Information Cascades, Herding and Emotional Investors in an IPO: Rational Decision-Making Distorted by Phantasy

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Abstract

This paper adds to existing Information Cascade Models and Emotional Finance by developing a herding model that examines the effects of phantastic investors on the decisions of rational investors under dynamic pricing in an IPO scenario. The presence of irrational, phantastic herding in an IPO scenario leads to price inflation caused by irrationality. This reduces the likelihood of rational investors taking part in a new issue. Positive cascades by rational investors are completely eliminated when emotional investors view the new issue as infallible, and in some cases, negative abstaining cascades happen with certainty, regardless of previous rational investors' decisions. When emotional investors are overcome by hatred towards the new issue, rational investors are now encouraged to invest in a new issue and, in some cases, will ignore their private information in order to conform with previous rational investors' decisions. Thus, emotional investors cause the market to be stressed as they all herd, initially by investing and then abstaining. We find that herding in times of market stress by emotional investors can lead to rational herding, but in the opposite direction.

1. Introduction

Traditionally, research in financial markets has been based upon the assumption that agents are fully-rational, self-interested, non-psychological, unemotional, maximisers of expected utility (the ‘homo economicus’ approach). In a recent development, behavioural finance recognises that real-world humans are less than fully rational (bounded rationality), emotional , and subject to psychological biases (the ‘homo sapiens’ approach). In an even more recent paradigm shift, Taffler and Tuckett have initiated a new area of research arising from behavioural finance, namely, emotional finance. This area of research examines the effect of unconscious emotions, in a Freudian psychoanalytical framework, on investors’ (and manager) behaviour in the financial market s.

This development of research is mirrored in the theoretical work on herding behaviour. The early herding models were based on rational behaviour. Each investor decides sequentially whether to invest or not. When making this decision, each Investor gains a private signal, and also observes all of the previous investors’ decisions (to invest or not). From observing the previous investors’ decisions, the rational investor rationally forms expectations of the previous investors’ signals. He uses these signals to make his investment/abstain decision. If his expectations of the other investors’ private signals overwhelms his own signal, he will make his decision to follow the herd: hence, in this framework, herding is rational.

The later herding models introduced behavioural finance. In these models, herding is driven by behavioural factors, such as envy, anger, regret: however, all of these emotions are consciously anticipated. Thus, in this paper, we make a major contribution by being the first to develop an emotional finance Herding framework, in which unconscious emotions play a major role.

1.1. Emotions and Herding

A fundamental problem with the majority of financial theory is the absence of models that mimic or show the effect of an investor’s emotions that often overwhelm and dictate decisions. “Much of finance is modeled in a Robin Crusoe economy-isolated from the social system from which it is a part” (Nofsinger, 2005, pp.144).

Since the introduction of the Efficient Market Hypothesis, CAPM and Expected Utility Theory, there have been numerous papers that find contradictory evidence of these long-standing, firmly-rooted theories. For example, Fischoff et al.’s (1977) work on investor overconfidence, Lord et al.’s (1979) belief perseverance and Chang et al.’s (2000) evidence of investors herding towards the market.

Adding to this evidence, the last decade or so has seen a paradigm shift from Behavioural to Emotional Finance, where the effects of emotions like love, hate, greed and shame are examined and used to explain contemporary phenomena such as the Internet Bubble and its subsequent collapse (Cooper et al., 2001 and Taffler and Tuckett, 2005). This shift did not create an isolated school of thought, but rather it encompassed and built upon previous work on Rational and Behavioral theory.

Importantly, this shift dismisses assumptions that decision-makers are purely rational and ignore emotional impulses. Instead, a century's worth of psychology, and in particular psychoanalysis, is combined with existing Financial Theory to model various types of irrationality that present themselves time and time again in financial markets.

In our emotional finance herding model, we combine the works of Taffler and Tuckett (2005) and Fairchild (2009), and the Information Cascade models of Banerjee (1992), Bikhchandani et al. (1992) and Welch (1992) to create a model that introduces the Freudian (1911,1916) phantastic object into an IPO scenario, as well as dynamic pricing to see what effects this has on rational investor cascading. Furthermore, this idea is rooted in Shiller's (1990) work on "fads" within IPOs, which contradicted the traditional underpricing theories and first brought irrational investors into an IPO scenario.

The work of Shiller (1990) introduces the idea that investors believe in ''fads" in the IPO market. After conducting a thorough survey on investors' decisions, he finds that most investors buy stocks based on what stocks they think are becoming attractive to other investors rather than on a rational basis of a stock's potential profits or future dividends. Such theory of investor psychology, which contradicts rational expectation theory.

Our model is an extension of the early information based cascade models. We review these, in detail below, as well as give the necessary definitions.

1.2. Financial Market Herding

Bikhchandani and Sharma (2000, pp.3) define herding behaviour as follows: "An individual can be said to herd if she would have made an investment without knowing other investors' decisions, but does not make that investment when she finds that others have decided not to do so". They also give reasons for why a profit-maximising investor would disregard their own thought-out decision in favor of imitating the actions of others. For example, other investors' private information may be revealed through their actions so mimicking them may lead to a successful investment decision.

Hirshleifer and Teoh (2003, pp.28) define an Informational Cascade as “Observational learning in which the observation of others (their actions, payoffs, or even conversation) is so informative that an individual’s action does not depend on his own private signal”. By such reasoning, any private information that an investor has received will be ignored in favour of inferences they make from publically available information.

A positive cascade is a situation when public information leads to repeated “invest” decisions. Thus, a negative cascade is a situation when public information leads to repeated “do no invest” decisions.

Basic information based herding models are put forward by Banerjee (1992), Bikhchandani et al. (1992) and Welch (1992). Under such models, it is assumed that the same investment is available to all investors at the same price although they invest sequentially. Welch’s (1992) model in particular is in reference to a fixed-price IPO setting. Each investor receives either a good or bad signal concerning their investment decision and the probability of receiving either signal depends on the payoff they receive. Each investor updates their beliefs according to the actions of previous investors by using conditional probabilities under Bayes’ Law.

The first investor, acting rationally, will follow their signal and invest if their signal was good and doesn’t invest if the signal was bad. Even though the second investor cannot see the first investors’ signal, it can infer from their investment decision what signal they received. In the situation where the first investor does not invest but the second investor receives a good signal, it is as if he has received both a good and bad signal, so is left with a decision equivalent to a coin toss. The situation where the first investor invests and the second receives a bad signal is identical.

The crucial determinant of whether an Information Cascade is initiated is the action of the third investor.

If the first two investors invest then so will the third, even if they have received a bad signal, since they assume the first two both received good signals. Any investor after the third investor will learn nothing from the fact that the third investor has invested and so will also invest regardless of their signal. Thus, a positive cascade has started in which investors ignore their own private signals in favour of the inferences they make about previous investors’ decisions. The third investor starts a negative cascade in the case when the first two investors do not invest and so neither does he.

The general cases are: a positive cascade occurs if, and only if, the number of previous participants who invest exceed the number who don't by two or more. The opposite can be said for when a negative cascade is started.

There is a negative externality formed by the investors in the cascade since their actions are uninformative regarding their signal. Followers of previous investors cannot benefit since those in the cascade do not add to the amount of publically available information, but rather increase uncertainty. Thus, the investment decisions on an individual level are inefficient. Importantly however, due to lack of an informative information set of those within a cascade, their decision to follow the actions of previous investors is considered rational. In Bayesian terms, public information outweighs any private signal, thus the decision to cascade is justified.

In such a model, the addition of any relevant information can interrupt the cascade and allow investors to reassess their beliefs before following previous investors.

Chari and Kehoe (2004) develop a model where the cascade persists even when the public information set is larger and with the more realistic assumption that information can be shared amongst individual investors. In this model, three other assumptions are altered.

They allow a continuous rather than binary investment decision, assets are dynamically priced and also investors no longer have to move in a pre-determined, exogenous order, they can make their move whenever they choose. Herding behaviour is only present when all three assumptions are included.

Welch (1992) models the consequences of Information Cascades on fixed-price IPO selling procedures under the assumptions that investors have different information, and that investors make their decisions whether to invest or not sequentially. In this model, investors attempt to evaluate the overall market interest in an IPO by observing actions of previous investors. He finds, just like Banerjee (1992) and Bikhchandani et al. (1992), that such a scenario can lead quickly to cascades in which investors ignore their private information in order to imitate earlier investors. He notes that the pricing decision of the underwriter is key to subsequent Information Cascades. Pricing a new issue either slightly too high or too low will mean a complete failure or a complete success will occur almost certainly. Success or failure in this model is determined by overwhelming subscription to shares or ignoring them (respectively). Therefore, if the issuer acts on good inside information and raises the price of the issue ever so slightly, then it could cause a huge issue failure and wide spread under-subscription of the shares issued. In such framework, a negative cascade occurs. In the case of a slight underpricing, a positive cascade emerges quickly.

Our model, although in an IPO situation, focuses on the implications that inflated prices and then a sudden price drop, due to irrational investors, have on investors' decision rather than the decisions of the underwriter.

Scharfstein and Stein (1990) develop a model in which, under certain circumstances, managers rationally attempt to enhance their reputations by mimicking the actions of other managers. This model captures the view of John Maynard Keynes (1936, pp. 157-158), where he stated, that "It is better for reputation to fail conventionally than to succeed unconventionally".

