Voluntary Disclosure: The Context Dependency of the Unraveling Result

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Abstract

The unraveling result identifies conditions under which senders who possess private information voluntary disclose all their private information. This paper puts the unraveling result and its underlying conditions in separate models with an identical context, in order to test their validity. These models show how the underlying conditions are individually shaped and only hold in their own specific contexts. In the context built in this paper, two conditions are unable to reject the unraveling result, suggesting that not all conditions are necessary for the unraveling result to hold in every possible context. This also implies that the unraveling result is not a closed book and requires further research in order to become a valid part of the theory on voluntary disclosure.

Introduction

Theories on disclosure in accounting are fairly unfinished and most of the existing literature on disclosure was written in the last four decades. Nonetheless, their importance is deemed significant by some. Dye (2001) shared his thoughts on the absence and importance of the development of such theories within the field of accounting, stating that, regarding the importance of mandatory disclosure within the field, research is falling behind. However, he also argues that one type of disclosure, being voluntary disclosure, has past the point of being worthy to be called a theory. This theory is generally interesting for its insights on how to interpret silence(e.g. when a sender with information chooses not to disclose this information). The unraveling result identifies the situation in which parties with private information voluntarily disclose all their private information. Once the party without information suspects that the party with private information conceals some if its information, expectations about the value of this information is being adjusted downwards (Milgrom, 1981). In this case all information unravels. However, in contrast to what the unraveling result suggests, full voluntary disclosure rarely occurs even for the most profit-maximizing firms (Dye, 2001). In order to explain why the unraveling result fails to hold for firm-disclosures in the accounting context, Dye argues that the essential underlying settings are absent in situations that do not resolve in full voluntary disclosure. Starting from the conditions formulated by Milgrom (1981) and Grossman (1980), Dye and Verrecchia (2001) discuss various models on information disclosure, resulting in market conditions necessary for information to fully unravel. Beyer et al. (2010) go on to formally list these conditions which are heavily based on the discussion between Dye and Verrecchia.

This paper models the unraveling result and its underlying assumptions (as argued by Beyer et al.) in order to question its theoretical validity and to further extent the literature on models of voluntary disclosure. Within the context of the constructed models, it is shown that a violation of most of the conditions does indeed to some extent prevent full voluntary disclosure. However, two conditions are unable to prevent full voluntary disclosure. All other models prevent disclosure to at least some extent, ruling out full voluntary disclosure and preventing the game to fully 'unravel'.

Although the unraveling result is commonly referred to in research, including signaling games, research on the unraveling result itself is fairly absent. The majority is rather focused on firm characteristics and their effect on the rates of voluntary disclosures made by those firms(e.g. Marston et al., 2002). Although Dye and Verrecchia laid the foundation, Beyer et al. are (one of) the first to list the conditions crucial for a signaling game to end in full voluntary disclosure (and therefore the unraveling result), i.e. a dynamic Bayesian game with a sender and a receiver. Once these conditions hold, the sender will have an incentive to disclose all possible outcomes (except for the worst possible one), based on the reasoning that withholding information causes a rational receiver to think that the actual outcome is lower than the average of the distribution. This forces the sender to disclose outcomes lower than this average, which moves the expected value of the outcome downwards. Withholding information once more again causes the receiver the estimate the outcome downwards, repeating the previous process and eventually resulting in a sender fully disclosing all possible outcomes. However, if there are factors justifying the sender's choice to withhold information, the sender cannot be sure about the real outcome, since the sender can have legitimate reasons to do so. The unraveling therefore indirectly suggests that any legitimate reason for the sender to withhold information prevents full voluntary disclosure. The six conditions formulated by Beyer et al. all formulate such a possible reason.

