being trustworthy. However, except under certain circumstances, the rational manager will switch from mimicking to be the trustworthy manager with probability one to mimicking to be the trustworthy manager with a certain probability strictly less than one. I define two regimes, in both of which there is information asymmetry but only one allows for disclosure in the form of communication of private information. I show that the regime with disclosure allows for a greater time of mimicking with probability one and this additional reputation building opportunity results in higher probability of investment and higher probability of high returns on investment. I also show that a manager will prefer the regime without disclosure while an investor will prefer the regime with disclosure.

Keywords. Disclosure, Reputation, Investment, Trust.

1. Introduction

"In the United States, home to some of the largest corporate collapses, trust in business collapsed as well, dropping 20 percentage points over the course of one year. With only 38% of informed public in the United States trusting business today, levels are the lowest they have been in the Barometer's tracking history – even lower than in the wake of Enron and the dot-com bust…For U.S. businesses, this downturn marks a stark reversal from the steady uptick in trust of the last five years…."

– Edelman Trust Barometer 2009

"Something important was destroyed in the last few months. It is an asset crucial to production…. While this asset does not enter standard national account statistics or standard economic models, it is so crucial to development that its absence – according to Nobel laureate Kenneth Arrow – is the cause of much of the economic backwardness in the world. This asset is **TRUST**….Without trust, co-operation breaks down, financing breaks down and investment stops. One can bomb a country back to the Stone Age, destroy much of its human capital, and eliminate its political institution. But, if trust persists, the country may be able to right itself in just a few years, as in Germany and Japan after World War II. Conversely, you can endow a country with all the greatest natural resources but if there is no trust, there is no progress."

– Sapienza and Zingales, 2009

In the backdrop of the financial meltdown, trust and corporate reputation have been a huge casualty. As businesses launch what print media refers to as the "Great Trust Offensive (BusinessWeek, Sept 28th 2009)" to reclaim their lost trust and reputation in a bid to win back consumer confidence, a natural question that arises is the role financial disclosure may play in facilitating this trust. Extant literature in accounting attributes to financial disclosure a role in reducing the information asymmetry component of cost of capital (Verrecchia, 2001 and Dye, 2001). Another strand of literature explicates the role

financial disclosure plays in real investment and managerial decisions of a firm (Kanodia, 2006). This work establishes an additional role of financial disclosure, namely that of building reputation for being trustworthy.

While anecdotally it seems that voluntary disclosure should provide opportunities for reputation building, there are subtleties in the relation between disclosure and reputation that are not so obvious. For example, I show that full disclosure will be sub-optimal and that a rational manager will (except under certain specific circumstances) choose full disclosure with a certain probability strictly less than one in order to ensure credibility of her disclosure in instances where she chooses to disclose. The only exception will be where the investor's belief about a manager's trustworthiness is exceptionally high and then the manager will choose full disclosure to maintain the belief at that high level.

I examine the reputation building role of disclosure in a sender–receiver game, where the sender / investor is endowed with some wealth and chooses whether or not to invest it in a receiver / manager. The receiver is endowed with some production technology because of which she channels the investment to productive uses. Depending on the state of nature that obtains, the production may lead to a high or low yield. The manager may be trustworthy or untrustworthy. A trustworthy manager will choose to share a fair proportion of the yield with the investor whereas an untrustworthy manager's action will be guided by her self-interest. This game is repeated finitely to allow for reputation building.

I define two regimes, namely disclosure regime and no disclosure regime. In both regimes, the manager learns the state of nature but the investor does not. However, in the disclosure regime, the manager is allowed to share her private knowledge of the state of nature with the investor. The finitely repeated nature of the game in both regimes allows for reputation building. I solve for a sequential equilibrium in both regimes and examine

whether the ability to disclose private information provides reputation building opportunities over and above those provided by the institution of dividend payment.

A question that arises is whether additional reputation building opportunities provided by disclosure will result in higher investment and higher return in economies. This paper sheds light on that question by comparing the probability of investment and the probability of high returns on investment in the disclosure and no disclosure regimes.

While disclosure may result in higher investment and higher return on investment and may therefore be socially optimal, do a manager and an investor both benefit from higher disclosure? That is, given a choice will a manager opt for higher disclosure and will an investor want her to do so? This paper examines the question by comparing an investor's and a manager's payoffs in the disclosure and no disclosure regimes.

The sender-receiver game I define derives from the "investment game" first studied experimentally in Berg, Dickhaut and McCabe, 1995. In this investment game a sender is endowed with 10 units of wealth and decides how much of this endowment to send to a receiver. The amount sent by the sender is tripled before it reaches the receiver. The receiver decides how much of this tripled amount to keep and how much to send back. Additionally, Dickhaut, Hubbard, Lunawat and McCabe, 2008 study a repeated investment game where subjects play the investment game for 2 periods. Both studies find evidence of trust, but trust is enhanced when the game is repeated. Specifically, Dickhaut et al find that the amount returned by the receiver in period 1 is significantly larger than the amount returned by the receiver in period 2, suggesting that in period 1 rational agents try to develop a reputation for being altruistic or trustworthy. Dickhaut, Lunawat, Waymire and Xin, 2008 take the repeated investment game setting and replace the multiplier of 3 by a stochastic multiplier. The receiver learns the multiplier but the sender does not allowing for a definition of income (It is the amount received by the receiver before sending something back) in their setting. They examine the relation of

disclosure and non-enforceable contract formation in single-venture settings and compare the results as an economy grows in size and complexity. The question that remains open is of the relation between disclosure and reputation and this works sheds light on that relation.

While the setting derives from the investment game, the equilibrium solution derives from Kreps and Wilson, 1982 and Kreps, Milgrom, Roberts and Wilson, 1982. Kreps and Wilson, 1982 solve a sequential equilibrium for a monopolist entry deterrence game and formally establish the role of reputation in a finitely repeated entry-deterrence game. Kreps, Milgrom, Roberts and Wilson, 1982 solve for a sequential equilibrium in a finitely repeated prisoners' dilemma game. Given the complexity of the equilibrium, Camerer and Weigelt, 1988 play the lender-borrower game in a laboratory setting and find experimental evidence supportive of sequential equilibrium. I solve for a sequential equilibrium in both the disclosure and the no disclosure regimes.

The rest of the paper proceeds as follows. Sections 2 reviews related literature. Sections 3 and 4 respectively define the disclosure and no disclosure regimes and solve for sequential equilibrium in respective regimes. Section 5 compares investment, return and payoffs in the two regimes. Section 6 summarizes and concludes.

2. Literature Review

This paper contributes to the emerging literature looking at the very foundational issues in accounting. Basu, Dickhaut, Hecht, Towry and Waymire, 2009 tests the evolutionary hypothesis developed in Basu and Waymire, 2006 to provide evidence of the role of financial recordkeeping in promoting trade and exchange. Jamal, Maier and Sunder, 2005 contrast the role of voluntary disclosure as a social norm with enforced standards and conventions. This work explores foundational issues regarding the relation between reputation and financial disclosure.

Theoretically, voluntary disclosure has been shown to occur because it is in the best interest of rational agents (e.g. Grossman, 1981 and Dye, 1985a). Disclosure has also been shown to have a co-ordination role in an economy where higher-order beliefs are crucial (Morris and Shin, 2002 and Angeletos and Pavan, 2004). This paper considers a model of reputation formation under different institutional structures of disclosure to show that voluntary disclosure occurs because rational self-interested agents have an incentive to look like altruistic or trustworthy agents.

This paper is related to the strand of literature that looks at the different roles played by disclosure. That literature has been surveyed by Healy and Palepu, 2001; Bushman and Smith, 2001; and Leuz and Wysocki, 2008. Healy and Palepu, 2001 discuss several motives for voluntary disclosure including its role in reducing cost of capital, in reducing the likelihood of undervaluation, in avoiding litigation, in signaling managerial talent and in lowering the cost of private information acquisition. It is also used strategically by managers in receipt of stock-based compensation. Bushman and Smith, 2001 discuss several channels through which financial accounting information affects economic performance. It leads to better project identification, better governance and mitigates adverse selection. Leuz and Wysocki, 2008 discuss the economic costs and benefits of disclosure.

Arrow, 1972; Putnam, 1993; Fukuyama, 1995 and Solow, 1995 have written about the effects of trust on economic activity. The question has been studied empirically by La Porta, Lopez de Silanes, Shleifer and Vishny, 1997; Knack and Keefer, 1997; and Guiso, Sapienza and Zingales, 2004 among others. However, the role of disclosure in facilitating trust and thereby stimulating economic activity has not been analyzed and this paper sheds light on that question.

Reputation for truthful reporting has been studied experimentally (e.g. King, 1996) and reputation for informative reporting has been studied using archival data (e.g. Healy and

Palepu, 1993). The role of information disclosure in markets has been examined experimentally in the context of market efficiency studies (e.g. Bloomfield, 1996 and Bloomfield and Libby, 1996) and game-theoretic strategic disclosures (e.g. King and Wallin, 1991, 1995). The role of information reporting or disclosure in developing reputation for being trustworthy has not been studied and this paper sheds light on this role.

Trust has been shown to induce reciprocity (e.g. Berg, Dickhaut and McCabe, 1995) and foster economic exchange. The role of reputation versus reciprocity in repeated interactions has been explored (e.g. McCabe, Rassenti and Smith, 1996). While these questions have mostly been examined using behavioral theories and human subjects experiments, at a theoretical level, trust has been conceptualized as a strategic attempt to build reputation in a repeated game (e.g. Kreps, Milgrom, Roberts and Wilson, 1982). Dickhaut, Hubbard, Lunawat and McCabe, 2009 explicitly model reputation for being trustworthy while this paper introduces information asymmetry in the model to examine the role of disclosure in building reputation for being trustworthy.

Berg, Dickhaut and McCabe, 1995 use the amount invested by the sender as a measure of trust the sender has in the receiver. The efficacy of this measure in studying trust using the World Values Survey is explored by Glaeser, Laibson, Scheinkman and Soutter, 2000. Sapienza, Toldra and Zingales, 2007 proposes the sender's expectation of the receiver's behavior as a measure of trust and studies the efficacy of their measure in studying trust using the World Values Survey. This paper shows that both the amount invested by the sender and the sender's expectation of the receiver's behavior are higher in the disclosure regime compared to the no disclosure regime.

3. Disclosure Regime

There are two players, A (sender / investor) and B (receiver / manager). Nature moves first and selects B's type to be either trustworthy or untrustworthy. I will define

momentarily what I mean by each type. B knows her type but A does not. The game then proceeds through n periods in each of which the A and B make a sequence of choices. In what follows, the subscript t ($t = 1, 2, \ldots, n$) will be used to denote a period. B chooses whether or not to disclose private information she will learn in the course of the game. A decision to disclose is denoted by $d_t = 1$ and a decision not to disclose is denoted by $d_t = 0$. Note that B is not privy to the private information at the time she makes the choice of whether or not to disclose it. It is information she *will* learn in the course of the game. It is as if B is making a choice of an accounting system – B could choose an accounting system that will generate information that both A and B will learn (by choosing to disclose) or alternatively, B could choose an accounting system that will generate information only B will learn (by choosing not to disclose).