1.3. Behavioural Factors Causing Herding

"The economy is not a physical system. It is a system of human interactions" (Lo, 2002 ,pp.81)

As such, in the last twenty years or so, economists have started incorporating investor psychology into finance in order to explain anomalous or contradictory data with respect to fundamental financial theory like the CAPM or Efficient Market Hypothesis. Implicitly, Behavioural Finance works on the assumption that all investors are irrational to some extent. Under such an assumption investors' irrationality can account for numerous financial phenomena such as overreaction to public information, seasonal stock price effects, and, importantly for our research, herding amongst investors.

Barberis and Thaler (2003, pp. 2) give a dual definitional of investor rationality: "First, when they receive new information, agents update their beliefs correctly, in the manner described by Bayes' law. Second, given their beliefs, agents make choices that are normatively acceptable, in the sense that they are consistent with Savage's notion of Subjective Expected Utility (SEU)". Notably, the use of Bayes' law in updating investors' beliefs is fundamental in the herding models described so far of Banerjee (1992), Bikhchandani et al. (1992), Welch (1992) and Scharfstein and Stein (1990).

Other relevant fields of investor psychology include the work of Fischhoff et al. (1977) who believe that people in general have the inability to determine probabilities accurately. They find overconfidence leads people, for example, to state something is due to occur with certainty when in fact the actual probability of it occurring is only 80%.

The herding models discussed so far heavily rely on probability of either an investor being of a certain quality, or them receiving a useful signal. Adding to this, Barber and Odean (1999) suggest that overconfidence amongst investors can cause over-trading and subsequent excessive losses. Also, Barbaris et al. (1998) and Daniel et al. (1998) have explained over and under reaction to good and bad financial news as a result of investors' overconfidence. Overconfidence then could distort the Information Cascade models discussed so far, shifting or even eliminating some equilibria.

In Lo's (2002) work on social mood in Financial Markets, he discusses the effect of investors' overconfidence on the economy as a whole. He argues that there is a correlation between the level of optimism/pessimism in society and the conditions in Financial Markets. Specifically, optimism in society will translate to more optimistic investors. Consistent with Fischhoff et al. (1977) and Barber and Odean (1999), this optimism and overconfidence will cause overestimations of probabilities of success and underestimation of relevant risks. Finally, this will lead to more investors wanting to be part of Initial Public Offerings. This work is particularly consistent with the basis of our model.

An example of how the presence of a small group of overconfident entrepreneurs changes the outcome of a group of investors, is discussed by Bernardo and Welch (2001). The model is based, once again, on the Information Cascade models of Banerjee (1992), Bikhchandani et al. (1992) and Welch (1992), whereby information aggregation is poor amongst groups of investors. This in turn leads to Information Cascades.

Lord et al. (1979) found evidence on belief perseverance, whereby once a person has formed an opinion, they stick with it irrationally and for far too long. They find that people do not wish to find evidence that would contradict their opinion and also if such evidence is found, it is viewed very skeptically.

For example, the investors involved in a positive Informational Cascade cling to the belief that the decision of previous investors to invest indicates they should do the same. Their own private signal will be viewed skeptically and is dismissed. Consequently, the positive cascade continues. Even if it is argued that this is justified rationally, introducing a group of investors who display excessive overconfidence would involve a certain level of belief perseverance since Bayesian updating is not followed rigorously, but rather is distorted to allow positive aspects of it to remain and negative aspects to be dismissed.

The Efficient Market Hypothesis, as put forward by Fama (1969), states that, in a Strong Form Efficient Capital Market, investors are fully rational and therefore trade without any emotional input. Thus, prices fully reflect all available information at all times. Any mispricing is arbitraged away by investors buying and selling to form a new equilibrium price.

Contrary to this, Shefrin (1999) believes that market prices react to fear and greed and trading is not a calculated effort, but rather executed on emotional impulse. This idea is fundamental to our model and the justification of this idea is developed when we look at the recent literature concerning Emotional Finance.

1.4. Behavioural Herding

Now we consider behavioural motives behind herding in Financial Markets and look at the relevant evidence to support such theories.

Valance (2001) notes that herding amongst investors is created due to a consensus of safety in numbers that overpowers any individual's own opinions or any signals they receive. This type of behaviour causes groups of investors large enough to significantly alter the course of stocks and specific markets.

A possible reason for believing in "safety in numbers" is given by Landberg (2003) who is in concurrence with Shefrin (1999). He gives the point of view that herding is a product of the two opposing emotions of fear and greed.

This is elaborated on by Kok et al. (2009). They state that fear is a more powerful emotion than greed since it is linked to risk-aversion and remorse. Remorse, in a Financial Market is experienced either when money is lost as the result of a poor decision, or when an opportunity to make money is lost.

They add further that, people would rather not lose anything than not gain anything. In terms of greed, they view this as an inferior experience than the pain experienced due to regret or remorse caused from losing out financially. Thus, they believe that herding confirms the power of fear over greed.

With more emphasis given to Financial markets as a whole, Persaud (2000, pp. 17) gives a simple summary of the factors causing herding behavior. "There are three main explanations for why bankers and investors herd. First, in a world of uncertainty, the best way of exploiting the information of others is by copying what they are doing. Second, bankers and investors are often measured and rewarded by relative performance so it literally does not pay a risk-averse player to stray too far from the pack. Third, investors and bankers are more likely to be sacked for being wrong and alone than being wrong and in company". The last two reasons are particularly relevant for being able to justify the scenario of Maug and Naik's (1996), and Admati and Pfeiderer's (1997) compensation-based herding models. The intense competition of Financial Markets and the desperation of those working within them to keep their jobs creates an environment where herding is normal as a means of survival.

1.5. Emotional Finance

In recent years, economists have studied the field Psychology, particular Psychoanalysis, in order to develop further reasoning for stock valuations and investors' and managers' investment decisions.

"Psychoanalysis comprises a developed and systematic body of knowledge seeking to understand the regularities of human emotional and subjective experience based on ubiquity of unconscious phantasy […] the idea is that inner subjective or "psychic" reality is based on wishes and systems of affect regulation only loosely related to "objective" external realities" (Taffler and Tuckett 2005, pp. 2)

In their research into the dot.com bubble of the 21st Century, Taffler and Tuckett (2005) pioneered the field of emotional finance by introducing Freud's (1911, 1916) theory of Psychoanalysis and "phantasy" objects to financial decision-making. "We have in mind an object of perception whose qualities are primarily determined by an individual's unconscious beliefs or phantasies. The word "phantasy" implies the existence of organized unconscious ideation" (Taffler and Tuckett 2005, pp. 6).

Laplanche and Pontalis (1973, pp.314) describe the scenario in which such ideas form: "An imaginary scene in which the subject is a protagonist representing the fulfillment of a wish in a manner that is distorted to a greater or lesser extent by defensive processes". In our model, the wish that is to be fulfilled is to make large profits on shares of a new issue.

Taffler and Tuckett (2005) theorise that investors let a range of unconscious and infantile emotions dictate their actions regarding dot.com stocks, rather than knowledge of company fundamental or future growth potential. They put forward a sequential set of emotions that a group of investors base their decisions on, decisions, which mirror the dot.com bubble and its subsequent bursting. Tying in with the work on herding models, the emotions, which distort and overwhelm an investor's cognitive capacity, are further exaggerated by the collective behaviour of the group.

In their first stages of the process, individuals unconsciously treat dot.com stocks as phantastic objects and deny to themselves they are doing so. This results in overvaluation, as individuals are determined to purchase these stocks at any price. This bares some similarity to Bernardo and Welch's (2001) overconfidence model where the excitement concerning an investment decision was echoed in the distorted probabilities of success rather than pricing.

In the latter stages, reality sets in and investors question their decisions and euphoric craze towards the stocks. Thus, phantasies erode and stock values would collapse instantaneously. Now shame and guilt dominate investors' feelings and the stocks are stigmatised. Individuals seek to shift the blame from themselves to others for allowing them to be overcome by emotionally charged objects. This causes the Internet Sector to be adversely affected, as valuations across the sector plummet. In the final stages, the investors either go through a phase of learning from their bad experiences, or there is a potential for a new phantastic object to be activated and the process starts again.

Taffler and Tuckett's (2005) framework was motivated by Cooper et al.'s (2001) empirical study regarding Internet companies' valuation rise between 1998-1999. Here it was found that companies that added ".com" to their name experienced a cumulative average abnormal return of more than 63% on the first few days around the date of the name-change announcement. This increase was independent of the companies' actual involvement with the Internet, rather it was the slightest association with the Internet which caused these excess value rises. This kind of empirical finding justifies the inclusion of cognitive biases, where fundamental valuation is ignored. This finding is also consistent with Shiller's (1990) IPO "fad'' theory.

In his work on Behavioural Corporate Finance, Shefrin (2007) identifies 3 main categories of emotions, which have an effect on an individual making a financial decision. Namely, these are biases, heuristics and framing effects. In the category most relevant to our model and research leading up to it (biases), overconfidence and excessive optimism, confirmation bias, and illusion of control are included. Viewing an object as a thing of phantasy ties in with extreme overconfidence and optimism, which can cause confirmation biases and an illusion that the investor is in control of his potential future profit.

Following Taffler and Tuckett's (2005) groundbreaking work on Emotional Finance, Fairchild (2009) used the same sequence of emotions in the field of Corporate Finance.

This time, instead of investors viewing investments as phantastic objects, firm managers viewed potential projects as phantastic objects. In the initial stage of this model when managers fall in love with the project, they may mistakenly invest in projects with negative net present values due to a term in the payoff equation, which increases perceived payoff and hence encourages investment.