First off, disclosing information must be costless to the sender in order for disclosing to be the most profitable strategy in every possible value of private information (Jovanovic, 1982). The sender should always disclose his private information when the benefits of doing so outweigh the costs. Assuming zero costs suggests that the costs can never outweigh the benefits and therefore never prevent disclosure, but once this is not the case, the sender has an incentive not to disclose his private information. Secondly, the receiver must know for sure that the sender has, in fact, private information. Otherwise, receiving no information from the sender could suggest that the sender has no private information to send. This gives the receiver less information and opens up the possibility for the sender to withhold information without the receiver estimating the value of the sender's private information at its minimum (Dye, 1985). Thirdly, all receivers must react identical to disclosure. In other words, the utility function of the receiver is known to the sender, allowing the sender to predict the strategy of the receiver. Suijs (2007) argues that once the probability of a receiver underinvesting is sufficiently high, senders are inclined to withhold information. In the same sense, once a sender cannot be sure about the strategy of the receiver and has reason to belief this strategy may be less beneficial than withholding information, the sender is not likely to disclose his private information. Fourthly, the receiver must be sure about the intentions of the sender (Einhorn, 2007). For example, a car salesman wants to sell the car to the receiver, rather than not wanting to sell the car. Fifthly, disclosure must be verifiable, indicating that the receiver can be sure that the value of the information is indeed 'x' when receiving 'x' from the sender. This rules out the possibility for the sender to lie to the receiver. Only when the interests of the sender and the receiver are not 'too' far apart, the game won't end in a babbling equilibrium, where the receiver ignores the sender's messages (Stocken, 2000). Full voluntary disclosure can only occur when interests are identical or when truth telling is compulsory. Lastly, the sender is not able to commit to any strategy before actually obtaining private information. A sender who credibly commits to not disclosing information can force a none-zero reaction from the sender, since sending no information does not necessarily indicate the lowest possible value of information. Verrecchia (2001) shows how the possibility of ex-ante commitment to a disclosure strategy allows the sender to successfully withhold private information, without the receiver estimating the value of the private information at its worst possible outcome.

Each of these conditions was constructed in different models, indicating that they could be context reliable. Next to that, some discussions about the conditions' characteristics were built on reasoning rather than actually testing the validity of the conditions (e.g. the discussion between Dye and Verrecchia on the type of cost of disclosure, rather than testing the outcomes regarding voluntary disclosure). The unraveling result however, is not context specific and suggests that these conditions are universal. This paper collects all these different models and puts them into the same context in order to exam whether all conditions prevent full voluntary disclosure, which if not the case, arguably puts weight on the validity and reliability of the conditions, both as argued by Beyer et al. and Dye.

The model

Every condition is added to the 'standard model'. The standard model consists of an interaction between two players; an investor i and a manager M. The investor has the option to invest in project z, but the investor does not have information on the profitability of project z. The profitability of project *z* depends on the value of $x \in [0,1]$. The value of *x* is only known to the manager. The manager can send two different messages, $m \in \{x, \phi\}$, to the investor. $m = x$ contains the value of x and $m = \phi$ contains no information (empty message). The investor then decides which amount *I* to invest in project *z*. Both the investor's and manager's payoff function depend on both x and i:

- $U_i = -(I - x)^2$
- $U_M = I * x$

Maximizing the utility function of the investor with respect to *I* gives $I = x$, which indicates that the investor prefers to invest an amount I equal to x. The manager simply prefers I to be as high as possible, as long as $x > 0$. If $x = 0$ the manager does not care about the value of I, since his payoff will be 0 regardless of *I*. The investor prefers I to be as close as possible to x, since the bigger the difference between I and x, the higher the utility loss for the investor.

Since the manager prefers I to be as high as possible, sending $m = x$ for a value of $x = A$ results in the manager always sending $m = x$ when $x > A$. In the same way, when the manager sends $m = \phi$, he will always send $m = \phi$ when $x < A$. Whether the manager prefers to send message $m = x$ or $m = \phi$, depends on the manager's threshold; the minimum value of x for which the manager prefers to send $m = x$ over $m = \phi$ and let $A \in [0,1]$ represent this threshold.

The Timing of the game is as follows.

- Nature draws x and the manager observes x
- The manager sends message $m \in \{x, \phi\}$ to the investor
- Investor receives m and invests amount I
- Payoffs are realised.

If the investor receives $m = x$, he knows the true value of x and will always set I=x. However, receiving $m = \phi$ forces the investor to estimate the expected value of x (= $E(x|\phi)$). In this model, the manager sends $m = \phi$, only when $x < A$ (he is indifferent between $m = x$ and $m = \phi$ when $x = A$). $E(x|\phi)$ is then equal to ½A.