A sees B's disclosure decision, is endowed with $e > 0$ units of wealth and chooses whether or not to invest in B. Regardless of whether or not A chooses to invest, e is common knowledge. That is, both A and B know the amount of wealth A in endowed with. A's decision to invest is denoted by $m_t = e$ and A's decision not to invest is denoted by $m_t = 0$. If A chooses to invest, then the amount e is multiplied by a multiplier λ_t before B receives it. $\lambda_t \in \{l, h\}$ and is equally likely to be either l or h in every period. $1 \leq l < 2 < h$, $l + h > 4$.

Now B receives $e\lambda_t$ and learns λ_t. However, A learns λ_t only if B had earlier chosen to disclose her private information. That is, if B had chosen an accounting system that generates information both A and B learn, then A learns λ_t. Otherwise, if B had chosen an accounting system that generates information only B learns, then A does not learn λ_t. In this sense, λ_t is B's private information – she always learns the realized value of λ_t but A's knowledge of λ_t is dependent on B's choice of accounting system.

After B receives $e\lambda_t$, she chooses to send back k_t to B. If $\lambda_t = l$, $k_t \in \{0, el / 2\}$. If $\lambda_t = h$, $k_t \in \{0, el / 2, eh / 2\}$. A receives k_t and B keeps the residual $e\lambda_t - k_t$.

A trustworthy B is defined as one that always chooses to disclose (d_t = 1) and always chooses to return returns half of what she receives (That is, if $\lambda_t = l$, she chooses $k_t = el$ / 2 and if $\lambda_t = h$, she chooses $k_t = eh$ / 2). An untrustworthy B is defined as a B that is not trustworthy. The multiplied amount ($e\lambda_t$) may be thought of as the gross income of the firm comprising A and B and the amount sent back by B (k_t) may be thought of as the dividend B pays to A. Risk neutrality, additively separable utility and no time discounting are assumed.

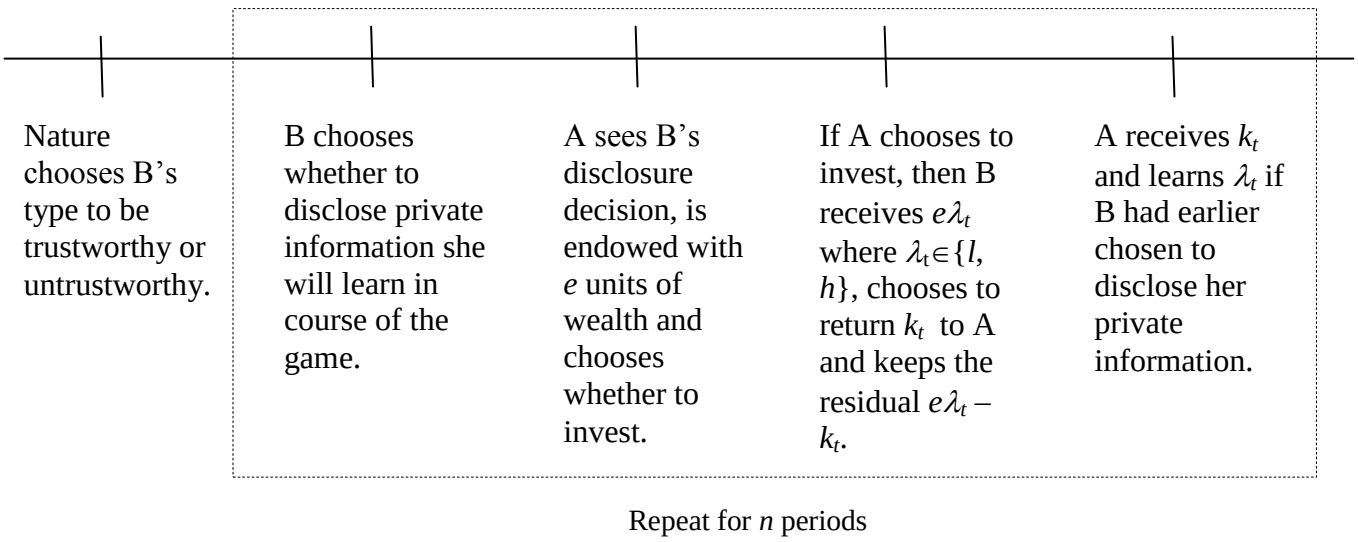

Figure 1A – Timeline of Disclosure Regime

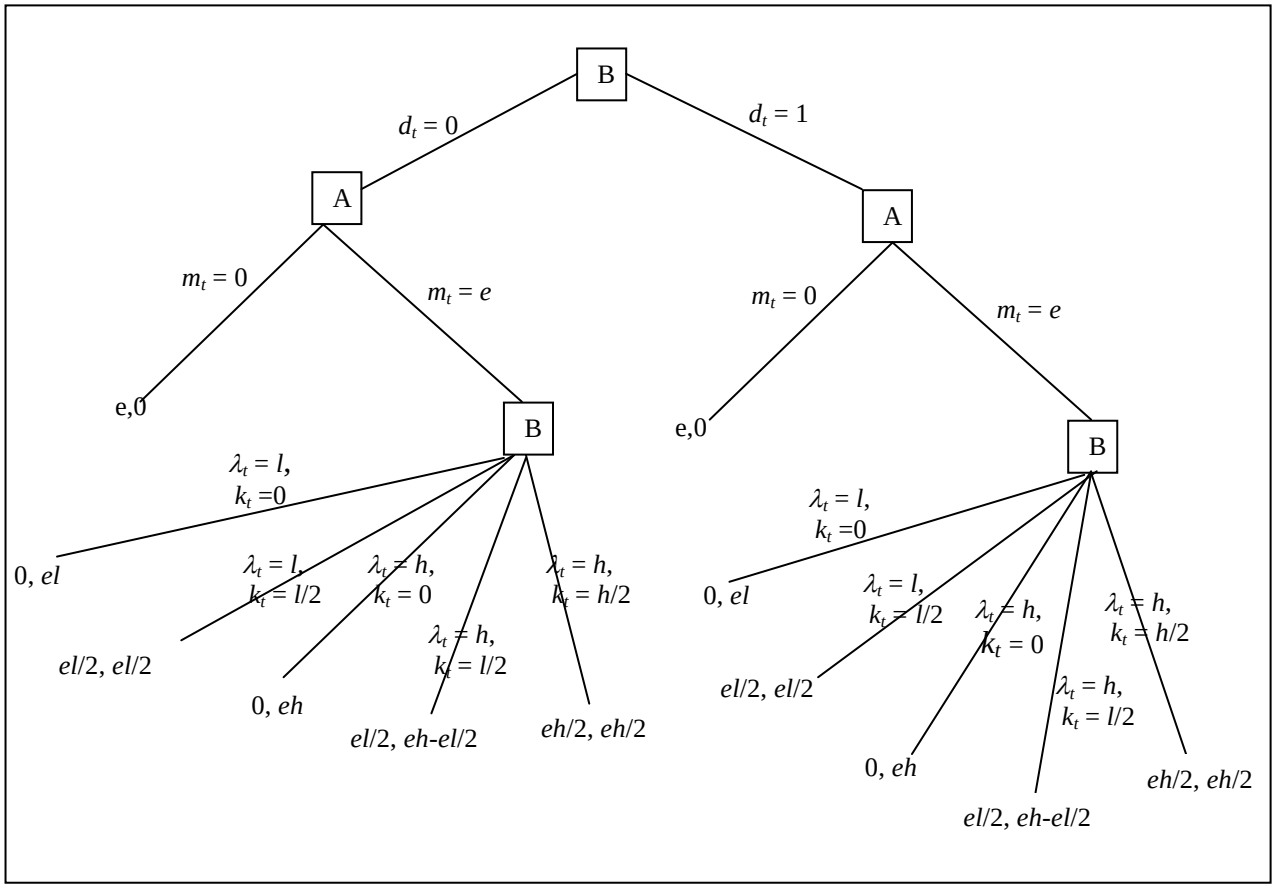

Figure 1B – Extensive Form Representation of the Stage Game in Disclosure Regime

A sequential equilibrium of this game is defined as follows. An equilibrium comprises a strategy for each player and for each period t a function P_t^D that takes the history of moves up to period t into numbers in [0 , 1] such that :

(i) Starting from any point in the game where it is B's move, B's strategy is a best response to A's strategy.

(ii) Starting from any point in the game where it is A's move, A's strategy is a best response to B's strategy given that A believes B is trustworthy with probability $P_t^D(h_t)$.

(iii) The game begins with $P_0^D = \delta$.

(iv) Each P_t^D is computed from P_{t-1}^D and B's strategy, using Bayes' rule whenever possible.

I will first define the function P_t^D. But before defining P_t^D, note that the set of subscripts for P_t^D is different from the set of subscripts for each of d_t, m_t, λ_t and k_t. While each of d_t, m_t, λ_t and k_t is subscripted using the set {1, 2, …., n}, P_t^D is subscripted using the set {0, 1, 2, …., n}. A enters the game with $P_0^D = \delta$. She sees d_1 and updates to P_1^D before choosing m_1. Since A's updating from P_0^D to P_1^D occurs before her choice of investment for the first period 1 (m_1), this necessitates introduction of an additional element (namely, '0') in the set of subscripts for P_t^D.

Set $P_0^D = \delta$. If B fails to disclose in period 1, then $P_1^D = 0$ and if B discloses in period 1, then $P_1^D = P_0^D = \delta$. For $t > 1$, if the history of play up to period t either includes any instance where B fails to disclose or includes any instance where B fails to return half of what she receives, set $P_t^D = 0$. If B has always chosen to disclose and has always returned half of what she receives, then set $P_t^D = \max\left((2/E(\lambda_t))^{n-t+1}, \delta\right)$. If A has never invested, set $P_t^D = \delta$. In other words, P_t^D may be defined as:

(i) If B does not disclose in period 1 (that is, B chooses $d_1 = 0$), then $P_1^D = 0$ and if B discloses in period 1 (that is, B chooses $d_1 = 1$), then $P_1^D = P_0^D = \delta$.

(ii) For $t > 1$, if A does not invest in period t-1 (that is, A chooses $m_{t-1} = 0$), then $P_t^D = P_{t-1}^D$.

(iii) For $t > 1$, if A invests in period t-1 (that is, A chooses $m_{t-1} = e$) and B discloses in period t and B returns half of what she receives in period t-1 and $P_{t-1}^D > 0$ (that is, B chooses $d_t = 1$ and $k_{t-1} = e\lambda_{t-1}/2$), then $P_t^D = \max\left((4/(l+h))^{n-t+1}, \delta\right)$.

(iv) For $t > 1$, if A invests in period *t-1* (that is, A chooses $m_{t-1} = e$) but B either does not disclose in period *t* or B does not return half of what she receives in period *t-1*, (that is, B chooses either $d_t = 0$ or $k_{t-1} = 0$) then $P_t^D = 0$.

(v) If $P_{t-1}^D = 0$, then $P_t^D = 0$.

Now, I will describe the strategies of A and untrustworthy B in terms of P_t^D . Note that by definition, a trustworthy B always chooses to disclose and always chooses to return half of what she receives. An untrustworthy B's strategy depends on *t* and P_t^D. The strategy may be outlined as:

(i) If $\delta > (4/(l+h))^n$, then $d_1 = 1$.

(ii) If $t = n$, B chooses to disclose but does not return anything. That is, B chooses $d_n = 1$ and $k_n = 0$.