In the next stage, an initial outcome of the project is realised. If it is unsuccessful then the love parameter turns to hate and shame. However, if the project succeeds after the first stage, the parameter for love remains and the manager continues to overestimate the potential outcome of the project.

Similarly, Eshraghi and Taffler (2009) analyse the expansive growth and rapid decline of the hedge fund industry using the Taffler and Tuckett (2005) Internet bubble framework for Emotional Finance.

Both Fairchild (2009) and Eshraghi and Taffler (2009) emphasise that when a Phantastic object is established, whether it a new project or a hedge fund, then it, and those associated with it, are considered infallible. This means that the emotional individuals ignore any potential negative outcome associated with the phantastic object. Such love for the object can be viewed as an extreme case of overconfidence as researched by Fischhoff et al. (1977), Barber and Odean (1999), Barbaris et al. (1998) and Daniel et al. (1998).

The work of Taffler and Tuckett (2005) and Fairchild (2009) bridge the gap and extend the work of Behavioural Finance into Emotional Finance. Thus, the empirical findings relating to overconfidence cannot be dismissed when an investors' emotional state is considered, nor can any other cognitive biases. Also, due to the overlapping and concurrent nature of Emotional and Behavioural Finance, a wide range of cognitive biases can be considered simultaneously. For example, belief perseverance, overconfidence, phantasy and love can all present themselves in an investor who shows excessive willingness to invest in a particular issue.

2. Our Model of Emotional Finance Herding: An Overview

Our model is based on the basic information cascade models of Banerjee (1992), Bikhchandani et al. (1992) and Welch (1992) whereby rational investors base their investment decisions on the inferred signals of previous investors and their own private, informative signal. However, we introduce the additional presence of irrational, emotional investors and also dynamic pricing. We find that these "phantasy" investors initially inflate the share price and in turn, this affects the investment decisions of rational agents and thus alter potential cascade scenarios within the economy. Although, we impose an exogenous switching point where the phantasy investors (in line with the propositions of Taffler and Tuckett (2005)) are suddenly struck by reality and their love for their shares turn to hatred. This causes irrational selling of the shares, once again affecting the pricing and decisions of subsequent rational investors.

We consider an IPO scenario where the economy consists of N investors, where a proportion N-M<N are rational risk-neutral investors. The rest of the economy, M investors, are phantasy investors (based on Freud's (1911,1916) and Taffler and Tuckett (2005)).

We denote R_i as the i^{th} rational investor and Ph_i as the i^{th} phantasy investor. Investment decisions occur in an exogenous, alternating order as such:

$(R_1 , Ph_1, R_2, Ph_{2,} \dots . R_{M,} Ph_{N-M})$

meaning, the first investor is a rational one, then a phantasy investor and then a rational and so on [1] .

As Banerjee (1992), Bikhchandani et al. (1992) and Welch (1992) devise, rational investors make their investment decisions based upon their own private, informative signal and also the investment decisions of previous agents. Although previous agents' signals are unobservable, in some cases these signals can be inferred correctly.

[1] For future research we could examine the effect of ordering with particular emphasis on the effect of ordering on rational investors' decision-making.

The ex ante value of the shares is binary, whereby, with equal probability, the total value of the shares is either: a random high value, V_H or a random low value $V_L$with , $V_H > V_L \geq 0$ This means that the ex ante fundamental value of the shares is

$$V_{o\ (IPO)} = \frac{V_H + V_L}{2} \quad (1)$$

First, nature chooses a state, either good or bad. In the good state, V_H is the total value of the shares. In the bad state, V_L is the total value of the shares. Secondly, the investors' signals and decisions commence. Finally, the outcome is realised at the end of the model. Thus, investors cannot observe which state has occurred when they make their investment decision. They can only observe a signal that relates to future outcome. Each rational investor, initially, is faced with the decision of whether to buy a share or to abstain.

We assume that each investor has sufficient wealth to purchase at most one share and, as such, there are N shares in total which are initially offered by the underwriter. The Investment Bank, acting as the underwriter, is risk-neutral and initially sets the price of one share as its fundamental value:

$$P_{(IPO)} = \frac{V_{o\ (IPO)}}{N} = \frac{V_H + V_L}{2N} \quad (2)$$

This takes into account the myopic nature of the investment bank. In a competitive new issue market, the bank believes that all investors will partake in buying a share. They therefore set the price so that, if all investors buy a share, they will break-even.

2.1.1. Phantasy Investors

Phantasy investors view the new shares as “phantastic” objects, whereby they originally view the IPO as infallible and thus dismiss the chance of the shares being of low value. In other words, they assume that the shares offer only a high potential profit. In accordance with and Taffler and Tuckett (2005), the phantasy investors are willing to purchase the shares at almost any price. Furthermore, these shares could be thought of as part of initial offering from an extremely entrepreneurial, innovative company and thus their shares could be in very high demand. So a major part of this irrationality and subsequent phantasy is the asymmetric information regarding the fundamental value of the company and its shares (this idea is based on Rock ‘s (1986) idea that asymmetric information will affect the pricing of shares in an IPO).

We develop a model whereby this uncertainty causes a proportion of the IPO investors (M) to “fall in love” with this new issue and thus are much more willing to buy these stocks than the rational investors. The phantasy investors then drive the price of the shares up and alter rational investors’ investment decisions, which in turn, affects cascading. Under certain circumstances this love turns to hate and irrational investors cause the share price to drop suddenly as they all sell the share they have previously bought.

The dynamic pricing of one share, caused by the presence of phantasy investors is as follows:

$$\widehat{P}\,(\widehat{m}) = P_{(IPO)}(1 + \widehat{m}\Delta_{LOVE}) \qquad (3)$$

Where Δ_{LOVE} >0 is an inflation parameter on the potential value of the shares in a good economy. Δ_{LOVE} increases with the intensity of phantasy felt by the irrational investors. On the other hand, when love/phantasy turns to hatred and resentment, all irrational investors will sell their shares they previously purchased at a value below the fundamental value. This will reflect their hatred to towards the issue and their beliefs that the shares can only fail now. The case when phantasy and love turns to hatred and resentment will be considered in the second stage of this model.

The term $\widehat{m}$ indicates the number of phantasy investors that have already made their decision. For example investor $R_2's$ decision will involve the term $\widehat{m}$=1. We will change this equation when hatred investors are introduced instead of phantasy investors.

Unlike, rational investors, the phantasy investors pay no attention to public information (in the form of previous investment decisions) nor do they put any weighting on their private signal. We therefore propose that a phantasy investor's decision is based purely on their expected payoff, which, due to their emotional attachment to the shares, leaves them initially with no choice but to invest. This assumption is in accordance with Taffler and Tuckett's (2005) reasoning that investors are so caught up in their emotions towards the investment that they will buy at any price.

As such, a phantasy investor's perceived payoff from buying one share is as follows:

$$\Pi_{Ph_i}(\widehat{m}) = \frac{V_H(1+\widehat{m}\Delta_{LOVE})}{N} + \theta_L - \left(\frac{V_{o\,(IPO)}}{N}\right)(1+\widehat{m}\Delta_{LOVE})$$

$$= \frac{V_H(1+\widehat{m}\Delta_{LOVE})}{N} + \theta_L - \frac{V_H+V_L}{2N}(1+\widehat{m}\Delta_{LOVE}) \qquad (4)$$

The first term on the right-hand side is the inflated perceived value of one share.

The phantasy investor's idea that investing into this company is infallible is also captured in the first term on the right hand side. This is since the outcome V_L is ignored completely. This is due to the fact that phantasy investors assign zero probability to the low outcome and choose to inflate the value in the good economy instead.

The term $\theta_L > 0$ in (4) is a term, which takes into account a phantasy investor's love of investing. It has no effect on the value on V_H. Importantly, the following holds:

$$\frac{V_H(1+\widehat{m}\Delta_{LOVE})}{N} > \frac{V_H+V_L}{2N}\ (1+\widehat{m}\Delta_{LOVE}) \qquad \forall\ \widehat{m}\ \epsilon\ [0,\overline{m}\ ] \tag{5}$$

where $\overline{m}$ is the critical number of irrational investors, after which love changes to hate.

Now, if (5) holds, then this ensures (4)>0 ∀ $\widehat{m}\ \epsilon\ [0,\overline{m}\ ]$ In other words, the perceived future value of a share is greater than its true fundamental value. Thus, all phantasy investors, under this condition, will buy a share and keep inflating the price for the rest of the economy.

Once $\overline{m}$ is reached, then irrational investors are suddenly struck by reality, but instead of acting as a rational investor would, they all sell their share as they are overwhelmed with hatred and shame towards the new issue. At this point the value of the shares dramatically drop below the fundamental value. Now the issue is no longer viewed as infallible, but instead they believe it will only fail, hence why they all sell the shares they previously bought. As such, their perceived payoff, the factor that ensures they sell, is:

$$\Pi_{H_i} = \left(\frac{V_L}{N} - \theta_H\right) - \left(\frac{V_H+V_L}{2N} - \varphi\right) < 0 \tag{6}$$

Where $\varphi > 0$. The first term indicates their belief with that the issue will fail with certainty and θ_H is a parameter capturing their hatred for investing. This parameter is fixed for all hatred investors in any given stage. The second term is the fixed share price when it drops below the fundamental value. Thus, the hatred overwhelms the irrational investors so much that even this underpriced value is too high for them to buy. We discuss this case in Stage 2 of the model.