Equilibrium

The game is in equilibrium once the manager does not want to deviate from his current strategy. The investor's strategy will always depend on the manager's strategy, since the message that he receives is crucial for his decision of I. If he receives $m = x$, he sets $I = x$ and when he receives $m = \phi$, he sets $I = E(x|\phi)$. Since the manager uses a threshold strategy, the equilibrium of the game depends on his point of indifference. Recall that the manager is indifferent between sending $m = x$ and $m = \phi$ when $x = A$. Sending $m = x$ at this point gives him $U_M = A * A = A^2$, since $x = A$ and $I = x$. sending $m = \phi$ gives him

$U_M = ½A * A = ½A^2$. Solving $A^2 = ½A^2$ gives $A = 0$, indicating that the manager is indifferent between sending $m = x$ and $m = \phi$, when $x = 0$. This leads to the first proposition.

Proposition: In the standard model, the manager uses a threshold ($A \in [0,1]$) strategy to determine which message $m \in \{x, \phi\}$ to send to the investor. Then a perfect Bayesian equilibrium in dynamic strategies exists, in which the manager always sends $m = x$ and the investor invests $I = m$, if and only if $x > 0$.

It follows from the equilibrium that in the standard model managers do indeed disclose their private information, regardless of the value of x. Not disclosing information when $x > 0$ suggests that x is below the threshold of the manager and results in the investor estimating $E(x|\phi)$ at half of the manager's threshold. However, the real value of x can be below this estimated value which gives the manager an incentive to lower his threshold, in order to increase his payoff, which then results in the investor also lowering his estimation of $E(x|\phi)$. Again, the manager has the incentive to lower his threshold further, eventually resulting in the lowest possible threshold; $A = 0$. The standard model therefore results in the unraveling result.

However, according to Beyer et al.(2010), for the unraveling result to hold, its six conditions have to be met:

- Disclosing private information is costless
- Investors know that firms have private information
- All investors interpret firm disclosure in the same way and firms know how investors will react to disclosed information
- Managers want to maximize firm share prices
- Firms can credibly disclose their private information
- Firms cannot commit to any disclosing strategy prior to obtaining private information

The following models all include one of these conditions as if they are not met.

Disclosure costs model

The first of the underlying assumptions of the unraveling result is that disclosure is costless to the manager. However, disclosing information can come at a cost. Including a disclosure cost c into the previous model changes the utility function of the manager and moves the equilibrium. The utility function of the investor remains the same and the new utility function of the manager is $U_M = I * x - d$, where $d = 0$ when the manager sends $m = \phi$ and $d = c$ when the manager sends $m = x$. From this new utility function, it is clear that the manager will not disclose information once the costs of doing so are higher than the benefits. Not sending any information is costless for the manager.

The timing of the game including disclosure costs is as follows.

- Nature draws *x* and the manager observes *x*

- The manager sends message $m \in \{x, \phi\}$ to the investor.

- Investor receives *m* and invests amount I

- Payoffs are realised.

If the investor receives $m = \phi$, the investor has to estimate $E(x|\phi)$, just as the standard model (and for all following models). The manager knows that when he sends $m = x$, the investor sets $I = x$, giving the manager information about his payoff when sending $m = x$, which is $x^2 - c$. Recall from the standard model; $E(x|\phi) = \frac{1}{2}A$, which is the value if I the investor sets after receiving $m = \phi$.

Equilibrium

All values of x lower than the indifference point of the manager result in the manager sending $m = \phi$ and all values above this point result in the manager sending $m = x$. Again, note that at the indifference point $A = x$. The indifference point of the manager lies at $A^2 - c = \frac{1}{2}A^2$, which gives $A = \sqrt{2c}$. The indifference point depends on the cost of disclosure, which is logical, considering higher disclosure costs lower the payoff from disclosing private information. If $x < \sqrt{2c}$, the manager sends $m = \phi$ and if $x > \sqrt{2c}$, the manager sends $m = x$. Note that since $x \in [0,1]$ and $c \in [0,1]$, for any $c > \frac{1}{2}$ the manager always sends $m = \phi$. This leads to the second proposition.

Proposition: In the disclosure cost model, the manager suffers a cost c when disclosing information, which affects his decision of which message $m \in \{x, \phi\}$ to send to the investor. Then depending on the value of c, two perfect Bayesian equilibria in dynamic strategies can be distinguished:

(i) an equilibrium exists, in which the manager always sends $m = x$, if and only if $x > \sqrt{2c}$.
(ii) an equilibrium exists, in which the manager always sends $m = \phi$, if and only if $x < \sqrt{2c}$.
In equilibrium (ii), all values of c where $c > \frac{1}{2}$, result in the manager sending $m = \phi$, regardless of x.