(iii) If $t < n$ and $P_t^D \geq (4/(l+h))^{n-t}$, B chooses to disclose and chooses to return half of what she receives. That is, B chooses $d_{t+1} = 1$ and $k_t = e\lambda_t / 2$.

(iv) If $t < n$ and $P_t^D < (4/(l+h))^{n-t}$, then with a probability $S_t^D = P_t^D(1-(4/(l+h))^{n-t})/(4/(l+h))^{n-t}(1-P_t^D)$, B chooses to return half of what she receives in period *t*. With probability $1-S_t^D$, B chooses not to return anything in period *t*. In the instance where B returns half of what she receives in period *t*, she chooses to disclose in period *t+1*. That is, with a probability S_t^D, B chooses $d_{t+1} = 1$ and $k_t = e\lambda_t / 2$ and with a probability $1-S_t^D$, B chooses $k_t = 0$. Note that if $P_t^D = 0$, then $S_t^D = 0$ and if $P_t^D = (4/(l+h))^{n-t}$, then $S_t^D = 1$.

A's strategy may be outlined as:

(i) If $P_t^D < (4/(l+h))^{n-t+1}$, A chooses not to invest, that is, $m_t = 0$.

(ii) If $P_t^D > (4/(l+h))^{n-t+1}$, A chooses to invest, that is, $m_t = e$.

(iii) If $P_t^D = (4/(l+h))^{n-t+1}$, with a probability $V_t^D = \lambda_{t-1}/(l+h)$, A chooses to invest and with a probability $1-V_t^D$, A chooses not to invest. That is, with a probability V_t^D, A chooses $m_t = e$ and with a probability $1-V_t^D$, A chooses $m_t = 0$.

Proposition 1. The strategies and beliefs described above constitute a sequential equilibrium.

Proof. There are two things to verify. First, A's beliefs must be consistent with B's strategy, in the sense that Bayes Rule hold wherever applicable. Second, starting from any information set in the game no player has a profitable deviation, that is, no player has an incentive to deviate.

I will first verify the criterion of Bayesian consistency. If B chooses $d_1 = 0$, then it must be the case that B is untrustworthy and $P_{t+1}^D = 0$. If A does not invest in period t, then she does not learn anything about B's type and therefore $P_{t+1}^D = P_t^D$. If $P_t^D \geq (4/(l+h))^{n-t}$, untrustworthy B chooses $d_{t+1} = 1$ and $k_t = e\lambda_t/2$. If $P_t^D = 0$, untrustworthy B chooses $k_t = 0$. In both cases, Bayes rule implies $P_{t+1}^D = P_t^D$. If $P_t^D \in (0,(4/(l+h))^{n-t})$, then with a probability S_t^D, B chooses $d_{t+1} = 1$ and $k_t = e\lambda_t/2$ and with a probability $1-S_t^D$, B chooses $k_t = 0$. In the instance, B chooses $k_t = 0$, it must be the case B is untrustworthy and $P_{t+1}^D = 0$. In the instance, B returns half of what she receives in period t, Bayes rule requires:

$$P_{t+1}^D = \text{Prob}(\text{B is trustworthy} \mid \text{B returns half of what she receives})$$

$$= \frac{\text{Prob}(\text{B is trustworthy and returns half of what she receives})}{\text{Prob}(\text{B returns half of what she receives})}$$

$$= \frac{\text{Prob (B returns half | B is trustworthy) Prob (B is trustworthy)}}{\left(\begin{array}{l}\text{Prob (B returns half | B is trustworthy) Prob (B is trustworthy) +} \\ \text{Prob (B returns half | B is untrustworthy) Prob (B is untrustworthy)}\end{array}\right)}$$

$$= \frac{1.P_t^D}{1.P_t^D + S_t^D(1-P_t^D)}$$

$$= \left(\frac{4}{l+h}\right)^{n-t}$$

This satisfies the criterion of Bayesian consistency.

I will now verify that A's strategy is optimal. A's payoff from not investing (choosing m_t = 0) = e. If $P_t^D \geq (4/(l+h))^{n-t}$, untrustworthy B chooses $k_t = e\lambda_t/2$ and then A's expected payoff from investing (choosing $m_t = e$) $= (e/2)((l+h)/2)$. Since $(l + h) > 4$, A's expected payoff from choosing $m_t = e$ is greater than A's payoff from choosing m_t = 0. Therefore, it is optimal for A to choose $m_t = e$.

If $(4/(l+h))^{n-t+1} < P_t^D < (4/(l+h))^{n-t}$, then with a probability S_t^D, untrustworthy B chooses $k_t = e\lambda_t/2$ and with a probability $1-S_t^D$, untrustworthy B chooses $k_t = 0$. Therefore, A's expected payoff from investing (choosing $m_t = e$) $= e/2((l+h)/2)(P_t^D + (1-P_t^D)S_t^D)$. Inserting $S_t^D = P_t^D(1-(4/(l+h))^{n-t})/(4/(l+h))^{n-t}(1-P_t^D)$ in the expression for A's expected payoff and simplifying the expression yields – A's expected payoff $= eP_t^D((l+h)/4)^{n-t+1}$. Since $P_t^D > (4/(l+h))^{n-t+1}$, A's expected payoff from choosing $m_t = e$ is greater than A's payoff from choosing m_t = 0. Therefore, it is optimal for A to choose $m_t = e$.

If $P_t^D < (4/(l+h))^{n-t+1}$, then with a probability S_t^D, untrustworthy B chooses $k_t = e\lambda_t/2$ and with a probability $1-S_t^D$, untrustworthy B chooses $k_t = 0$. Note

$P_t^D < (4/(l+h))^{n-t+1} < (4/(l+h))^{n-t}$. Now, A's expected payoff from investing (choosing $m_t = e$) $= e/2((l+h)/2)(P_t^D + (1-P_t^D)S_t^D)$. Once again, inserting $S_t^D = P_t^D(1-(4/(l+h))^{n-t})/(4/(l+h))^{n-t}(1-P_t^D)$ in the expression for A's expected payoff and simplifying the expression yields – A's expected payoff $= eP_t^D((l+h)/4)^{n-t+1}$. However, since $P_t^D < (4/(l+h))^{n-t+1}$, A's expected payoff from choosing $m_t = e$ is less than A's payoff from choosing $m_t = 0$. Therefore, it is optimal for A to choose $m_t = 0$.

If $P_t^D = (4/(l+h))^{n-t+1}$ then A's expected payoff from investing (choosing $m_t = e$) $= e/2((l+h)/2)(P_t^D + (1-P_t^D)S_t^D)$. Now $P_t^D = (4/(l+h))^{n-t+1} < (4/(l+h))^{n-t}$. Recall that if $P_t^D < (4/(l+h))^{n-t}$, then with a probability S_t^D, untrustworthy B chooses $k_t = e\lambda_t/2$ and with a probability $1-S_t^D$, untrustworthy B chooses $k_t = 0$. Once again, inserting $S_t^D = P_t^D(1-(4/(l+h))^{n-t})/(4/(l+h))^{n-t}(1-P_t^D)$ in the expression for A's expected payoff and simplifying the expression yields – A's expected payoff $= eP_t^D((l+h)/4)^{n-t+1}$. However, since $P_t^D = (4/(l+h))^{n-t+1}$, A's expected payoff from choosing $m_t = e$ is equal to A's payoff from choosing $m_t = 0$. At this point, A is indifferent between choosing $m_t = e$ and choosing $m_t = 0$. Therefore, with a probability V_t^D, A chooses $m_t = e$ and with a probability $1-V_t^D$, A chooses $m_t = 0$. The choice of the probability V_t^D is such that it makes B indifferent between choosing $k_{t-1} = e\lambda_{t-1}/2$ and choosing $k_{t-1} = 0$. To verify B's indifference at this point, note that B's payoff from choosing $k_{t-1} = 0$ is $e\lambda_{t-1}$ and B's expected payoff from choosing $k_{t-1} = e\lambda_{t-1}/2$ is $e\lambda_{t-1}/2 + eV_t^D(l+h)/2$. Since $V_t^D = \lambda_{t-1}/(l+h)$, B's expected payoff from choosing $k_{t-1} = 0$ equals B's payoff from choosing $k_{t-1} = e\lambda_{t-1}/2$.

Finally, I need to verify that untrustworthy B's strategy is optimal. $d_1 = 0$ implies that B must be untrustworthy ($P_1^D = 0$) and therefore, A chooses $m_1 = 0$. $d_1 = 1$ implies that B may be trustworthy ($P_1^D = P_0^D = \delta$) and the if $\delta > (4/(l+h))^n$, A will invest[1]. Consequently when $\delta > (4/(l+h))^n$, it is optimal for B to choose $d_1 = 1$. If $t = n$, B's payoff from choosing $k_n = 0$ is $e\lambda_n$ while B's payoff from choosing $k_n = e\lambda_n / 2$ is $e\lambda_n / 2$ making it optimal for B to choose $k_n = 0$.

If $t < n$ and $P_t^D > (4/(l+h))^{n-t}$, then A chooses $m_{t+1} = e$. Thus, B's payoff from choosing $k_t = 0$ is $e\lambda_t$ while B's expected payoff from choosing $k_t = e\lambda_t / 2$ is $e\lambda_t / 2 + eE(\lambda_{t+1}) = e\lambda_t / 2 + e(l+h)/2$. Clearly, it is optimal for B to choose $k_t = e\lambda_t / 2$. If $P_t^D = (4/(l+h))^{n-t}$, then B's expected payoff from choosing $k_t = e\lambda_t / 2$ is $e\lambda_t / 2 + eE(\lambda_{t+1})V_{t+1}^D = e\lambda_t / 2 + e((l+h)/2)(\lambda_t /(l+h)) = e\lambda_t$. At this point, B is indifferent between choosing $k_t = 0$ and choosing $k_t = e\lambda_t / 2$. Therefore, B chooses $k_t = 0$ with such a probability (and $k_t = e\lambda_t / 2$ with complementary probability) that makes A indifferent between choosing $m_{t+1} = e$ and choosing $m_{t+1} = 0$. A is indifferent between choosing $m_{t+1} = e$ and choosing $m_{t+1} = 0$ when $P_{t+1}^D = (4/(l+h))^{n-t}$. Now, $P_{t+1}^D = P_t^D = (4/(l+h))^{n-t}$ requires B choose $k_t = e\lambda_t / 2$ with probability 1.