In the early herding models, the critical number of investors is 3. This is since after 3 investors then Information Cascades may have formed. Following this, we will consider a situation where there is 3 rational and 3 phantasy investors and then love turns to hate. This way we can see what effect the presence of irrational investors has on the payoffs and investment decisions of rational investors.

In a sense, we will exogenously impose a buy cascade on the love investors in Stage 1 and a sell cascade in Stage 2 to see how this affects rational payoff and decision-making. Such irrational cascading is consistent with Taffler and Tuckett's (2005) framework. Importantly, we follow Bernardo and Welch's (2001) assumption that if an investor is indifferent (payoff is zero) then they will abstain from investing in the shares of the IPO.

2.1.2. Rational Investors

As mentioned above, phantasy investors view the new issue with such love and emotional attachment that they will invest no matter what the cost. The term θ_L offsets any rational decision making such that their perceived payoff from buying outweighs what they will pay for it. With this in mind, our model focuses on the payoffs of rational agents and their subsequent investment decisions.

We follow the methods used in the early Information Cascade models of Banerjee (1992), Bikhchandani et al. (1992) and Welch (1992) with the additional pricing component, which is also a substantial part of their decision-making.

As in the early Information Cascade models, each investor receives an informative, but imperfect signal (the irrational investors receive signals but completely ignore them, this is one of the defining features of their irrationality and is consistent with Barberis and Thaler's (2003) definition of rationality in the sense that they do no update their probabilities of success or failure using Bayes' Law). In a sense this is similar to Bernardo and Welch's (2001) model of overconfidence, where overconfident investors overweight their personal signal, and thus manipulate Bayes' Law, however, phantasy investors ignore it completely.

We thus consider the signals for the rational investors only. Denote S_G and S_B as the events of getting a good signal and a bad signal, respectively. Then we have the following probabilities:

$$\Pr(\, S_G \mid V_H \,) = q \qquad (7)$$

$$\Pr(\, S_B \mid V_L \,) = q \qquad (8)$$

Equation (7) states that the probability of receiving a good signal, given the good economy has occurred is q. Similarly, equation (8) gives the probability of a bad signal, given the bad economy has occurred, where q ϵ $(0.5,1)$ and thus the signals are informative but imperfect.

It follows that $\Pr(\, S_G) = \frac{1}{2}q + \frac{1}{2}(1-q) = \frac{1}{2}$ (9)

Diagram A1 in Appendix 2.1 shows all possible signal paths for three investors. This diagram will form the basis of our analysis for each of the 3 Stages in our model.

We now proceed by deriving the payoffs and subsequent decisions of the first 3 rational investors using Bayes' Law.

First rational investor: Remember, this is the first investor in the sequence so there has been no price inflation due to phantasy investors.

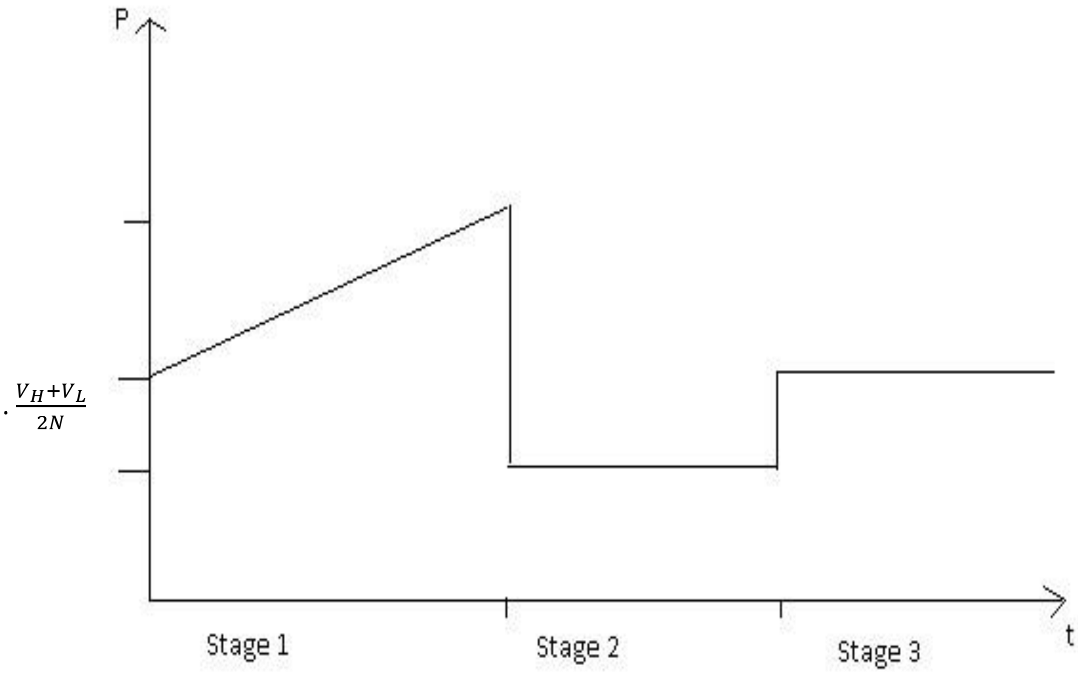
$$\Pr(\, V_H \mid S_G \,) = \frac{\Pr(\, S_G \mid V_H\,)\Pr(\, V_H)}{\Pr(\, S_G)} = \frac{\frac{1}{2}q}{\frac{1}{2}} = q$$

Similarly, $\Pr(V_L \mid S_B) = q$

Before we begin our analysis of each stage, we have this diagram below that

shows how the price changes in each stage.

Figure 1: Price Evolution For Each of the Three Stages



2.2. Stage One: Rational and Phantasy Investment Stage

For the first investor, if they receive a good signal they invest and if they receive a bad signal they abstain from investing. With the inclusion of pricing it follows that:

$$\Pi_{R_1} | S_G = \frac{qV_H + (1-q)V_L}{N} - \left(\frac{V_H + V_L}{2N}\right) > 0 \quad (10)$$

$$\Pi_{R_1} | S_B = \frac{(1-q)V_H + qV_L}{N} - \left(\frac{V_H + V_L}{2N}\right) < 0 \quad (11)$$

As such, we have our first proposition:

Proposition 1: In Stage 1, if (i) $S_1 = S_G$ then R_1 will invest.

(ii) $S_1 = S_B$ then R_1 will abstain.

Second rational investor: Now, a crucial difference between our model and the early herding models is introduced. Not only do the decisions of the second investor (and any subsequent investors) depend upon their own private signal and the inferred signal of the rational predecessor(s), but also on their expected payoff, which is determined by the increasing price set by irrational investors.

The four possible probability combinations of $R_2's$ signal and his (correct) inference of $R_1's$ signal are given in Appendix 2.1. From these, we can derive the following ex ante conditional probabilities:

$$\Pr(V_H | S_1 = S_G, S_2 = S_G) = \frac{\Pr(S_1 = S_G, S_2 = S_G | V_H) \Pr(V_H)}{\Pr(S_1 = S_G, S_2 = S_G)} =$$

$$\frac{q^2}{q^2 + (1-q)^2} = \dot{p} \qquad (12)$$

and, by symmetry, $\Pr(V_H | S_1 = S_G, S_2 = S_G) = \Pr(V_L | S_1 = S_B, S_2 = S_B)$

$$\Pr(V_L | S_1 = S_G, S_2 = S_G) = \frac{\Pr(S_1 = S_G, S_2 = S_G | V_L) \Pr(V_L)}{\Pr(S_1 = S_G, S_2 = S_G)} =$$

$$\frac{(1-q)^2}{q^2 + (1-q)^2} = \ddot{p} = 1 - \dot{p} \qquad (13)$$

and, by symmetry, $\Pr(V_L | S_1 = S_G, S_2 = S_G) = \Pr(V_H | S_1 = S_B, S_2 = S_B)$

(Note that $\dot{p}$ and $\ddot{p}$ is just notation for algebraic simplicity)

$$\Pr(V_H | S_1 = S_G, S_2 = S_B) = \frac{\Pr(S_1 = S_G, S_2 = S_B | V_H) \Pr(V_H)}{\Pr(S_1 = S_G, S_2 = S_B)} =$$

$$\frac{(1-q)q\frac{1}{2}}{(1-q)q} = \frac{1}{2} \qquad (14)$$

and, by symmetry again, $\Pr(V_H | S_1 = S_G, S_2 = S_B) = \Pr(V_H | S_1 = S_B, S_2 = S_G)$

$$\Pr(V_L | S_1 = S_G, S_2 = S_B) = \frac{\Pr(S_1 = S_G, S_2 = S_B | V_L) \Pr(V_L)}{\Pr(S_1 = S_G, S_2 = S_B)} =$$

$$\frac{(1-q)q\frac{1}{2}}{(1-q)q} = \frac{1}{2} \qquad (15)$$

and, by symmetry, $\Pr(V_L | S_1 = S_G, S_2 = S_B) = \Pr(V_L | S_1 = S_B, S_2 = S_G)$

Now for $R_2's$ expected payoffs:

$$\Pi_{R_2} | (S_1 = S_G, S_2 = S_G) =$$

$$\frac{1}{N}(\dot{p}V_H + (1 - \dot{p})V_L) - \frac{V_H + V_L}{2N}(1 + \Delta_{LOVE}) \qquad (16)$$

Where $\dot{p}$ is given in (12) and the last term on the right hand side of (16) is the amount that R_2 would have to pay for one share due to the price increase by Ph_1. Now, given that, in this case, R_2 correctly infers a good signal from R_1 and receives a good signal himself he still needs (16) to be greater than 0 for him to buy one share and invest.