From the equilibrium it is clear that the manager is less inclined to disclose his private information for higher values of c, which is not surprising as a higher cost of disclosure lowers the payoff of disclosing, regardless of the value of x. The investor is aware of the fact that receiving no information can be due to high disclosure costs, which causes the manager to estimate $E(x|\phi)$ above 0, which is not the case in the standard model. This also gives the manager an incentive to send no information for values of x that are above 0, since this can result in a payoff bigger than 0 also in contrast with the standard model. The investor anticipates on this incentive and uses this information to again estimate $E(x|\phi)$, eventually resulting in the equilibrium as found above. Once $c > \frac{1}{2}$ the manager never sends his private information, since his maximum payoff of disclosing will always be lower than his payoff from sending no information.

Probabilistic information endowment model

The second assumption is that the manager observes the value of *x,* which indicates that the manager always has information. However, it could be that the manager does not observe *x.* This possibility should be taken into account by the investor when interpreting a received message. Let *p* be the chance that the manager observes *x.* In the standard model, if the investor receives $m = \phi$, he knows that $x = 0$. Receiving $m = \phi$ in the situation where the manager does not always observe *x,* means that there is a chance of $1 - p$ that $x \geq 0$. Including the threshold *A* of the manager, the investor does not know for sure whether *x* is below *A* or *x* isn't observed by the manager.

The timing of the game where the manager might not observe *x* is as follows.

- Nature draws *x* and the manager observes *x* with a chance *p*
- If the manager observes *x,* he sends message $m \in \{x, \phi\}$ to the investor.
- If the manager does not observe *x,* he sends message $m = \phi$
- Investor observes p, receives message m and invests amount I
- Payoffs are realised.

Receiving $m = x$ results in the investor investing $I = x$, which remains the same as in previous models. Calculating $E(x|\phi)$ however, differs given the possibility that the manager does not actually have private information.

Observing $m = \phi$ then gives two options with the following probabilities. The first is that the manager does observe *x,* but *x* is below his threshold. The probability that this happens is equal to $\frac{p*A}{p*A+(1-p)}$, since the chance of $x < A$ is equal to A. The expected value of *x* in this situation is equal to ½A. The second option is that the manager does not observe *x,* which happens with probability $\frac{(1-p)}{p*A+(1-p)}$ and has expected value $x =$ ½. $E(x|\phi)$ will then be equal to $\frac{p*A}{p*A+(1-p)} * \frac{1}{2}A + \frac{(1-p)}{p*A+(1-p)} * \frac{1}{2} = \frac{p*\frac{1}{2}A^2+(1-p)\frac{1}{2}}{p*A+(1-p)}$.

Equilibrium

The indifference point for the manager when observing x is equal to A, which results in $U_M = A^2$.The manager is then indifferent between sending $m = x$ and $m = \phi$ when $A^2 = \frac{p*\frac{1}{2}A^2+(1-p)\frac{1}{2}}{p*A+(1-p)} * A$. Solving this for A results in $A = \frac{p+\sqrt{1-p}-1}{p}$ when $p \neq 0$ and $A = \frac{1}{2}$ when $p = 0$

Proposition: In the probabilistic information endowment model, the manager observes x with a chance p, which causes uncertainty about whether the manager has indeed private information. Then depending on the value of p, two perfect Bayesian equilibria in dynamic strategies can be distinguished:

(i) an equilibrium exists, in which the manager always sends m=x, if and only if $x > \frac{p+\sqrt{1-p}-1}{p}$

(ii) an equilibrium exists, in which the manager always sends $m = \phi$, if and only if $x < \frac{p+\sqrt{1-p}-1}{p}$

If $p = 1$, the investor knows that the manager observed x and the game will continue in the same way as the standard model. Once the probability that the manager observed x decreases, the bigger the probability that $E[x] = \frac{1}{2}$. The estimation of x by the investor will simply increase from 0 to ½ once p starts decreasing from 1 to 0. At 0, the investor knows for sure that the manager did not observe x, resulting in $E(x|\phi) = \frac{1}{2}$.