Now I am required to verify that if $t < n$ and $P_t^D < (4/(l+h))^{n-t}$, then with a probability $S_t^D = P_t^D(1-(4/(l+h))^{n-t})/(4/(l+h))^{n-t}(1-P_t^D)$, B chooses to return half of what she receives in period t. Suppose instead that B chooses $k_t = e\lambda_t / 2$ with a probability $S_t^D + \varepsilon$ for some $\varepsilon > 0$ such that $S_t^D + \varepsilon \le 1$. Then, the posterior probability P'_{t+1} is given by $P_t / \left(P_t + (S_t + \varepsilon)(1-P_t)\right)$. Now, $P'_{t+1} < P_{t+1}^D = (4/(l+h))^{n-t}$. Therefore, A chooses

[1] If $\delta \le (4/(l+h))^n$, A will not invest making B indifferent between $d_1 = 0$ and $d_1 = 1$.

m_{t+1} = 0. This implies the sum of B's expected payoff in periods t and (t+1) = $e\lambda_t(1-S_t-\varepsilon)+e(\lambda_t/2)(S_t+\varepsilon)$. In contrast, if B chooses $k_t=\lambda_t/2$ with a probability S_t^D then her expected payoff = $E_t\left[e\lambda_t(1-S_t)+S_t(e\lambda/2_t+eV_{t+1}\lambda_{t+1})\right]=e\lambda_t$. Since B's expected payoff from choosing $k_t=e\lambda_t/2$ with a probability S_t^D is higher than her expected payoff from choosing $k_t=e\lambda_t/2$ with a probability $S_t^D+\varepsilon$, she will not choose $k_t=e\lambda_t/2$ with a probability $S_t^D+\varepsilon$. Similarly, it can be shown that B will not choose $k_t=e\lambda_t/2$ with a probability $S_t^D-\varepsilon$ for some $\varepsilon>0$ such that $S_t^D-\varepsilon>0$. The only case remaining to be ruled out is one where B choose $k_t=e\lambda_t/2$ with a probability $S_t^D-\varepsilon$ for some $\varepsilon>0$ such that $S_t^D-\varepsilon=0$. That is, the case where B never chooses $k_t=e\lambda_t/2$. In this case, the posterior probability $P''_{t+1}=1$. That is, given a return of $k_t=e\lambda_t/2$, A believes with probability 1 that B is trustworthy. This strategy can never constitute an equilibrium because a profitable deviation for an untrustworthy B is to mimic to be the trustworthy type and choose $k_t=e\lambda_t/2$ and then because $P''_{t+1}=1$, A will chose $m_{t+1}=e$.

This completes the proof that the set of beliefs and strategies described earlier constitutes a sequential equilibrium.

Reputation Threshold. P_{t+1}^D must be at least $(4/(l+h))^{n-t+1}$ for A to invest with some probability. This threshold $(4/(l+h))^{n-t+1}$ may be thought of as B's reputation. B starts mixed strategy play in some period *t* to ensure that A's updated (period *t+1*) belief about B's type is exactly on the threshold. This threshold increases in *t*. That is, B's reputation over time must be progressively higher for A to invest. For example, if *n* = 10, *l* = 1 and *h* = 5, then this reputation threshold may be graphed as in Figure 2A.

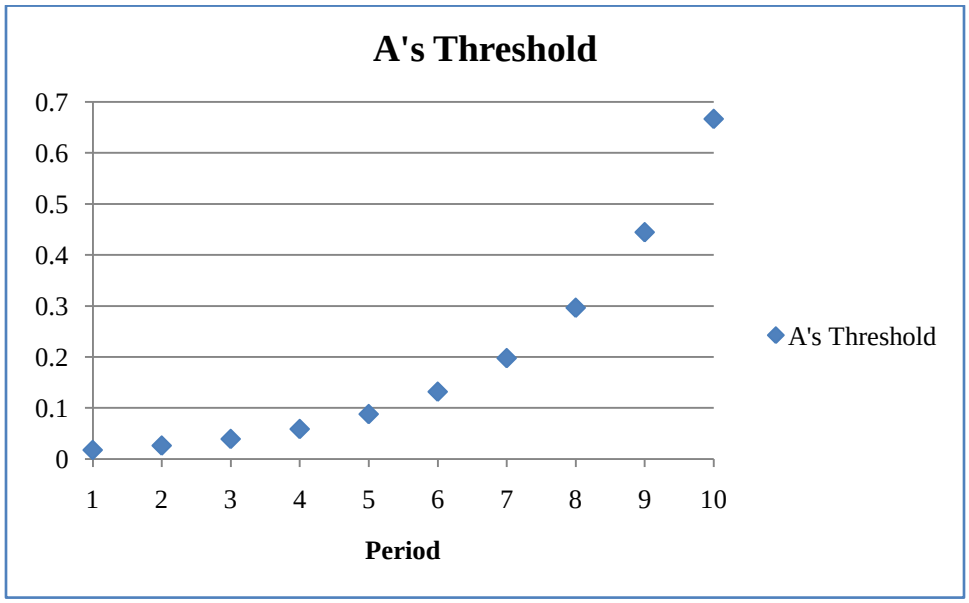

Figure 2A – Reputation Threshold at which A invests with some probability when n = 10, l = 1 and h = 5

Full Disclosure Strategy. What happens if untrustworthy B follows a strategy of choosing $d_t = 1$ and $k_t = e\lambda_t / 2$? That is, untrustworthy B chooses to mimic to be the trustworthy type with probability 1. This strategy will be a part of the equilibrium described earlier if $P_0^D \geq 4/(l+h)$. However, when $P_0^D < 4/(l+h)$, then by Bayesian updating $P_{t+1}^D = P_t^D = ... = P_0^D$. At some $t = i$, $P_i^D < \left(4/(l+h)\right)^{n-i+1}$ and therefore, A will not invest in any period $t \geq i$. In contrast, if B follows the strategy outlined in the equilibrium described earlier, A will invest with some positive probability in period $t \geq i$. In other words, full disclosure does not constitute equilibrium and will result in lower investment. In equilibrium, B will mimic to be the trustworthy type but will do so selectively instead of indiscriminately in order to ensure the credibility associated with her choice in the instances where she actually chooses to mimic (except when $P_0^D \geq 4/(l+h)$).

For example, if n = 10, l = 1, h = 5 and $P_0^D = 0.4$, then the reputation threshold is given by the blue dotted line in Figure 2B. The way A's belief about B's type evolves in equilibrium and under the full disclosure strategy respectively is shown by the red dotted line and the green dotted line in Figure 2B. Note that under full disclosure strategy, A's belief falls below the reputation threshold in period 9 but remains on the threshold under equilibrium. Consequently, under full disclosure, A does not invest in periods 9 and 10 but in equilibrium, A may invest in both periods.

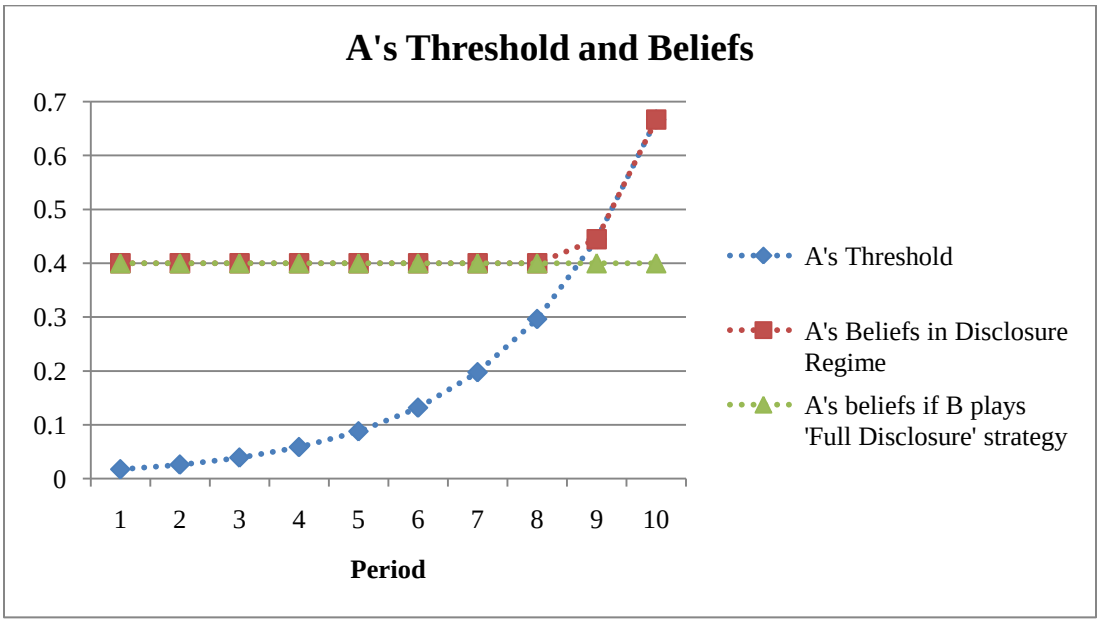

Figure 2B – Reputation Threshold at which A invests with some probability and A's beliefs about B's type when n = 10, l = 1 , h = 5 and $P_0^D = 0.4$

4. No Disclosure Regime

Now consider a world without disclosure. As before, there are two players, A (sender / investor) and B (receiver / manager). Nature moves first and selects B's type to be either trustworthy or untrustworthy. I will define momentarily what I mean by each type in this regime. B knows her type but A does not. The game then proceeds through n periods in each of which the A and B make a sequence of choices. In what follows, the subscript t (t

= 1, 2, …. , n) will be used to denote a period. A is endowed with $e > 0$ units of wealth and chooses whether or not to invest in B. Regardless of whether or not A chooses to invest, e is common knowledge. That is, both A and B know the amount of wealth A in endowed with. A's decision to invest is denoted by $m_t = e$ and A's decision not to invest is denoted by $m_t = 0$. If A chooses to invest, then the amount e is multiplied by a multiplier λ_t before B receives it. $\lambda_t \in \{l, h\}$ and is equally likely to be either l or h in every period. $1 \leq l < 2 < h$, $l + h > 4$. As before, B receives $e\lambda_t$ and learns λ_t. However, A never learns λ_t. That is, B does not have any means available to communicate her private information to A even if she wishes to share this information. After B receives $e\lambda_t$, she chooses to send back k_t to B. If $\lambda_t = l$, $k_t \in \{0, el / 2\}$. If $\lambda_t = h$, $k_t \in \{0, el / 2, eh / 2\}$. A receives k_t and B keeps the residual $e\lambda_t - k_t$.

A trustworthy B is defined as one that always chooses $k_t = e\lambda_t / 2$. An untrustworthy B is defined as a B that is not trustworthy. This is a setting where there is a firm comprising A and B, there is gross income of $e\lambda_t$ but there is no accounting system available. Dividend of k_t can still be paid but the income $e\lambda_t$ cannot be reported. Risk neutrality, additively separable utility and no time discounting are assumed.