Rearranging (16), this is equivalent to:

$$\frac{2(\dot{p}V_H + \ddot{p}V_L)}{V_H + V_L} - 1 \geq \ \Delta_{LOVE} \qquad (17)$$

By noting that $\ddot{p} =$ 1- $\dot{p}$, (17) can be re-written as:

$$\frac{2(\dot{p}(V_H - V_L) + V_L)}{V_H + V_L} - 1 \geq \ \Delta_{LOVE} \qquad (18a)$$

or, in terms of the strength of the signal:

$$p \geq \frac{(\Delta_{LOVE} + 1\dot{)}(V_H + V_L) - 2V_L}{2(V_H - V_L)} \qquad (18b)$$

We look at 2 extreme cases of q, both of which lie just outside our understanding of an informative signal:

When q=1 => (18a) becomes: $\frac{2V_H}{V_H+V_L} - 1 \geq \ \Delta_{LOVE}$ (18c)

which is possible with V_H, V_L fixed.

When q=$\frac{1}{2}$ => (18a) becomes: $0 \geq \ \Delta_{LOVE}$. This would be feasible in the case that Δ_{LOVE}=0 (no phantasy investors). But this would simply lead to the assumptions of the early cascading models, which we are not interested in here.

So if $\frac{2V_H}{V_H+V_L} - 1 < \Delta_{LOVE}$ then R_2 does not invest for any q ϵ $(0.5,1)$. This leads us to the conclusion that, if (18c) holds, there exits a critical value $\bar{q}\ \epsilon\ (0.5,1)$, with V_H, V_L, Δ_{LOVE} fixed, such that (18a) is an equality and below $\bar{q}$ then R_2 does not invest as (18a) no longer holds. In algebraic terms there exists a $\bar{q}\ \epsilon\ (0.5,1)$ such that when q ϵ $(0.5, \bar{q}\ )$then R_2does not invest. Whereas, for q ϵ $(\bar{q}, 1\ )$ then R_2does invest.

We still consider the last 3 cases for R_2in more detail below.

$(S_1 = S_B, S_2 = S_B)$:

$$\Pi_{R_2}|(S_1 \ = S_B, S_2 = S_B) = \frac{1}{N}(\dot{p}V_L + \ddot{p}V_H) - \frac{V_H + V_L}{2N}(1 + \Delta_{LOVE}) \qquad (19)$$

In this case, this payoff off is negative ∀ q ϵ $(0.5,1)$. We can see this clearly from:

$$\frac{2(\dot{p}V_L + \ddot{p}V_H)}{V_H + V_L} - 1 < \quad \Delta_{LOVE} \qquad (20)$$

Or more succinctly:

$$\frac{2(\dot{p}(V_L - V_H) + V_H)}{V_H + V_L} - 1 < \ \Delta_{LOVE} \qquad (20a)$$

Thus, in the case where R_2 views a bad signal and can correctly infer that R_1 also received a bad signal, R_2's payoff is negative so he does not buy a share. The effect of the price inflation by the phantasy investor is greater than their expected payoff, given their signal.

So far, for R_2 to invest in case of $(S_1 \ = S_G, S_2 = S_G)$ and to abstain in the case of $(S_1 \ = S_B, S_2 = S_B)$ we have:

$$\frac{2(\dot{p}(V_H - V_L) + V_L}{V_H + V_L} > \Delta_{LOVE} + 1 > \frac{2(\dot{p}(V_L - V_H) + V_H)}{V_H + V_L} \quad (21)$$

Note that, the right-hand inequality holds certainty, for all q ϵ (0.5,1), whereas the left-hand inequality only holds above a critical value $\bar{q}\ \epsilon\ (0.5,1)$ andV_H, V_L, Δ_{LOVE} fixed otherwise it does not hold and R_2 does not invest, despite observing two good signals.

Consider the cases of ($S_1 = S_G, S_2 = S_B$) and ($S_1 = S_B, S_2 = S_G$) simultaneously as they give the same Bayesian payoff:

$$\Pi_{R_2}|(S_1 = S_G, S_2 = S_B) = \frac{1}{N}\left(\frac{1}{2}V_H + \frac{1}{2}V_L\right) - \frac{V_H + V_L}{2N}(1 + \Delta_{LOVE}) =$$

$$\frac{1}{2N}((V_H + V_L) - (V_H + V_L)(1 + \Delta_{LOVE})) \quad (22)$$

Once again, (22) needs to be positive for investment to occur, however, since $\Delta_{LOVE} > 0$ it follows that (22)<0. Thus there is no investment in the case of ($S_1 = S_G, S_2 = S_B$) or ($S_1 = S_B, S_2 = S_G$). So far the presence of an irrational investor and the price inflation they cause will cause the second rational investor to abstain in all cases except if (18a) holds. In this case, investment only occurs once two good signals are viewed.

Proposition 2: In Stage 1,

(a) If R_1 invests then:

(i)If $S_2 = S_G$ then R_2 will invest if q>$\bar{q}\ \epsilon\ (0.5,1)$ and will abstain otherwise.

(ii) If $S_2 = S_B$ then R_2 will abstain.

(b) If R_1 abstains then so will R_2 whatever their signal is.

R_3 's Payoffs and investment decisions

Looking back to the early Information Cascade models, we know that the third investor is the critical case, since this is where cascading can first occur. In the existing models, in the case of two investments previously, the third investor has no choice but to invest also and so do all subsequent investors. Symmetrically, there is a negative "no invest" cascade when the third investor sees that the first two investors abstained. With the introduction of price inflation due to phantasy investors however, we will see that, under certain conditions, the invest cascade may not occur. Furthermore, the presence of phantasy investors makes it a lot more difficult for any rational investor to decide to invest.

Once again, we have included ex ante probabilities of viewing previous decisions in Appendix 2.2. However, now the third investor can only infer which decision is made by previous investors, we replace S_i with D_i for all previous investors, where D_i denotes the investment decision of rational investor i. Also we use either I or DI, indicating investment or abstaining, respectively.

Case when: ($D_1 = I, D_2 = I, S_3 = S_G$)

(Note: (18b) must hold for this to occur, q>$\bar{q}$)

$$\Pr(V_H | D_1 = I, D_2 = I, S_3 = S_G) = \frac{\frac{1}{2}q^3}{\frac{1}{2}(q^3 + (1-q)^3)} = \frac{q^3}{(q^3 + (1-q)^3)} = \dot{p}' \qquad (23)$$

$$\Pr(V_L | D_1 = I, D_2 = I, S_3 = S_G) = \frac{\frac{1}{2}(1-q)^3}{\frac{1}{2}(q^3 + (1-q)^3)} = \frac{(1-q)^3}{(q^3 + (1-q)^3)} = \ddot{p}' = (1 - \dot{p}') \qquad (24)$$

$$\Pi_{R_3} | (D_1 = I, D_2 = I, S_3 = S_G) = \frac{1}{N}\left(\dot{p}' V_H + \ddot{p}' V_L\right) - \frac{V_H+V_L}{2N}(1 + 2\Delta_{LOVE}) \quad (25)$$

In this case we focus on when q>$\bar{q}$ and so (18b) holds. Now, R_3can correctly infer that (18b) holds and that R_2 received a good signal just by knowing that R_2invested.

So the condition that R_3 will invest is equivalent to:

$$\frac{\left(\dot{p}' V_H + \ddot{p}' V_L\right)}{V_H + V_L} - \frac{1}{2} \geq \Delta_{LOVE} \qquad (26)$$

Or,

$$\frac{\left(\dot{p}'(V_H - V_L) + V_L\right)}{V_H + V_L} - \frac{1}{2} \geq \Delta_{LOVE} \qquad (26a)$$

When q=1 then (25) becomes:

$$\frac{1}{N} V_H - \frac{V_H + V_L}{2N}(1 + 2\Delta_{LOVE}) \qquad (26b)$$

If (26b)≥0 , then there exists a value $\bar{q}' \neq \bar{q} \, \epsilon \, (0.5,1)$, with V_H, V_L, Δ_{LOVE} fixed such that for all q $\epsilon \, (0.5, \overline{q'} \,)$ then R_3 will not invest. If q $\epsilon \, (\overline{q'}, \, 1)$then after observing $(D_1 = I, D_2 = I, S_3 = S_G)$ R_3 will invest.

Unlike the early cascade models, this does not necessarily mean a positive invest cascade occurs since the 4th investor still has to ensure his payoff is positive. Thus, a positive invest cascade does not happen with certainty under any situation where two positive signals in succession are received and inferred. This then differs significantly from the early cascading models where two successive positive signals are enough for an investor to disregard his own signal and invest. Since, by the definition of cascading we are using, there is in fact no positive cascade at all since the investment decision requires a positive payoff for each invest rather than acting entirely on previous information.

In our analysis, we only consider the decisions of the first 3 rational investors in the presence of phantasy investors, but, in general, the condition for rational investor i to invest, given all investors before him invested, is:

$$\frac{2}{\hat{m}}\left(\frac{(\dot{p}^i V_H + \ddot{p}^i V_L)}{V_H + V_L}\right) - \frac{1}{\hat{m}} > \Delta_{LOVE} \qquad (27)$$

where, $\dot{p}^i$=Pr(V_H |$D_1, \dots D_{i-1} = I, S_i = S_G$) $\forall\, i \,\epsilon\, [\,4, N-M]$

$\ddot{p}^i = 1 - \dot{p}^i$=Pr($V_L$ |$D_1, \dots D_{i-1} = I, S_i = S_G$) $\forall\, i \,\epsilon\, [\,4, N-M]$

Cases when: ($D_1 = I, D_2 = I, S_3 = S_B$),($D_1 = I, D_2 = DI, S_3\, \epsilon\{S_G, S_B\}$) and ($D_1 = DI, D_2 = I, S_3\, \epsilon\{S_G, S_B\}$)

The cases when: ($D_1 = DI, D_2 = I, S_3 = S_B$) and

($D_1 = DI, D_2 = I, S_3 = S_G$) will not occur due to our earlier finding that if a bad and good signal are received/inferred then the payoff will be negative so $D_2 = I$ will not be observed after $D_1 = DI$.