Uncertain investor response

Another underlying assumption of the unraveling result includes an identical utility function for all investors, since people with the same utility functions will take identical actions in identical situations. Next to that, this utility function is common knowledge. If the assumption does not hold, managers do not have perfect knowledge on how an investor is going to react to the different messages. Although it would be illogical to assume that investors increase their investments for lower values of *x,* the exact investment cannot be predicted by a manager. Let's assume that the manager has one of the following possible utility functions:

- $U_{i1} = -(I - x)^2$
- $U_{i2} = -(I - (x + a))^2$

Let d be the probability that the investor is a type 1 invester and $1 - d$ be the probability that he is a type 2 investor. A type 1 investor behaves according to the standard model and prefers to invest $I = E(x|d)$, whereas a type 2 investor prefers to invest $I = E(x + a|d)$. The expected value of x for the investor depends on d since it is taken into account by the manager when deciding upon which message to send. The timing of the game where the investor's preferences are not known is as follows.

- Nature draws *x* and the manager observes *x*
- The manager sends message $m \in \{x, \phi\}$ to the investor
- Investor receives *m* and invests amount I
- Payoffs are realised.

The expected utility of the manager when sending $m = x$ is then equal to $dx^2 + (1-d)(x^2 + xa) = x^2 + xa - dxa$ and when sending $m = \phi$ the expected utility is equal to $dx * E(x|d) + (1-d)\big(x * E(x + a|d)\big)$.

Equilibrium

Whether the manager discloses his private information depends on his indifference point, which lies at the manager's threshold A. Comparing the expected utilities of sending $m = x$ and $m = \phi$, when $x = A$ then results in this point of indifference for the manager. Note that since $x = A$; $E(x|d) = \frac{1}{2}A$ and $E(x + a|d) = \frac{1}{2}A + a$. Solving $A^2 + Aa - dAa = dA * \frac{1}{2}A + (1-d)\left(A(\frac{1}{2}A + a)\right)$ results in $A^2 = \frac{1}{2}A^2$, which only holds for $A = 0$.

Proposition: In the uncertain investor response model, the manager does not have perfect information on the utility function of the investor, which results in uncertainty for the manager on how the investor will react. Then depending on the investor's type, a perfect Bayesian equilibrium in dynamic strategies can be distinguished:

(i) an equilibrium exists, in which the manager always sends $m = x$ after which a type 1 investor invests $I = m$ and a type 2 investor invests $I = m + a$, if and only if $x > 0$

As shown above, the manager's strategies does not depend on either a or d. This can be explained by the fact that sending $m = \phi$ can never result in a higher investment then sending $m = x$, regardless of the investor's type. Even when sending $m = \phi$ results in a positive investment ($I > 0$), due to a positive value of a, sending $m = x$ will then result in $I = x + a$. This is always bigger than $I = a$, since x can only be positive. Within the model as described above , the unraveling result still holds when the underlying assumption that all investors react the same to disclosures does not hold.

Uncertain disclosure incentives model

There exist reasons for which managers prefer to lower their firm's share prices. For example, if the manager is sure he will receive a certain bonus amount in stock options at the end of a year, then he has an incentive to reduce share prices, since this would grant him more shares. Next to that, it could be that the investor is not aware of the link between the manager in the investment. For example, it could be that the investment in question benefits a competitor of the manager and not the manager himself. It is reasonable to think that the manager therefore suffers a disutility if the investment project is successful. This results in the possibility that the manager prefers to have as little as possible invested in the project as well as a low value of x. This results in two possible manager types, $T \in \{g, b\}$, where g is the good type who prefers the investment project to be very profitable, while b is the bad type who prefers the project to be unprofitable, assuming that the project's profitability is increasing in both *x* and *I.* The two types mainly differ in their utility functions:

- $U_{Mg} = I * x$
- $U_{Mb} = -I * x$

With a probability *p*, the manager is the good type, and is the bad type with probability $1 - p$. The bad manager prefers both *I* and *x* to be as low as possible, just as a good manager prefers both to be as high as possible. The timing of the game where the investor does not observe the manager's type is as follows.

- Nature draws *x* and the manager observes *x*
- With probability *p*, the manager is a good type and sends message $m \in \{x, \phi\}$ to the investor
- With probability $1 - p$, the manager is a bad type and sends message $m \in \{x, \phi\}$ to the investor
- Investor receives *m* and invests amount I
- Payoffs are realised.

From the manager's point of view, this model is identical to the standard model, since there are no uncertainties or additional factors included in his utility function. The manager simply uses a threshold strategy, where the value of A depends on his type. So we have threshold A_g and A_b for the good type and the bad type respectively. Note that the threshold of the bad type indicates all values of x for which the bad type manager sends $m = x$ instead of $m = \phi$, since the bad type prefers a low investment.