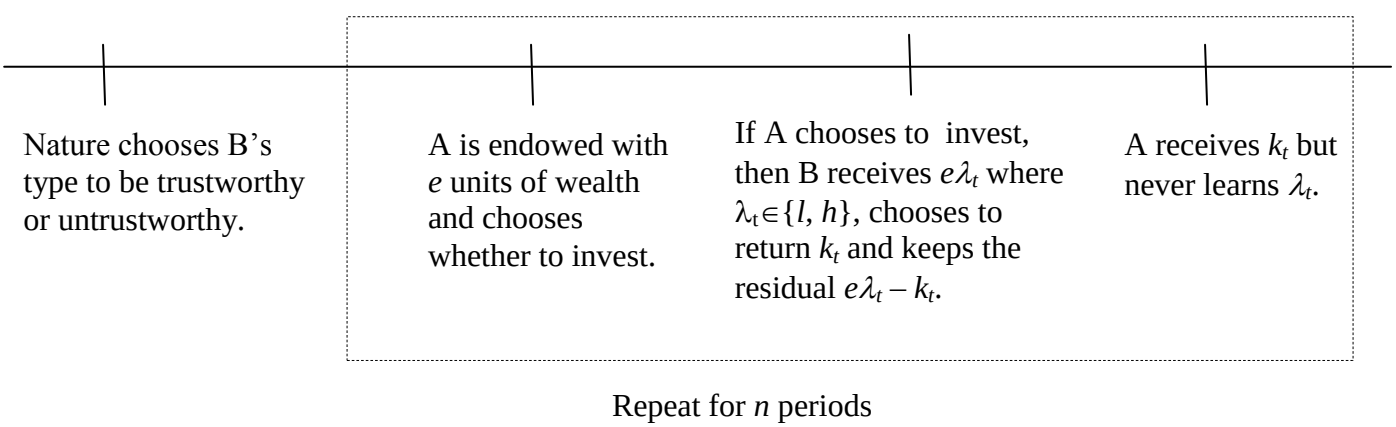

Figure 3A – Timeline of No Disclosure Regime

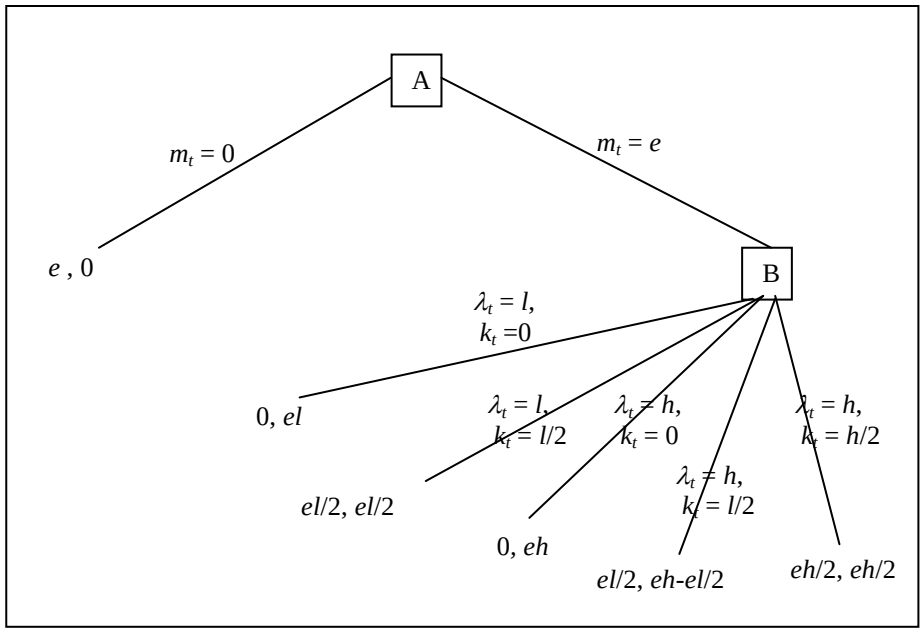

Figure 3B – Extensive Form Representation of the Stage Game in No Disclosure Regime

A sequential equilibrium of this game is defined as follows. An equilibrium comprises a strategy for each player and for each period t a function P_t^{ND} that takes the history of moves up to period t into numbers in [0 , 1] such that :

(i) Starting from any point in the game where it is B's move, B's strategy is a best response to A's strategy.

(ii) Starting from any point in the game where it is A's move, A's strategy is a best response to B's strategy given that A believes B is trustworthy with probability $P_t^{ND}(h_t)$.

(iii) The game begins with $P_1^{ND} = \theta$.

(iv) Each P_t^{ND} is computed from P_{t-1}^{ND} and B's strategy, using Bayes' rule whenever possible.

I will first define the function P_t^{ND} as:

(i) Set $P_1^{ND} = \theta$.

(ii) For $t > 1$, if A chooses $m_{t-1} = 0$, then $P_t^{ND} = P_{t-1}^{ND}$.

(iii) For $t > 1$, if A chooses $m_{t-1} = e$ and B chooses $k_{t-1} > 0$ and $P_{t-1}^{ND} > 0$, then $P_t^{ND} = \max\left((4/(l+h))^{n-t+1}, \theta/(2^{t-1} - (2^{t-1}-1)\theta)\right)$.

(iv) For $t > 1$, if A chooses $m_{t-1} = e$ but B chooses $k_{t-1} = 0$, then $P_t^{ND} = 0$.

(v) If $P_{t-1}^{ND} = 0$, then $P_t^{ND} = 0$.

Now, I will describe the strategies of A and untrustworthy B in terms of P_t^{ND} . Note that by definition, a trustworthy B always to return half of what she receives. An untrustworthy B's strategy depends on t and P_t^{ND}. The strategy may be outlined as:

(i) If $t = n$, B chooses $k_n = 0$.

(ii) If $t < n$ and $P_t^{ND} \geq 2.(4/(l+h))^{n-t} / \left(1 + (4/(l+h))^{n-t}\right)$, B chooses $k_t = el/2$.

(iii) If $t < n$ and $P_t^{ND} < 2.(4/(l+h))^{n-t} / \left(1 + (4/(l+h))^{n-t}\right)$ and $\lambda_t = l$, B chooses $k_t = el/2$ with some probability S_{3t}^{ND} $(0 < S_{3t}^{ND} < 1)$ and chooses $k_t = 0$ with probability $1 - S_{3t}^{ND}$.

(iv) If $t < n$ and $P_t^{ND} < 2.(4/(l+h))^{n-t} / \left(1 + (4/(l+h))^{n-t}\right)$ and $\lambda_t = h$, B chooses $k_t = eh/2$ with some probability S_{1t}^{ND} $(0 < S_{1t}^{ND} < 1)$, chooses $k_t = el/2$ with some probability S_{2t}^{ND} $(0 < S_{2t}^{ND} < 1, 0 < S_{1t}^{ND} + S_{2t}^{ND} < 1)$ and chooses $k_t = 0$ with probability $1 - S_{1t}^{ND} - S_{2t}^{ND}$ such that $S_{1t}^{ND} = S_{2t}^{ND} + S_{3t}^{ND} = P_t^{ND}(1 - (4/(l+h))^{n-t})/(4/(l+h))^{n-t}(1 - P_t^{ND})$.

A's strategy may be outlined as:

(i) If $P_t^{ND} < (4/(l+h))^{n-t+1}$, A chooses $m_t = 0$.

(ii) If $P_t^{ND} > (4/(l+h))^{n-t+1}$, A chooses $m_t = e$.

(iii) If $P_t^{ND} = (4/(l+h))^{n-t+1}$ and $k_{t-1} = eh/2$, with a probability $V_{1t}^{ND} = h/(l+h)$, A chooses to invest and with a probability $1-V_{1t}^{ND}$, A chooses not to invest. That is, with a probability V_{1t}^{ND}, A chooses $m_t = e$ and with a probability $1-V_{1t}^{ND}$, A chooses $m_t = 0$.

(iv) If $P_t^{ND} = (4/(l+h))^{n-t+1}$ and $k_{t-1} = el/2$, with a probability $V_{2t}^{ND} = l/(l+h)$, A chooses to invest and with a probability $1-V_{2t}^{ND}$, A chooses not to invest. That is, with a probability V_{2t}^{ND}, A chooses $m_t = e$ and with a probability $1-V_{2t}^{ND}$, A chooses $m_t = 0$.

Proposition 2. The strategies and beliefs described above constitute a sequential equilibrium.

Proof. There are two things to verify. First, A's beliefs must be consistent with B's strategy, in the sense that Bayes Rule hold wherever applicable. Second, starting from any information set in the game no player has a profitable deviation, that is, no player has an incentive to deviate.

I will first verify the criterion of Bayesian consistency. If A does not invest in period *t*, then she does not learn anything about B's type and therefore $P_{t+1}^{ND} = P_t^{ND}$. If $P_t^{ND} = 0$, untrustworthy B chooses $k_t = 0$ and Bayes rule implies $P_{t+1}^{ND} = P_t^{ND}$.

If $P_t^{ND} \geq 2.(4/(l+h))^{n-t} / \left(1+(4/(l+h))^{n-t}\right)$, untrustworthy B chooses $k_t = el/2$ and Bayes Rule requires:

$$P_{t+1}^{ND} = \text{Prob}(\text{B is trustworthy} \mid \text{B chooses } k_t = el/2)$$

$$= \frac{\text{Prob (B is trustworthy and chooses } k_t = el/2)}{\text{Prob (B chooses } k_t = el/2)}$$

$$= \frac{\text{Prob (B chooses } k_t = el/2 \,|\, \text{B is trustworthy)Prob (B is trustworthy)}}{\left(\begin{array}{l}\text{Prob (B chooses } k_t = el/2 \,|\, \text{B is trustworthy)Prob (B is trustworthy)} + \\ \text{Prob (B chooses } k_t = el/2 \,|\, \text{B is untrustworthy)Prob (B is untrustworthy)}\end{array}\right)}$$

$$= \frac{1/2.P_t^{ND}}{1/2.P_t^{ND} + (1 - P_t^{D})}$$

$$= \frac{P_t^{ND}}{2 - P_t^{ND}}$$

$$= \frac{\theta}{2^{t-1} - (2^{t-1} - 1)\theta}, \text{ since } P_1^{ND} = \theta.$$

Now, if $P_t^{ND} < 2.(4/(l+h))^{n-t} / \left(1 + (4/(l+h))^{n-t}\right)$ and $k_t = el/2$, it could be $\lambda_t = l$ and B chose $k_t = el/2$ with probability S_{3t}^{ND} $(0 < S_{3t}^{ND} < 1)$ or it could be $\lambda_t = h$ and B chose $k_t = eh/2$ with probability S_{2t}^{ND} $(0 < S_{2t}^{ND} < 1)$. Recall that $S_{2t}^{ND} + S_{3t}^{ND} = P_t^{ND}(1 - (4/(l+h))^{n-t})/(4/(l+h))^{n-t}(1 - P_t^{ND})$. By Bayes Rule:

$$P_{t+1}^{ND} = \text{Prob (B is trustworthy} \,|\, \text{B chooses } k_t = el/2)$$

$$= \frac{\text{Prob (B is trustworthy and chooses } k_t = el/2)}{\text{Prob (B chooses } k_t = el/2)}$$

$$= \frac{\text{Prob (B chooses } k_t = el/2 \,|\, \text{B is trustworthy)Prob (B is trustworthy)}}{\left(\begin{array}{l}\text{Prob (B chooses } k_t = el/2 \,|\, \text{B is trustworthy)Prob (B is trustworthy)} + \\ \text{Prob (B chooses } k_t = el/2 \,|\, \text{B is untrustworthy)Prob (B is untrustworthy} \\ \text{and receives } el) + \text{ Prob (B chooses } k_t = el/2 \,|\, \text{B is untrustworthy)} \\ \text{Prob (B is untrustworthy and receives } eh)\end{array}\right)}$$

$$= \frac{1/2.P_t^{ND}}{1/2.P_t^{ND} + 1/2.(1 - P_t^{ND})S_{3t}^{ND} + 1/2.(1 - P_t^{ND})S_{2t}^{ND}}$$

$$= \frac{P_t^{ND}}{P_t^{ND} + (1 - P_t^{ND})(S_{3t}^{ND} + S_{2t}^{ND})}$$

$$= \left(\frac{4}{l+h}\right)^{n-t+1}$$

Finally, if $P_t^{ND} < 2.(4/(l+h))^{n-t} / \left(1+(4/(l+h))^{n-t}\right)$ and $\lambda_t = h$, B chooses $k_t = eh/2$ with probability $S_{1t}^{ND} = P_t^{ND}(1-(4/(l+h))^{n-t})/(4/(l+h))^{n-t}(1-P_t^{ND})$. By Bayes Rule:

$$\begin{aligned}
P_{t+1}^{ND} &= \text{Prob (B is trustworthy} \mid \text{B chooses } k_t = eh/2) \\
&= \frac{\text{Prob (B is trustworthy and chooses } k_t = eh/2)}{\text{Prob (B chooses } k_t = eh/2)} \\
&= \frac{\text{Prob (B chooses } k_t = eh/2 \mid \text{B is trustworthy) Prob (B is trustworthy)}}{\left(\begin{array}{l}\text{Prob (B chooses } k_t = eh/2 \mid \text{B is trustworthy) Prob (B is trustworthy)} + \\ \text{Prob (B chooses } k_t = eh/2 \mid \text{B is untrustworthy) Prob (B is untrustworthy)}\end{array}\right)} \\
&= \frac{1/2.P_t^{ND}}{1/2.P_t^{ND} + 1/2.(1-P_t^{ND})S_{1t}^{ND}} \\
&= \left(\frac{4}{l+h}\right)^{n-t+1}
\end{aligned}$$

This satisfies the criterion of Bayesian consistency.