This leaves us to look at the cases: ($D_1 = I, D_2 = I\, S_3 = S_B$) and ($D_1 = I, D_2 = DI, S_3\, \epsilon\{S_G, S_B\}$) .The Bayesian probabilities, which we have calculated for each rational investor so far, are in Appendix 2.3. Thus, it follows that:

$\Pi_{R_3}|(D_1 = I, D_2 = I, S_3 = S_B)$=

$$\frac{1}{N}(qV_H + (1-q)V_L) - \frac{V_H + V_L}{2N}(1 + 2\Delta_{LOVE}) \quad (28)$$

Then the condition that must be satisfied, as well as (18b), for R_3 to invest is:

$$\frac{(qV_H + (1-q)V_L)}{V_H + V_L} - \frac{1}{2} > \Delta_{LOVE} \quad (29)$$

As in the case when ($D_1 = I, D_2 = I, S_3 = S_G$), no invest cascade can occur due to the condition that payoffs must be positive and this does not happen with certainty. On the other hand, (29) still indicates scenarios when R_3 will invest and will abstain. In other words, there exists a q''' ε $(0.5, 1)$ such that when q> q''' then (29) holds and R_3 will invest.

Interestingly, this is a case when R_3 can exhibit herding behavior. If (29) holds, then R_3 will ignore his bad signal and invest in favour of his positive payoff. In other words, he will ignore his private information in favour of the actions of the previous two investors. Given that signals are ignored in order to pursue a positive payoff, this is consistent with Maug and Naik's (1996) herding for compensational reasons. All other herding in our framework will be for compensation also. However, no cascade has started since R_4 must still consider their own payoff. Also, note that R_3's actions then become uninformative so R_4 will effectively become R_3 as he is forced to ignore R_3's actions.

Perhaps the most interesting two cases for R_3 are

($D_1 = I, D_2 = DI, S_3$ ε $\{S_{G,}S_{B,}\}$). Now, in the case when (18b) holds, R_3can observe that R_2 did not invest due to a bad signal. Thus, he is left with a payoff decision equivalent to (29) when $S_3 = S_G$ and abstains otherwise.

However, if (18b) does not hold, then he can only observe that there was no investment. He is unable to know with any certainty if this is because R_2 received a bad signal, or R_2 received a good signal but the price inflation was so great that their expected payoff was non-positive. Therefore, R_2's action is completely uninformative and R_3 will ignore it. So for ($D_1 = I, D_2 = DI, S_3 = S_G$), only ($D_1 = I, S_3 = S_G$) is considered, leaving him with an expected payoff:

$$\Pi_{R_3}|(D_1 = I, S_3 = S_G) =$$

$$\frac{1}{N}(\dot{p}V_H + (1-\dot{p})V_L) - \frac{V_H + V_L}{2N}(1 + 2\Delta_{LOVE}) \tag{30}$$

and for R_3 to invest then the following must hold:

$$\frac{(\dot{p}(V_H - V_L) + V_L)}{V_H + V_L} - \frac{1}{2} > \Delta_{LOVE} \tag{31}$$

Since (18b) doesn't hold, then neither does (31).

Then for ($D_1 = I, D_2 = DI, S_3 = S_B$), only ($D_1 = I, S_3 = S_B$) is considered, and R_3 considers:

$$\Pi_{R_3}|(D_1 = I, S_3 = S_B) = \frac{1}{N}\left(\frac{1}{2}V_H + \frac{1}{2}V_L\right) - \frac{V_H + V_L}{2N}(1 + 2\Delta_{LOVE}) =$$

$$\frac{1}{2N}((V_H + V_L) - (V_H + V_L)(1 + 2\Delta_{LOVE})) \tag{32}$$

Similarly, to (22), this is never positive in the presence of phantasy investors so investment will not occur. When the second investor's decision is completely uninformative, R_3 effectively becomes R_2 in Bayesian terms. However, they face an additional phantasy investor, which further inflates the price.

Proposition 3: In Stage 3,if $D_1 = I$ then:

(a) If q>$\bar{q}$ then,
   (i) If R_3 observes $(D_1 = I, D_2 = I, S_3 = S_G)$, then he will invest if q>$\bar{q}' \varepsilon$ $(0.5,1)$ and abstain otherwise.
   (ii) If R_3 observes $(D_1 = I, D_2 = I, S_3 = S_B)$, then he will invest if q> q''' ε $(0.5,1)$ and will abstain otherwise.

(b) If q<$\bar{q}$ then, $R_2's$ signal becomes completely uninformative and R_3 does not invest after receiving either signal.

These cases above once again highlight how crucial the necessity of (18b) holding is since without it, $R_3$is forced to disregard $R_2's$ decision, further limiting the little knowledge he has to base the investment decision on. Even though we do not discuss it here, R_4 would be left in a similar situation in the cases of $(D_1 = I, D_2 = I, D_3 = I, S_4 = S_G)$ and $(D_1 = I, D_2 = I, D_3 = DI, S_4 = S_G)$. In each case, one of the previous investor's decisions would be ignored.

Case when: ($\boldsymbol{D_1 = DI, D_2 = DI, S_3 = S_G}$)

This is another case of R_2 providing an uninformative decision and reducing $R_3's$ information set to $(D_1 = DI, S_3 = S_G)$ and an expected payoff:

$$\Pi_{R_3}|(D_1 = DI, S_3 = S_G) = \frac{1}{N}\left(\frac{1}{2}V_H + \frac{1}{2}V_L\right) - \frac{V_H+V_L}{2N}(1 + 2\Delta_{LOVE}) \quad (33)$$

This is never greater than 0 and R_3, in this case would not invest. In a way, this can be considered as herding that has exogenously been imposed by the phantasy investor's price inflation.

Case when: **($\boldsymbol{D_1 = DI, D_2 = DI, S_3 = S_B}$)**

In this case, the payoff equation will be negative with certainty for q ε $(0.5,1)$ and hence no investment will occur despite the fact that the second investor's decision is uninformative. Furthermore, all subsequent investors who receive negative signals will not invest. This is not evidence of herding though because their private information does not contradict the decisions of previous investors.

Proposition 4: In Stage 1, if $D_1 = DI$, then R_3 will abstain in every case.

We see that in Stage 1, due to the price inflation factor that must be considered, if the number of bad signals is greater than or equal to the number of good signals that an investor can infer when making their decision, no investment occurs.

Before moving onto the case when phantasy investors become hatred/resentment investors, we briefly sum up the results so far. In the presence of phantasy investors whom inflate the prices for all other investors, there is no longer any positive, invest cascade since investors must evaluate both their signal and their expected payoff from investing in order to make their decision. They cannot ignore both of these pieces of information when making their decision. There are cases where herding behaviour occurs. Specifically, a private signal is ignored in favour of public information, only if the payoff equation is positive.

In the case when the first 3 rational investors' signals are negative, no investment occurs due to a negative payoff equation, but this is not evidence of herding. It is however evidence of cascading since the cumulative effect of bad signals will outweigh a single good signal and thus private information is ignored.

There are cases when the third investor has no choice but to ignore the actions of the second investor since they are unable to know with certainty why they hadn't invested. This limits their information set and leaves them with Bayesian updating similar to the second investor's choices but price inflation is too high and no investment occurs.

It is crucial that (18b) is satisfied. Without this, then there would be no investment for the second and third rational investors at all. Such a scenario would lead to negative cascading due to inflation outweighing expected payoffs determined by signals.

2.3. Stage 2: Love and Phantasy Turns to Hatred and Remorse

We move onto the next stage of the model where phantasy investors suddenly turn from loving the new issue to hating it. The reasoning for this based on the framework of Taffler and Tuckett (2005), whereby, in our case, the new issue of shares is no longer realized by irrational investors as phantastic, but instead shame and hatred overwhelms the irrational investors and they all sell their share which they purchased in the last stage. Rational investors play a buy and hold strategy in our framework so any rational investors introduced in this new stage will have not purchased a share previously. Thus, the effect of the irrational investors now is to increase the likelihood that Rationals will invest because the share price has dropped below the fundamental value, to a fixed low price. The Rationals no longer have to weigh up their payoff against an inflation factor. They still must consider their signals, the actions of previous investors and the subsequent payoffs.