When the investor receives $m = x$, the game will continue the same as previously discussed games, where the investor invests $I = x$. Receiving $m = \phi$ is what makes things complicated for the investor. $E(x|\phi)$ fully depends on p in this context. The expected value of x given that the manager is the good type is equal to $½A_g$ and equal to $½\ (1 + A_b)$ if the manager is the bad type. Note that the expected value of x for the bad type is based on a threshold that decreases once it gets closer to 1, instead of 0 as with the good type. This results in $E(x|\phi) = p * ½A_g + (1 - p) * ½\ (1 + A_b)$

Equilibrium

The manager knows his type beforehand and acts according to that type's interests. This implies that the two types of managers can make different decisions.

The good type has his indifference point at A_g, which results in payoff A_g^2 when he sends $m = x$ and in payoff $A_g(p * ½A_g + (1-p) * ½\,(1 + A_b))$ when he sends $m = \phi$. Setting $A_g^2 = A_g(p * ½A_g + (1-p) * ½\,(1 + A_b))$ results in $A_g = \frac{(A_b+1)(p-1)}{p-2}$.

The bad type has his indifference point at A_b, which results in payoff $-A_b^2$ when he sends $m = x$ and in payoff $-\left(A_b * \left(p * ½A_g + (1-p) * ½\,(1 + A_b)\right)\right)$when he sends $m = \phi$. Setting $-A_b^2 = pA_g^2 - \frac{1}{2}A_g^2 - 2pA_g + 1.5A_g + p - 1$ results in $A_b = \frac{p(A_g-1)+1}{p+1}$. Substituting A_g into the bad types indifference point gives $A_b = \frac{p\left((\frac{(A_b+1)(p-1)}{p-2})-1\right)+1}{p+1} = 1 - p$ and substituting A_b into the bad types indifference point gives $A_g = \frac{((\frac{p(A_g-1)+1}{p+1})+1)(p-1)}{p-2} = 1 - p$. This indicates that both types have the exact same indifference point. The only difference is that they will send the opposite message compared to the other type for every possible value of x. Given the thresholds of both types, the investor estimates $E(x|\phi) = 1 - p$. This leads to the following proposition.

Proposition: In the uncertain disclosure incentive model, the manager is a good type with probability p and a bad type with probability 1-p, which results in uncertainty about the managers intentions for the investor. Given the two different possible types of managers, two perfect Bayesian equilibria in dynamic strategies can be distinguished:

(i) an equilibrium exists, in which a good manager always sends $m = x$ and the investor invests $I = m$, and a bad manager always sends $m = \phi$ and the investor invests $I = 1 - p$, if and only if $x > 1 - p$

(ii) an equilibrium exists, in which a good manager always sends $m = \phi$ and the investor invests $I = 1 - p$, and a bad manager always sends $m = x$ and the investor invests $I = m$, if and only if $x < 1 - p$

When receiving $m = \phi$, the investor's only reference point is the value of p indicating the chance that the real value of x is below $1 - p$. The higher p, the bigger the chance (when receiving $m = \phi$) that x is below $1 - p$. On top of that, increases in p also decrease the value of $1 - p$ showing how $E(x|\phi)$ decreases in p. Also note that once p is either equal to 0 or 1, both types' thresholds practically disappear, resulting in the manager always sending $m = x$ as in the standard model. this is unrelated to the manager's type since there is no uncertainty about the manager's type at $p = 0$ or $p = 1$.

Non-verifiable disclosure model

In a game where firm disclosure is non-verifiable by the investor, the game-settings are different from the previously discussed models. Once the investor cannot be sure about the real value of x when receiving $m = x$, there exists the possibility for the manager to lie about this value, which is not an option in any of the previous models. Next to that, considering what the manager prefers compared to what the investor prefers, preferences are thus far apart that in the current context all games would result in a babbling equilibrium (Stocken, 2000). In order to construct a more realistic and informative game, the utility function of the manager is adjusted resulting in the next utility functions for the manager and the investor:

- $U_M = -(I - (x + d))^2$
- $U_i = -(I - x)^2$

Where d equals the initial disposition of the manager regarding the investment. This context is similar to the one used by Gibbons (1992). Note that when $d = 0$ interests of the investor and the manager fully align. Note that in this context, sending no information is not an option. For simplicity, let's assume that the manager can only send two different messages; $m \in \{m_1, m_2\}$. Where m_1 indicates a 'low' x and m_2 indicates a 'high' x. The investor estimates $x = [0, r)$ when he receives $m = m_1$ and $x = [r, 1]$ when he receives $m = m_2$. The timing of the game where disclosure is unverifiable is as follows

- Nature draws *x* and the manager observes *x*
- Manager sends message $m \in \{m_1, m_2\}$
- Investor receives *m* and invests amount I
- Payoffs are realised.