I will now verify that A's strategy is optimal. A's payoff from not investing (choosing m_t = 0) = e. If $P_t^{ND} > \left(2.(4/(l+h))^{n-t}\right)/\left(1+(4/(l+h))^{n-t}\right)$, B chooses $k_t = el/2$. A's expected payoff from investing (choosing $m_t = e$) = $eP_t^{ND}\left((l+h)/4\right) + e(1-P_t^{ND})(l/2)$ is greater than A's payoff from not investing (choosing m_t = 0) = e if $eP_t^{ND}\left((l+h)/4\right) + e(1-P_t^{ND})(l/2) > e$. Simplifying yields A's expected payoff from choosing $m_t = e$ is higher if $P_t^{ND} > 2.(2-l)/(h-l)$. Now by definition of P_t^{ND}, it must be that $P_t^{ND} = \theta/(2^{t-1} - (2^{t-1}-1)\theta)$ and $P_{t+1}^{ND} = \theta/(2^t - (2^t-1)\theta)$. Algebraic simplification yields $P_{t+1}^{ND} = P_t^{ND}/(2-P_t^{ND})$. Also, $P_{t+1}^{ND} = \theta/(2^t - (2^t-1)\theta) > (4/(l+h))^{n-t}$ by definition of P_t^{ND}. That is, $P_{t+1}^{ND} = P_t^{ND}/(2-P_t^{ND}) > (4/(l+h))^{n-t}$. Simplifying

$P_t^{ND} > 2.4^{n-t} / \left((l+h)^{n-t} + 4^{n-t}\right)$ and I will have proved A's payoff from choosing $m_t = e$ is higher if I can show $2.(2-l)/(h-l) < 2.4^{n-t} / \left((l+h)^{n-t} + 4^{n-t}\right)$. Re-arranging this inequality is equivalent to $2.(l+h)^{n-t} + 2.4^{n-t} < l.(l+h)^{n-t} + h.4^{n-t}$. I will prove this by induction. Denote $2.(l+h)^{n-t} + 2.4^{n-t} < l.(l+h)^{n-t} + h.4^{n-t}$. by *. At $t = n - 1$, LHS of (*) $= 2.(l + h + 4)$ and RHS of (*) $= l^2 + lh + 4h$. This LHS < RHS since $(l + h) > 4$. Suppose LHS < RHS for some $t = k+1$. That is, $2.(l+h)^{n-k-1} + 2.4^{n-k-1} < l.(l+h)^{n-k-1} + h.4^{n-k-1}$.

Multiplying both sides by $(l+h)$ yields –

$2.(l+h)^{n-k} + 2.4^{n-k-1}(l+h) < l.(l+h)^{n-k} + h.4^{n-k-1}(l+h)$ …….. (**)

At $t = k$, (*) becomes $2.(l+h)^{n-k} + 2.4^{n-k} < l.(l+h)^{n-k} + h.4^{n-k}$. …….. (***)

LHS of (***) = $2.(l+h)^{n-k} + 2.4^{n-k}$

$< 2.(l+h)^{n-k} + 2.4^{n-k-1}(l+h)$ (since $4 < l+h$)

$< l.(l+h)^{n-k} + h.4^{n-k-1}(l+h)$ (from **)

$< l.(l+h)^{n-k} + h.4^{n-k}$ (since $4 < l+h$) = RHS of (***).

This completes the proof by induction. Note that $P_t^{ND} > \left(2.(4/(l+h))^{n-t}\right) / \left(1 + (4/(l+h))^{n-t}\right)$ implies $P_t^{ND} > (4/(l+h))^{n-t+1}$ since it can be shown that $(4/(l+h))^{n-t+1} < \left(2.(4/(l+h))^{n-t}\right) / \left(1 + (4/(l+h))^{n-t}\right)$.

If $P_t^{ND} < \left(2.(4/(l+h))^{n-t}\right) / \left(1 + (4/(l+h))^{n-t}\right)$ and $\lambda_t = l$, B chooses $k_t = el/2$ with probability S_{3t}^{ND} and chooses $k_t = 0$ with probability $1 - S_{3t}^{ND}$. If $P_t^{ND} < \left(2.(4/(l+h))^{n-t}\right) / \left(1 + (4/(l+h))^{n-t}\right)$ and $\lambda_t = h$, B chooses $k_t = eh/2$ with probability S_{1t}^{ND}, chooses $k_t = el/2$ with probability S_{2t}^{ND} and chooses $k_t = 0$ with probability $1 - S_{1t}^{ND} - S_{2t}^{ND}$. This implies A's expected payoff from investing (choosing $m_t = e$) = $eP_t^{ND}\left((l+h)/4\right) + e(1 - P_t^{ND})(l/4)(S_{2t}^{ND} + S_{3t}^{ND}) + e(1 - P_t^{ND})(h/4)S_{1t}^{ND}$. Inserting the expressions for S_{1t}^{ND} and $(S_{2t}^{ND} + S_{3t}^{ND})$ and simplifying yields A's expected payoff

from investing = $eP_t^{ND}\left((l+h)/4\right)^{n-t+1}$. Now $eP_t^{ND}\left((l+h)/4\right)^{n-t+1} > e$ if $P_t^{ND} > (4/(l+h))^{n-t+1}$. That is, when $P_t^{ND} < \left(2.(4/(l+h))^{n-t}\right)/\left(1+(4/(l+h))^{n-t}\right)$, it is optimal for A to invest if $P_t^{ND} > (4/(l+h))^{n-t+1}$ and not to invest if $P_t^{ND} < (4/(l+h))^{n-t+1}$.

At $P_t^{ND} = (4/(l+h))^{n-t+1}$, A's payoff from investing equals A's payoff from not investing. That is, A is indifferent between choosing $m_t = e$ and choosing $m_t = 0$. Therefore, A chooses to invest with a probability that makes B indifferent between the options available to her. That is when, $k_{t-1} = el/2$, with a probability $V_{2t}^{ND} = l/(l+h)$, A chooses to invest and with a probability $1-V_{2t}^{ND}$, A chooses not to invest. To verify B's indifference at this point, note that if $\lambda_{t-1} = l$, B's payoff from choosing $k_{t-1} = 0$ is el and B's expected payoff from choosing $k_{t-1} = el/2$ is $el/2 + eV_{2t}^{ND}(l+h)/2$. Since $V_{2t}^{ND} = l/(l+h)$, B's expected payoff from choosing $k_{t-1} = 0$ equals B's payoff from choosing $k_{t-1} = el/2$. If $\lambda_{t-1} = h$, B's payoff from choosing $k_{t-1} = 0$ is eh and B's expected payoff from choosing $k_{t-1} = el/2$ is $eh - el/2 + eV_{2t}^{ND}(l+h)/2$. Since $V_{2t}^{ND} = l/(l+h)$, B's expected payoff from choosing $k_{t-1} = 0$ equals B's payoff from choosing $k_{t-1} = el/2$. Now when, $k_{t-1} = eh/2$, with a probability $V_{1t}^{ND} = h/(l+h)$, A chooses to invest and with a probability $1-V_{1t}^{ND}$, A chooses not to invest. To verify B's indifference at this point, note that B's payoff from choosing $k_{t-1} = 0$ is eh and B's expected payoff from choosing $k_{t-1} = eh/2$ is $eh/2 + eV_{2t}^{ND}(l+h)/2$. Since $V_{1t}^{ND} = h/(l+h)$, B's expected payoff from choosing $k_{t-1} = 0$ equals B's payoff from choosing $k_{t-1} = eh/2$.

Finally, I need to verify that untrustworthy B's strategy is optimal. If $t = n$, B's payoff from choosing $k_n = 0$ is $e\lambda_n$ while B's payoff from not choosing $k_n = 0$ is strictly lower making it optimal for B to choose $k_n = 0$.

If $t < n$ and $P_t^{ND} \geq 2.(4/(l+h))^{n-t} / \left(1+(4/(l+h))^{n-t}\right)$, then A chooses $m_{t+1} = e$ since $P_t^{ND} \geq 2.(4/(l+h))^{n-t} / \left(1+(4/(l+h))^{n-t}\right)$ implies $P_{t+1}^{ND} > (4/(l+h))^{n-t}$. (It can be shown that $2.(4/(l+h))^{n-t} / \left(1+(4/(l+h))^{n-t}\right) > (4/(l+h))^{n-t}$). Thus, B's payoff from choosing $k_t = 0$ is $e\lambda_t$ while B's expected payoff from choosing $k_t = el/2$ is $e\lambda_t - el/2 + eE(\lambda_{t+1}) = e\lambda_t - el/2 + e(l+h)/2$. Clearly, it is optimal for B to choose $k_t = el/2$.

If $t < n$ and $P_t^{ND} < 2.(4/(l+h))^{n-t} / \left(1+(4/(l+h))^{n-t}\right)$, then by definition of P_t^{ND}, it must be that $P_{t+1}^{ND} = (4/(l+h))^{n-t}$. If $\lambda_t = l$ and $k_t = el/2$, then with a probability $V_{2t}^{ND} = l/(l+h)$, A chooses $m_{t+1} = e$ and with a probability $1 - V_{2t}^{ND}$, A chooses $m_{t+1} = 0$. Thus, while B's payoff from choosing $k_t = 0$ is el, B's expected payoff from choosing $k_t = el/2$ is $el/2 + eE(\lambda_{t+1})V_{2t}^{ND} = el/2 + e((l+h)/2)l/(l+h)$. At this point, B is indifferent between choosing $k_t = 0$ and choosing $k_t = el/2$. Therefore, B chooses $k_t = el/2$ with probability S_{3t}^{ND} (and $k_t = 0$ with complementary probability) that makes A indifferent between choosing $m_{t+1} = e$ and choosing $m_{t+1} = 0$. If $t < n$ and $P_t^{ND} < 2.(4/(l+h))^{n-t} / \left(1+(4/(l+h))^{n-t}\right)$, $\lambda_t = h$ and $k_t = el/2$, then also with a probability $V_{2t}^{ND} = l/(l+h)$, A chooses $m_{t+1} = e$ and with a probability $1 - V_{2t}^{ND}$, A chooses $m_{t+1} = 0$. Again, while B's payoff from choosing $k_t = 0$ is eh, B's expected payoff from choosing $k_t = el/2$ is $eh - el/2 + eE(\lambda_{t+1})V_{2t}^{ND}$ $= eh - el/2 + e((l+h)/2)l/(l+h)$. Therefore at this point too, B is indifferent between

choosing $k_t = 0$ and choosing $k_t = el/2$. B chooses $k_t = el/2$ with probability S_{2t}^{ND} ($k_t = eh/2$ with probability S_{1t}^{ND} and $k_t = 0$ with probability $1 - S_{1t}^{ND} - S_{2t}^{ND}$) that makes A indifferent between choosing $m_{t+1} = e$ and choosing $m_{t+1} = 0$. A is indifferent between choosing $m_{t+1} = e$ and choosing $m_{t+1} = 0$ when $P_{t+1}^{D} = (4/(l+h))^{n-t}$. By Bayes Rule, $P_{t+1}^{ND} = P_t^{ND} / \left(P_t^{ND} + (1 - P_t^{ND})(S_{3t}^{ND} + S_{2t}^{ND})\right)$. Inserting $S_{2t}^{ND} + S_{3t}^{ND} = P_t^{ND}(1-(4/(l+h))^{n-t})/(4/(l+h))^{n-t}(1-P_t^{ND})$ and simplifying, we get $P_{t+1}^{D} = (4/(l+h))^{n-t}$.