Now, it is public knowledge that the irrational investors in the economy have become overwhelmed with shame and hatred towards this issue, however, the Rationals disregard the actions of other rational investors in the last period. This occurs because Rationals know that the actions of previous investors were heavily influenced by the inflation caused by phantasy investors. But now that inflation is no longer present, the actions of previous Rationals are no longer helpful. This could also be seen as an example of bounded rationality. Thus, in Bayesian terms, it is as if the model restarts at a new, fixed share price of:

$$\frac{V_H + V_L}{2N} - \varphi \tag{34}$$

We continue with similar analysis as before, whereby we analyse the decisions of the rational investors in the presence of a group of irrational investors. To make clearer the extent to which irrational investors have now devalued the shares we give the following assumptions:

$$\Pi_{R_4} | \, S_G \; = \frac{qV_H + (1-q)V_L}{N} - \left(\frac{V_H + V_L}{2N} - \varphi\right) > 0 \qquad (35)$$

$$\Pi_{R_4} | \, S_B = \frac{(1-q)V_H + qV_L}{N} - \left(\frac{V_H + V_L}{2N} - \varphi\right) < 0 \qquad (36)$$

Thus, as in Proposition 1, the first investor will invest if they receive a good signal but will abstain if they receive a bad signal. So the extent to which the shares have been devalued is not enough for the first investor to ignore their signal in favour of a positive payoff.

It is very important to note that rational investors are aware that irrational investors are now overwhelmed with hatred and shame towards the issue so they are not discouraged by their actions that have devalued the shares. In fact the opposite occurs.

The equations (35) and (36) give us that there is a critical value $q_c \; \varepsilon \; (0.5,1)$such that $R_4's$ payoff is zero. We follow the early Information Cascade models and say that, in such a case, they will abstain from investing. The critical q is,

$$q_c = \frac{(V_H - V_L\,) - 2N\varphi}{2(V_H - V_L\,)} \qquad (37)$$

Now for $R_5's$ payoffs and subsequent decisions in the case when (35) and (36) hold.

$\Pi_{R_5} | (\, S_1 = S_G, S_2 = S_G) > 0$ thus, he will invest.

$$\Pi_{R_5} | \, (S_1 = S_G, S_2 = S_B) = \qquad \Pi_{R_5} | \, (S_1 = S_B, S_2 = S_G)$$

$$= \frac{1}{N}\left(\frac{1}{2}V_H + \frac{1}{2}V_L\right) - \left(\frac{V_H + V_L}{2N} - \varphi\right) = \varphi > 0 \qquad (38)$$

So in this stage, unlike Stage 1, an investor who can view both a positive and negative signal will have a positive payoff and so will invest. Clearly this is since he does not have to consider buying a share at an inflated value, but rather can buy it at a fixed value below the fundamental value. This is the first instance in this stage where an investor will ignore their signal. The effect of the devaluation is enough to make R_5 invest, unlike in Stage 1 when the inflation causes a negative payoff and subsequent no investment in this case.

$\Pi_{R_5} | (S_1 = S_B, S_2 = S_B)$<0 and no investment occurs.

Proposition 5: In Stage 2, R_5 will invest if the following signals are received:

$(S_1 = S_G, S_2 = S_G), (S_1 = S_G, S_2 = S_B), (S_1 = S_B, S_2 = S_G)$, and will abstain otherwise.

Moving onto R_6:

In the cases where R_6 can see $(D_1 = I, D_2 = I,\ S_3 = S_G)$ or $(D_1 = I, D_2 = I,\ S_3 = S_B)$ and (35) holds, they cannot tell with certainty what signal R_5 received since he will invest regardless of what signal he received. Thus, R_6 effectively becomes R_5 and will invest in both cases. As Bernardo and Welch's (2001) conclusion, an invest cascade is formed in any case where the number of invest decisions outnumbers abstain decisions by two or more, since the strength of the previously inferred signals is enough to outweigh any private signal, especially since the price of a share is fixed below its fundamental value. Notably, since the price is fixed, an investor will invest if the number of invest decisions is greater than or equal to the number of abstaining decisions.

By symmetry, the cases when $(D_1 = DI, D_2 = DI,\ S_3 = S_B)$ or $(D_1 = DI, D_2 = DI,\ S_3 = S_G)$ are both met with abstaining decisions. However, our assumptions mean that there is no ambiguity regarding the decisions of R_5. In particular, with (36) holding, R_6 knows that two consecutive bad signals were viewed as the presence of one invest decision is enough, in $R_5's$ position, to ensure investment occurs.

The case of $(D_1 = DI, D_2 = DI,\ S_3 = S_G)$ is an example of herding, since the good signal is outweighed by the previous two bad signals. In these two cases an abstaining cascade starts when the number of negative signals outweighs the good signals by two or more. This is clear when considering $R_7's$ decision, since they will find $R_6's$ decision completely uninformative, leaving them with an identical decision to R_6 . This is the same when the invest cascade is formed. Also, again, (36) means that an investor will abstain if the number of abstain decisions is greater than the number of invest decisions.

With the assumption (35), then the cases $(D_1 = I, D_2 = DI,\ S_3 = S_G)$ and $(D_1 = I, D_2 = DI,\ S_3 = S_B)$ cannot be viewed as the combination of a good then bad signal are enough for a positive payoff to be expected.

In the cases of $(D_1 = DI, D_2 = I,\ S_3 = S_G)$and $(D_1 = DI, D_2 = I,\ S_3 = S_B)$ then R_6 will follow their own signal leading them to invest and abstain respectively. In these cases, the inferred signals of the previous two investors cancel each other out (in Bayesian terms) and they then conform with assumptions in (35) and (36).

Proposition 6: In Stage 2, R_6 will invest if the following signals are viewed: $(D_1 = I, D_2 = I,\ S_3 = S_G), (D_1 = I, D_2 = I,\ S_3 = S_B)$ and $(D_1 = DI, D_2 = I,\ S_3 = S_G)$. R_6 will abstain otherwise. If the first two signal paths occur, then a positive cascade will occur.

In this stage we can see that the presence of irrational investors now, in some cases encourages investment rather than discourage it as in Stage 1. Like Stage 1, there are still examples of herding, as previous inferred signals outweigh an investor's private information. Furthermore, there are examples where cascades begin to inform, both invest and abstain cascades. Clearly, the low, fixed price is the cause. Thus, the presence of the irrational, hatred-stricken investors causes a positive externality to the rest of the IPO economy rather than a negative one as in Stage 1. Furthermore, rational investors do not have to suffer financially by paying an inflated price for a share in the scenarios where they do invest.

Of course, if we removed the condition that (36) has to hold, then we would see that investment would occur regardless of signals received or inferred and thus, the effect of irrationality would be so high as to cause the collective group information set to be restricted to invest only decisions. As such, only positive cascades would form, as subsequent investors would ignore any bad signal they received and also some previous, uninformative decisions.

Although it is considered unrealistic to assume a fixed price, given that we only consider it's impact on the first three rational investors it is likely that the price will not adjust if the these investors all make decisions in quick succession. Furthermore, if the cascades were able to start and then the price was to adjust, then this would highlight the fragility of such information cascades that we have mentioned previously and cause them to stop. We consider other effects on these first two stages in our discussion later, adding in more realistic assumptions that would complicate and alter the findings so far.

2.4. Stage 3: An Economy of Rational Investors Only.

We now consider a case when all irrational investors are absent from the IPO and rational investors weigh up their investment decision by considering signals and inferred signals against a fixed, fundamental IPO price. Although it is unrealistic to consider a fixed price, this Stage is used as a comparison to Stages 1 and 2. Furthermore, given we will only look at the decisions of the first three rational investors, there could be a realistic case when there is no price increase to consider, or the price increase is so small that it makes little difference to consider it.

We proceed to calculate payoffs as in the previous stages.

The decisions of the first investor are the same as the previous two cases where investment occurs only if a good signal is received.

Now R_2:

In the case of $(S_1 = S_G, S_2 = S_G)$ then R_2 will invest with certainty since:

$$\Pi_{R_2} | (S_1 = S_G, S_2 = S_G) = \frac{\dot{p}V_H + (1 - \dot{p})V_L}{N} - \left(\frac{V_H + V_L}{2N}\right) > 0 \qquad (39)$$

and similarly, when $(S_1 = S_B, S_2 = S_B)$ they will abstain with certainty.

When $(S_1 = S_G, S_2 = S_B)$ and $(S_1 = S_B, S_2 = S_G)$ the payoff is as follows:

$$\Pi_{R_2} | (S_1 = S_G, S_2 = S_B) = \qquad \Pi_{R_2} | (S_1 = S_B, S_2 = S_G)$$

$$= \frac{1}{N}\left(\frac{1}{2}V_H + \frac{1}{2}V_L\right) - \left(\frac{V_H + V_L}{2N}\right) = 0 \qquad (40)$$

We follow the rationale of Bernardo and Welch (2001) and say: when an investor's payoff makes them indifferent, they will abstain from investing. Thus, we see the first main difference to Stage 2, where in this case the fixed, fundamental value of the share is not enough for R_2 to invest after seeing both a good and bad signal. In the case where the share price has crashed due to irrational hatred investors, the Rationals will invest, as their payoff will always be positive.

Moving on to R_3:

When $(D_1 = I, D_2 = I, S_3 = S_G)$ and $(D_1 = I, D_2 = I, S_3 = S_B)$ investment will occur with certainty, since good signals will outweigh any bad signals and thus, the payoff will be positive with certainty. In the second case, R_3ignores his own signal and herds. This leads to an invest cascade as R_3's action becomes completely uninformative to R_4 and they will invest despite their signal. There is no ambiguity regarding $R_2's$ signal, since it is known that the only case when R_2 will invest, given the first signal was good, is when their signal was also good.

When $(D_1 = I, D_2 = DI, S_3 = S_G)$ and $(D_1 = I, D_2 = DI, S_3 = S_B)$ then investment and abstaining will occur, respectively. Once again, there are no ambiguous decisions to deal with and R_3will follow their own signal since it outweighs the two previous signals, which effectively cancel each other out.