The investor estimates $E[x] = \frac{1}{2}r$ when receiving $m = m_1$ and $E[x] = \frac{1}{2}(1 + r)$ when receiving $m = m_2$. In order for the m to contain actual information for the investor, the investor must be sure that the manager prefers $I = \frac{1}{2}r$ over $I = \frac{1}{2}(1 + r)$ when sending $m = m_1$ and $I = \frac{1}{2}(1 + r)$ over $I = \frac{1}{2}r$ when sending $m = m_2$. Otherwise, the manager has an incentive to lie, giving the investor no information on the real value of x.

Equilibrium

In order for the investor to receive some information about x, the indifference point of the manager must be at r. Once the manager's indifference point differs from r, there exists values for x for which the manager has an incentive to lie. This in return causes the investor to receive no information. The value of d that result in indifference point r is found solving $E(U_m | m = m_1) = E(U_m | m = m_2)$ for $x = r$. Given that $E(U_m | m = m_1) = -\Big(\frac{1}{2}r -$

$(x+d)\Big)^2$ and $E(U_m|m=m_2)=-\left(\frac{1}{2}(1+r)-(x+d)\right)^2$, this equation can be written as $-\left(\frac{1}{2}r-(r+d)\right)^2=-\left(\frac{1}{2}(1+r)-(r+d)\right)^2$, which results in $r=\frac{1}{2}-2d$. Depending on the message that the investor receives, d must be such that the above criterion is met in order for the investor to believe the manager. Note that r is bound to the interval [0,1], which indicates that the criterion is immediately violated once d takes on a value outside the interval $[-\frac{1}{4},\frac{1}{4}]$. Any value of d outside this interval directly results in no information being transferred between the manager and the investor.

Proposition: In the non-verifiable disclosure model, the investor is receives a message only indicating whether x is 'low'($x=[0,r)$) or 'high'($x=[r,1]$) from the manager. Then depending on the value of d and r, a perfect Bayesian equilibrium in dynamic strategies can be distinguished:

(i) an equilibrium exists, in which the manager send $m=m_1$ when $x<r$, and the investor invests $I=\frac{1}{2}r$, and the manager send $m=m_2$ when $x>r$, and the investor invests $I=\frac{1}{2}(1+r)$, if and only if $r=\frac{1}{2}-2d$

The discussion above shows that some information can be obtained by the investor as long as interests are not 'too' far apart. Next to that, d must be such that the indifference point of the manager lies at r. Otherwise, the manager has an incentive to lie for some possible values of x. Once these requirements are not met, the game will simply end in a babbling equilibrium where the message of the manager does not influence the investment decision of the investor.

Ex-ante commitment to disclosure strategies model

The last assumption of the unraveling results is that managers cannot decide upon a strategy before observing x. Allowing the manager to do so results in the manager sending a message that he decided to send before observing x. For example, if the manager decides to commit to sending $m=\phi$, the investor does not receive any information regarding the true value of x. Including the possibility that the manager can decide whether to send $m=x$ or $m=\phi$ before observing *x* results in a game with the following timing.

- Manager commits to sending message $m=x$ or $m=\phi$ to the investor with probability p and does not commit with probability $(1-p)$
- Nature draws *x* and the manager observes *x*
- Manager sends message $m\in\{x,\phi\}$
- Investor receives *m* and invests amount I

- Payoffs are realised.