If $t < n$ and $P_t^{ND} < 2.(4/(l+h))^{n-t} / \left(1 + (4/(l+h))^{n-t}\right)$, $\lambda_t = h$ and $k_t = eh/2$, then with a probability $V_{1t}^{ND} = h/(l+h)$, A chooses $m_t = e$ and with a probability $1 - V_{1t}^{ND}$, A chooses $m_t = 0$. B's payoff from choosing $k_t = 0$ is eh while B's expected payoff from choosing $k_t = eh/2$ is $eh/2 + eE(\lambda_{t+1})V_{1t}^{ND} = eh/2 + e((l+h)/2)h/(l+h)$. This makes B indifferent between choosing $k_t = 0$ and choosing $k_t = eh/2$. B chooses $k_t = eh/2$ with probability S_{1t}^{ND} ($k_t = el/2$ with probability S_{2t}^{ND} and $k_t = 0$ with probability $1 - S_{1t}^{ND} - S_{2t}^{ND}$) that makes A indifferent between choosing $m_{t+1} = e$ and choosing $m_{t+1} = 0$. A is indifferent between choosing $m_{t+1} = e$ and choosing $m_{t+1} = 0$ when $P_{t+1}^{D} = (4/(l+h))^{n-t}$. By Bayes Rule, $P_{t+1}^{ND} = P_t^{ND} / \left(P_t^{ND} + (1 - P_t^{ND})S_{1t}^{ND}\right)$. Inserting $S_{1t}^{ND} = P_t^{ND}(1-(4/(l+h))^{n-t})/(4/(l+h))^{n-t}(1-P_t^{ND})$ and simplifying, we get $P_{t+1}^{D} = (4/(l+h))^{n-t}$.

This completes the proof that the set of beliefs and strategies described earlier constitutes a sequential equilibrium.

The reputation threshold in the no disclosure regime turns out to the same as the reputation threshold in the disclosure regime. That is, P_{t+1}^{D} and P_{t+1}^{ND} in the disclosure and

no disclosure regimes respectively must be at least $(4/(l+h))^{n-t+1}$ for A to invest with some positive probability.

5. Investment, Return and Disclosure

Consider n = 10, l = 1, h = 5 and $P_0^D = P_1^{ND} = 0.4$. Then, the way A's belief about B's type evolves in the disclosure and no disclosure regimes respectively is shown by the red dotted line and the green dotted line in Figure 4. Note that when A's belief is above the reputation threshold, A plays a pure strategy of always investing. When A's belief is on the threshold, A switches to a mixed strategy play where the probability with which she invests is given by the equilibrium described earlier. B switches to mixed strategy play to prevent A's beliefs from falling below the threshold. In this example, even though the game in both regimes begins with identical initial probability of 0.4, the disclosure regime provides for more time of pure strategy play as compared to the no disclosure regime. In this sense, the disclosure regime provides for additional reputation building opportunities. Since probability of investment in a period of pure strategy play is higher than probability of investment in a period of mixed strategy play, therefore more time of pure strategy play in a disclosure regime should translate into higher investment in disclosure regime.

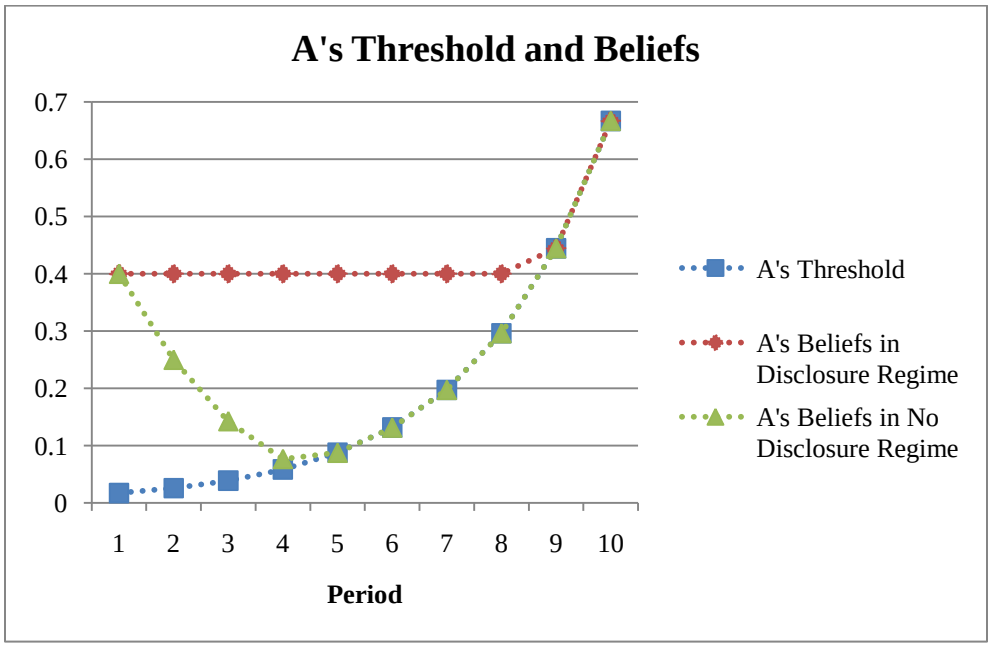

Figure 4 – Reputation Threshold at which A invests with some probability and A's beliefs about B's type when n = 10, l = 1 , h = 5 and $P_0^D = P_1^{ND} = 0.4$

Denote the total investment in the disclosure regime by $I^D = \sum_{t=1}^{n} m_t$ and the total investment in the no disclosure regime by $I^{ND} = \sum_{t=1}^{n} m_t$.

Proposition 3. If $n > 1$ and $(4/(l+h))^n < P_0^D = P_1^{ND} < (4/(l+h))^2$ then $E_1(I^D) \geq E_1(I^{ND})$. Additionally, if $n > 2$[3] and $P_0^D = P_1^{ND} > (4/(l+h))^{n-j+1}$ then $E_1(I^D) > E_1(I^{ND})$, where *j* is as defined below.

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[2] If $n > 1$ and $P_0^D = P_1^{ND} < (4/(l+h))^n$ then $E_1(I^D) = E_1(I^{ND}) = 0$; and if $n > 1$ and $P_0^D = P_1^{ND} > (4/(l+h))$ then $E_1(I^D) = E_1(I^{ND}) = ne$. If $n = 1$ and $P_0^D = P_1^{ND} > (4/(l+h))$, then $E_1(I^D) = E_1(I^{ND}) = e$ but if $n = 1$ and $P_0^D = P_1^{ND} < (4/(l+h))$, then $E_1(I^D) = E_1(I^{ND}) = 0$.

Proof. Let $P_0^D = P_1^{ND} = \gamma$. By definition, $P_t^D = \max\left((4/(l+h))^{n-t+1}, \gamma\right)$ and $P_t^{ND} = \max\left((4/(l+h))^{n-t+1}, \gamma/(2^{t-1} - (2^{t-1}-1)\gamma)\right)$. At some $t = k$, $P_k^D = (4/(l+h))^{n-k+1}$. For $t < k$, $P_t^D = \gamma$ and for $t > k$, $P_t^D = (4/(l+h))^{n-t+1}$. Also, at some $t = j$, $P_j^{ND} = (4/(l+h))^{n-j+1}$. For $t < j$, $P_t^{ND} = \gamma/(2^{t-1} - (2^{t-1}-1)\gamma)$ and for $t > j$, $P_t^{ND} = (4/(l+h))^{n-t+1}$. At $t < k$, A invests with probability 1 in the disclosure regime and similarly at $t < j$, A invests with probability 1 in the no disclosure regime. However, at $t \geq k$ and $t \geq j$ in the disclosure and no disclosure regimes respectively, A invests with a probability less than 1. Now, $P_t^D = \gamma$ is constant over time while $P_t^{ND} = \gamma/(2^{t-1} - (2^{t-1}-1)\gamma)$ is a decreasing function. Therefore, $k \geq j$ and this implies that $E_1(I^D) \geq E_1(I^{ND})$. That is, there is at least as much period of time in the disclosure regime where A invests with probability 1 as there is in the no disclosure regime and therefore, expected investment in the disclosure regime will be at least as high as in the no disclosure regime.

If $P_0^D = P_1^{ND} = \gamma > \left(4/(l+h)\right)^{n-j+1}$, then $P_k^D = (4/(l+h))^{n-k+1} > \gamma > \left(4/(l+h)\right)^{n-j+1} = P_j^{ND}$. This implies $k > j$ and therefore, $E_1(I^D) > E_1(I^{ND})$. That is, there is greater period of time in the disclosure regime where A invests with probability 1 than there is in the no disclosure regime and therefore, expected investment in the disclosure regime will be higher than in the no disclosure regime.

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[3] If $n = 2$ and $\left(4/(l+h)\right)^n < P_0^D = P_1^{ND} < \left(4/(l+h)\right)$, then $k = j = 2$ and $E_1(I^D) \geq E_1(I^{ND})$.

Denote the total return in the disclosure regime by $R^D = \sum_{t=1}^{n} k_t$ and the total return in the no disclosure regime by $R^{ND} = \sum_{t=1}^{n} k_t$.

Proposition 4. If $n > 2$ and $\left(4/(l+h)\right)^n < P_0^D = P_1^{ND} < \left(4/(l+h)\right)$[4] then $E_1(R^D) \geq E_1(R^{ND})$. Additionally, for $n > 1$, if $P_0^D = P_1^{ND} > \left(4/(l+h)\right)^{n-1}$ or $P_0^D = P_1^{ND} > \left(4/(l+h)\right)$ then $E_1(R^D) > E_1(R^{ND})$.

Proof. I will use the definition of *j* and *k* from proof of Proposition 3. At *t* < *k* - *2*, B returns $k_t = e\lambda_t / 2$ in the disclosure regime and similarly at *t* < *j* - *2*, B returns $k_t = el/2$. $E(e\lambda_t / 2) = e(l+h)/4 > E(el/2) = el/2$. At $t \geq k$ and $t \geq j$ in the disclosure and no disclosure regimes respectively, B returns a non-zero amount with a probability less than 1. Now, $P_t^D = \gamma$ is constant over time while $P_t^{ND} = \gamma/(2^{t-1} - (2^{t-1}-1)\gamma)$ is a decreasing function. Therefore, $k \geq j$ and this implies that $E_1(R^D) \geq E_1(R^{ND})$. That is, there is at least as much period of time in the disclosure regime where B returns a non-zero amount with probability 1 as there is in the no disclosure regime and therefore, expected return on investment in the disclosure regime will be at least as high as expected return on investment in the no disclosure regime.

If $P_0^D = P_1^{ND} > \left(4/(l+h)\right)^{n-1}$ then *k* > 2 since $P_1^D = P_2^D = \gamma > \left(4/(l+h)\right)^{n-1} > \left(4/(l+h)\right)^n$. Now, *j* > 1 since $P_1^{ND} = \gamma > \left(4/(l+h)\right)^{n-1} > \left(4/(l+h)\right)^n$. Therefore, in disclosure regime, $k_1 = e\lambda_1 / 2$ and E(k_1) = $e(l+h)/4$. In no disclosure regime, either $k_1 = el/2$ or for period

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[4] If $P_0^D = P_1^{ND} < \left(4/(l+h)\right)^n$ then $E_1(R^D) = E_1(R^{ND}) = 0$, for all *n*. If *n* = 1 and $P_0^D = P_1^{ND} > \left(4/(l+h)\right)$ then $E_1(R^D) = E_1(R^{ND}) = eP_1^D(l+h)/4 = eP_1^{ND}(l+h)/4$. If *n* = 2 and $\left(4/(l+h)\right)^n < P_0^D = P_1^{ND} < \left(4/(l+h)\right)$ then $E_1(R^D) \geq E_1(R^{ND})$.

1, B returns a non-zero amount with a probability less than 1. But in either of the two cases in no disclosure regime, E(k_1) < $e(l+h)/4$. This implies $E_1(R^D) > E_1(R^{ND})$. Similarly, if $P_0^D = P_1^{ND} > \left(4/(l+h)\right)$ then in disclosure regime, E(k_1) = $e(l+h)/4$. But in no disclosure regime, either $k_1 = el/2$ or for period 1, B returns a non-zero amount with a probability less than 1 which in turn implies E(k_1) < $e(l+h)/4$. That is, $E_1(R^D) > E_1(R^{ND})$. In other words, expected return on investment in the disclosure regime will be higher than expected return on investment in the no disclosure regime.

Denote A's total payoff in the disclosure regime by $\prod_A^D = \sum_{t=1}^{n}\left(e - m_t + k_t\right)$ and A's total payoff in the no disclosure regime by $\prod_A^{ND} = \sum_{t=1}^{n}\left(e - m_t + k_t\right)$.

Proposition 5. If $P_0^D = P_1^{ND}$ then $E_1(\prod_A^D) \geq E_1(\prod_A^{ND})$. If $P_0^D = P_1^{ND} > \left(2.(4/(l+h))^{n-1}\right)/\left(1+(4/(l+h))^{n-1}\right)$ then $E_1(\prod_A^D) > E_1(\prod_A^{ND})$.

Proof. If $P_t^D \geq (4/(l+h))^{n-t}$, then A's expected period t payoff $= (e/2)\left((l+h)/2\right)$. If $(4/(l+h))^{n-t+1} < P_t^D < (4/(l+h))^{n-t}$, then A's expected period t payoff $= eP_t^D((l+h)/4)^{n-t+1}$. If $P_t^D = (4/(l+h))^{n-t+1}$ then A's expected period t payoff = e. If $P_t^{ND} > \left(2.(4/(l+h))^{n-t}\right)/\left(1+(4/(l+h))^{n-t}\right)$, A's expected period t payoff = $eP_t^{ND}\left((l+h)/4\right) + e(1-P_t^{ND})(l/2)$. Recall $P_t^{ND} > \left(2.(4/(l+h))^{n-t}\right)/\left(1+(4/(l+h))^{n-t}\right)$ implies $P_t^{ND} > (4/(l+h))^{n-t+1}$ since it can be shown that $(4/(l+h))^{n-t+1} < \left(2.(4/(l+h))^{n-t}\right)/\left(1+(4/(l+h))^{n-t}\right)$. If $(4/(l+h))^{n-t+1} < P_t^{ND} < \left(2.(4/(l+h))^{n-t}\right)/\left(1+(4/(l+h))^{n-t}\right)$ then A's expected period t payoff = $eP_t^{ND}\left((l+h)/4\right)^{n-t+1}$. At $P_t^{ND} = (4/(l+h))^{n-t+1}$, A's expected period t payoff = e. Summarizing,

	A's Expected Period *t* Payoff in Disclosure Regime		A's Expected Period *t* Payoff in No Disclosure Regime
$P_t^D \geq (4/(l+h))^{n-t}$	$(e/2)\big((l+h)/2\big)$	$P_t^{ND} > \dfrac{2.\big(4/(l+h)\big)^{n-t}}{1+\big(4/(l+h)\big)^{n-t}}$	$eP_t^{ND}\big((l+h)/4\big)+$ $e(1-P_t^{ND})(l/2)$
$(4/(l+h))^{n-t+1} < P_t^D$ $< (4/(l+h))^{n-t}$	$eP_t^D((l+h)/4)^{n-t+1}$	$(4/(l+h))^{n-t+1} < P_t^{ND}$ $< \dfrac{2.\big(4/(l+h)\big)^{n-t}}{1+\big(4/(l+h)\big)^{n-t}}$	$eP_t^{ND}\big((l+h)/4\big)^{n-t+1}$
$P_t^D = (4/(l+h))^{n-t+1}$	e	$P_t^{ND} = (4/(l+h))^{n-t+1}$	e

Comparing the payoffs from the table, it can be said that if $P_0^D = P_1^{ND}$ then $E_1(\prod_A^D) \geq E_1(\prod_A^{ND})$. If $P_0^D = P_1^{ND} > \big(2.(4/(l+h))^{n-1}\big)/\big(1+(4/(l+h))^{n-1}\big)$ then A's expected period 1 payoff in the disclosure regime = $(e/2)\big((l+h)/2\big)$ is greater than A's expected period 1 payoff in the no disclosure regime = $eP_1^{ND}\big((l+h)/4\big)+e(1-P_1^{ND})(l/2)$. This implies $E_1(\prod_A^D) > E_1(\prod_A^{ND})$.

Denote B's total payoff in the disclosure regime by $\prod_B^D = \sum_{t=1}^{n}\big(\lambda_t m_t - k_t\big)$ and B's total payoff in the no disclosure regime by $\prod_B^{ND} = \sum_{t=1}^{n}\big(\lambda_t m_t - k_t\big)$.

Proposition 6. If $P_0^D = P_1^{ND}$ then $E_1(\prod_B^D) \leq E_1(\prod_A^{ND})$. If $P_0^D = P_1^{ND} > \big(2.(4/(l+h))^{n-1}\big)/\big(1+(4/(l+h))^{n-1}\big)$ then $E_1(\prod_B^D) < E_1(\prod_B^{ND})$.

Proof. If $t < n$ and $P_t^D > (4/(l+h))^{n-t}$, then B's expected period t payoff = $e\lambda_t/2 + e(l+h)/2$. If $P_t^D \leq (4/(l+h))^{n-t}$, then B's expected payoff $= e\lambda_t$. If $t < n$ and

$P_t^{ND} \geq 2.(4/(l+h))^{n-t} / \left(1+(4/(l+h))^{n-t}\right)$, then B's expected payoff $= e\lambda_t - el/2 + e(l+h)/2$. If $t < n$ and $P_t^{ND} < 2.(4/(l+h))^{n-t} / \left(1+(4/(l+h))^{n-t}\right)$ and $\lambda_t = l$, then B's expected payoff = *el*. If $t < n$ and $P_t^{ND} < 2.(4/(l+h))^{n-t} / \left(1+(4/(l+h))^{n-t}\right)$ and $\lambda_t = h$, then B's expected payoff $= eh - el/2 + e((l+h)/2)l/(l+h) = eh/2 + e((l+h)/2)h/(l+h) = eh$. Summarizing,

	B's Expected Period *t* Payoff in Disclosure Regime		B's Expected Period *t* Payoff in No Disclosure Regime
$P_t^D > (4/(l+h))^{n-t}$	$e\lambda_t/2 + e(l+h)/2$	$P_t^{ND} \geq \dfrac{2.\left(4/(l+h)\right)^{n-t}}{1+\left(4/(l+h)\right)^{n-t}}$	$e\lambda_t - el/2 + e(l+h)/2$
$P_t^D \leq (4/(l+h))^{n-t}$	$e\lambda_t$	$P_t^{ND} < \dfrac{2.\left(4/(l+h)\right)^{n-t}}{1+\left(4/(l+h)\right)^{n-t}}$	$e\lambda_t$

Comparing the payoffs from the table, it can be said that if $P_0^D = P_1^{ND}$ then $E_1(\prod_B^D) \leq E_1(\prod_B^{ND})$. If $P_0^D = P_1^{ND} > \left(2.(4/(l+h))^{n-1}\right)/\left(1+(4/(l+h))^{n-1}\right)$ then B's expected period 1 payoff in the disclosure regime = $(3/4)(l+h)$ is less than B's expected period 1 payoff in the no disclosure regime $= eh/2 + e(l+h)/2$. This implies $E_1(\prod_B^D) < E_1(\prod_B^{ND})$.

Choice between Regimes. From propositions 5 and 6, if a manager B has to choose between disclosure and no disclosure regimes, she will choose the no disclosure regime. On the contrary, if an investor A has to choose between disclosure and no disclosure regimes, she will choose the disclosure regime.

6. Conclusion

This paper examines how financial disclosure enhances the building of trust and trustworthiness to facilitate institutions for exchange and investment in complex economic settings where there is separation of ownership and control of key economic resources. In a setting with trustworthy and rational managers, choosing to disclose voluntarily is a natural act of the trustworthy manager which the rational manager mimics to receive additional future investments. However, a sequential equilibrium predicts that such mimicking will switch from being indiscriminate (or perfect) to selective in order to allow the rational manager to develop a reputation for being trustworthy. That is, a manager will find it optimal to use a strategy of selective disclosure over a strategy of full or perfect disclosure.

Disclosure and the concomitant credibility allow for a greater time of indiscriminate mimicking and in this sense, the institution of disclosure provides reputation building opportunities over and above those provided by the institution of dividend payment. Characteristic features of the period of perfect mimicking are higher probability of investment and higher probability of high returns on investment. By allowing for a greater time of perfect mimicking, disclosure results in greater investor-manager trust, higher investment and higher return.

While a manager's payoff will be higher in a world without disclosure, an investor's payoff will be higher in a world with disclosure. This implies that while a manager will prefer a world without disclosure, an investor will prefer a world with disclosure.

Given the complicated nature of the equilibrium described here, it is natural to ask if people actually behave as predicted and this calls for an empirical examination in future work. While disclosure has been argued to be a managerial talent signaling device, this paper abstracts away from this question to focus on reputation building. An unanswered question then is the role reputation building may play where managers have different abilities in that a better manager has a higher probability of obtaining the high yield.

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