The investor knows that the manager can commit to one message, which means that receiving $m = \phi$ indicates that the manager committed to sending no information or the value of x is lower than the manager's threshold. The game also includes two types of manager's; committing and non-committing manager's. In this game, committing is not a choice for the manager. Allowing the manager to choose whether to commit or not, renders the value of p meaningless and prevents the investor from making any accurate estimations of x. The investor only observes m and not whether this message is send by a committing or non-committing manager. This indicates that from the investor's perspective the expected value from a committed $m = \phi$ is equal to $E[x] = \frac{1}{2}$ and a none-committed $m = \phi$ is equal to $E[x] = \frac{1}{2}A$. This results in $E(x|m = \phi) = \frac{p}{zp+A(1-p)} * \frac{1}{2} + \frac{A(1-p)}{zp+A(1-p)} * \frac{1}{2}A = \frac{p+A^2(1-p)}{2zp+2A(1-p)}$, where z equals the chance that a committing manager sends $m = \phi$. A manager who commits to a certain message, has an expected utility equal to $\frac{1}{2} * \frac{1}{2} = \frac{1}{4}$ when sending $m = x$ and equal to $\frac{1}{2} * (\frac{p+A^2(1-p)}{2zp+2A(1-p)})$ when sending $m = \phi$. A manager who does not commit observes x and receives $U_M = x^2$ when sending $m = x$ and $x * (\frac{p+A^2(1-p)}{2zp+2A(1-p)})$ when sending $m = \phi$.

Equilibrium

Since there are two types of managers in this scenario(committing and non-committing), there will also be two indifference points. First off, the committing manager's indifference point is found by solving $\frac{1}{4} = \frac{1}{2} * (\frac{p+A^2(1-p)}{2zp+2A(1-p)})$. Note that the most right term functions as an average of the expected values of committed and non-committed empty messages. The higher the probability p of a committed empty message, the closer the investor estimates $E[x]$ towards $\frac{1}{2}$, while a lower p forces the investor to estimate $E[x]$ towards $\frac{1}{2}A$. Note that A can never go above 1, indicating that the average of these two estimations is never higher than $\frac{1}{2}$, regardless of the value of z. A committing manager therefore never strictly prefers sending $m = \phi$ over sending $m = x$.

The investor thus knows that a committing manager never sends $m = \phi$, indicating that receiving $m = \phi$ reveals the manager's type, being the non-committed manager.

Proposition: In the ex-ante commitment strategy model, the manager commits to a certain message m before observing x with probability p. Then one perfect Bayesian equilibrium in dynamic strategies can be distinguished:

(i) an equilibrium exists, in which a committed manager always sends $m = x$ and the investor invests $I = m$, and a non-committed manager always sends $m = x$ and the investor invests $I = m$, if and only if $x > 0$

In the end, the outcome of the game is identical to the outcome of the standard model; sending $m = \phi$ cannot fool the investor into thinking that the manager sends $m = \phi$ before observing x, resulting in the unraveling result.

Discussion & Conclusion

Although the majority of the models are able to prevent full voluntary disclosure in the given context, two models are not able to prevent the manager from disclosing his private information regardless of the value of his information. As for the first condition, since both I and x cannot take on negative values, not knowing the investors intentions can never lead to a lower payoff for the manager when sending $m = x$ compared to sending $m = \phi$. The second condition, in ex-ante commitment strategy model, committing manager have a strong preference for disclosing information rather than withholding information. This prevents the non-committing manager from credibly mimicking the committing managers, resulting in full voluntary disclosure. Changing the context could result in alternative findings, but taking the goal of this paper in mind would also indicate that the context has to be changed identically for all other models. Still, finding a context where the unraveling result does not hold for all models doesn't change the fact that there exists at least one context in which at least two of the conditions are unable to reject the unraveling result.

In conclusion this paper shows that the unraveling result is context dependent, rather than a general rule. This puts doubt on the conditions argued by Beyer et al., suggesting that either the unraveling result does not follow a strict list of assumptions and rather functions as a general term describing situations in which full voluntary disclosure occurs, or at least one of the conditions in question is not strictly preventing full voluntary disclosure and should arguably be revised or taken out. Next to that, it supports the argument by Dye that not enough research has been done on the subject and that we are still not at the point of developing an accurate theory on disclosure strategies. It also puts doubt on the arguments of Dye and Verrecchia on ex-ante commitment to disclosure strategies. The context within their argument differs a lot from the context of other conditions which, as shown in this paper, does not necessarily hold for other contexts. This shows once again how context dependent the underlying conditions of the unraveling result are. In conclusion, this paper has shown the need for further research on voluntary disclosure, especially on the conditions that are either incomplete or incorrect. It could also be that one or more conditions are missing for now.

Further research could venture in two slightly different directions. First off, the results obtained in this paper are bound to the chosen model and its characteristics. Different contexts could provide different results where all conditions could indeed prevent full voluntary disclosure, suggesting that the unraveling result only fully applies to specific interactions rather than all. Secondly, the conditions formulated by Beyer et al. could be incomplete in the sense that some legitimate conditions are not included or that some are not formulated specifically enough.

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