Since an investor will abstain from investing after both a good and bad signal have been seen, then the cases $(D_1 = DI, D_2 = I, S_3 = S_G)$ and $(D_1 = DI, D_2 = I, S_3 = S_B)$ will not be seen by R_3 so these cases are not considered.

Finally, when $(D_1 = DI, D_2 = DI, S_3 = S_G)$ and $(D_1 = DI, D_2 = DI, S_3 = S_B)$ occur, R_3 will abstain in both cases as the number of correctly inferred bad signals will outweigh any good signals received. The second case is an example of herding and would lead to an abstaining cascade, as R_4 would find R_3's decision uninformative. So he effectively becomes R_3 and invests regardless of his signal. This continues iteratively as long as the price remains fixed.

In this stage we see, like Stage 2 but unlike Stage 1, both invest and abstain cascades will form with certainty given the assumptions concerning the first investor. However, the fundamental price is not enough to encourage investment in the case when both a good and bad signal can be seen.

To tie in with our empirical findings, when we exogenously impose positive herding of irrational investors, this has the effect of inflating the price for rational investors and consequently, offering them few cases to invest. Rationals do not positively cascade at all in Stage 1 but there are situations when negative cascades will occur due to high inflation. Thus, in times of market stress (high prices imposed by phantasy investors in this case) we find evidence of wide-spread abstaining decisions by rational investors and subsequently, they move against a market that irrational investors have dominated.

In the case of low prices imposed by emotional investors, this encourages Rationals to once again herd and cascade away from the market in favour of positive payoffs.

We now move on to calculate the ex post welfare of the rational investors in each of the stages as well as the welfare of the irrational investors at the end of the model.

2.5. Welfare of the system

We now look at the payoffs of the investors in each stage after either the good or bad state has been realised.

2.5.1. Stage 1 Rational Welfare

First we consider the payoffs of the first three rational investors. We take in to account all situations when investment may occur.

$$E(\Pi_{R_1}) = \frac{1}{2}\left(q\left(\frac{V_H}{N} - \frac{V_H + V_L}{2N}\right)\right) + \frac{1}{2}\left((1-q)\left(\frac{V_L}{N} - \frac{V_H + V_L}{2N}\right)\right) \qquad (41)$$

Where the first term on the right-hand side indicates the expected payoff when the good state is realised (with probability one-half) and one of N shares is purchased. We simplify this as:

$$E(\Pi_{R_1}) = \frac{1}{2N}\left(qV_H + (1-q)V_L - \frac{V_H + V_L}{2}\right) \qquad (42)$$

We proceed in this fashion to derive R_2 and $R_3's$ expected payoffs.

If (18b) holds and by Proposition 2 then:

$$E(\Pi_{R_2}) = \frac{1}{2N}\left(q^2V_H + (1-q)^2V_L - (q^2 + (1-q)^2)\frac{V_H + V_L}{2}(1 + \Delta_{LOVE})\right) \quad (43)$$

otherwise, the payoff is zero since they do not invest.

For R_3 to always invest when possible then (18b), (26a) and (29) need to hold, yielding an expected payoff of:

$$E(\Pi_{R_3}) = \frac{1}{2N}\left((q^3 + (1-q)q^2)V_H + ((1-q)^3 + (1-q)^2q)V_L - (q^3 + (1-q)^3 + q^2(1-q) + (1-q)^2q)\frac{V_H + V_L}{2}\right)(1 + 2\Delta_{LOVE}) \quad (44)$$

and the total welfare of the rational investors in Stage 1 is:

$$W(R_{S1}) = E(\Pi_{R_1}) + E(\Pi_{R_2}) + E(\Pi_{R_3}) \quad (45)$$

2.5.2. Stage 2 Rational Welfare

Now, looking at the ex post expected payoffs for the rational investors in the second stage:

$$E(\Pi_{R_4}) = \frac{1}{2}\left(q\left(\frac{V_H}{N} - \frac{V_H + V_L}{2N} - \varphi\right)\right) + \frac{1}{2}\left((1-q)\left(\frac{V_L}{N} - \frac{V_H + V_L}{2N} - \varphi\right)\right)$$

$$= \frac{1}{2N}\left(qV_H + (1-q)V_L - \left(\frac{V_H + V_L}{2} - \varphi\right)\right) \quad (46)$$

$$E(\Pi_{R_5}) = \quad \frac{1}{2N}\left(q^2V_H + (1-q)^2V_L - (q^2 + (1-q)^2)\left(\frac{V_H + V_L}{2} - \varphi\right)\right)$$

$$+ \left(q(1-q)\left(\frac{V_H}{N} - \frac{V_H + V_L}{2N} - \varphi\right)\right) + \left(q(1-q)\left(\frac{V_L}{N} - \frac{V_H + V_L}{2N} - \varphi\right)\right) \quad (47)$$

$$= \frac{1}{2N}\left(q^2V_H + (1-q)^2V_L - (q^2 + (1-q)^2)\left(\frac{V_H + V_L}{2N} - \varphi\right)\right)$$

$$+ 2\varphi q(1-q) \quad (47a)$$

Where the first term of (47a) indicates the expected payoff when $(S_1 = S_G, S_2 = S_G)$ and the second term is the expected payoff when $(S_1 = S_G, S_2 = S_B)$ and $(S_1 = S_B, S_2 = S_G)$ occurs.

For $R_6's$ ex ante expected payoff, we have the cases: $(D_1 = I, D_2 = I, S_3 = S_G)$,

$(D_1 = I, D_2 = I, S_3 = S_B)$ and $(D_1 = DI, D_2 = I, S_3 = S_G)$ to consider. However, the first two cases do not know for certain the signal of R_5 so it is ignored.

$$E(\Pi_{R_6}) = \frac{1}{2N}\left(q^2V_H + (1-q)^2V_L - (q^2 + (1-q)^2)\left(\frac{V_H + V_L}{2} - \varphi\right)\right)$$

$$+ \frac{1}{2N}\left(q^2(1-q)V_H + q(1-q)^2V_L - (q^2(1-q) + q(1-q)^2)\left(\frac{V_H + V_L}{2} - \varphi\right)\right)$$

$$+ q(1-q)\varphi \quad (48)$$

and the total welfare of the rational investors in this stage is

$$W(R_{S2}) = E(\Pi_{R_4}) + E(\Pi_{R_5}) + E(\Pi_{R_6}) \qquad (49)$$

2.5.3. Stage 3 Rational Welfare

As in Stage 2, the buying price for rational investors is fixed, but this time it is at the fundamental value of one share. As such:

$$E(\Pi'_{R_1}) = \frac{1}{2N}\left(qV_H + (1-q)V_L - \frac{V_H + V_L}{2}\right) \qquad (50)$$

$$E(\Pi'_{R_2}) = \frac{1}{2N}\left(q^2V_H + (1-q)^2V_L - (q^2 + (1-q)^2)\frac{V_H + V_L}{2}\right) \qquad (51)$$

For the third investor, he will invest for the following signal/decision combinations: $(D_1 = I, D_2 = I, S_3 = S_G)$,

$(D_1 = I, D_2 = I, S_3 = S_B)$ and $(D_1 = DI, D_2 = I, S_3 = S_G)$. The last two give the same ex post expected payoff due to no ambiguity regarding the second investor's signal, so they are grouped together.

$$E(\Pi'_{R_3}) = \frac{1}{2N}\left(q^3V_H + (1-q)^3V_L - (q^3 + (1-q)^3)\left(\frac{V_H + V_L}{2}\right)\right)$$

$$+\frac{1}{N}\left(q^2(1-q)V_H + q(1-q)^2V_L - (q^2(1-q) + q(1-q)^2)\left(\frac{V_H + V_L}{2}\right)\right) \qquad (52)$$

$$\mathrm{W}(R_{S3}) = E(\Pi'_{R_1}) + E(\Pi'_{R_2}) + E(\Pi'_{R_3}) \qquad (52a)$$

2.5.4. Welfare of Irrational Investors

The welfare of the irrational investors is now calculated as the price they sell a share, minus the price that they bought their share. Thus, these are the payoffs that irrational investors receive after exhibiting both love and hatred towards the issue.

$$E(\Pi_{PH_1}) = \left(\frac{V_H + V_L}{2N} - \varphi\right) - \frac{V_H + V_L}{2N}(1 + \Delta_{LOVE}) \quad (53)$$

$$E(\Pi_{PH_2}) = \left(\frac{V_H + V_L}{2N} - \varphi\right) - \frac{V_H + V_L}{2N}(1 + 2\Delta_{LOVE}) \quad (54)$$

$$E(\Pi_{PH_3}) = \left(\frac{V_H + V_L}{2N} - \varphi\right) - \frac{V_H + V_L}{2N}(1 + 3\Delta_{LOVE}) \quad (55)$$

and,

W(Ph) $=$ $E(\Pi_{Ph_1})$+ $E(\Pi_{Ph_2})$+ $E(\Pi_{Ph_3})$=

$$3\left(\frac{V_H+V_L}{2N} - \varphi\right) - \frac{3(V_H+V_L)}{2N}(1 + 2\Delta_{LOVE}) \quad (56)$$

Now since (53), (54) and (55) are all negative, then so is (56). Thus, the irrational way phantasy and hatred first overvalues and then undervalues the shares causes all irrational investors to lose money.

The negative term in (56) is reflected in the payoffs of the rational investors in Stage 1, where they are forced to pay an inflated price in order to take part in the offering. As such, by comparing (45) and (49), we can see that the love factor inversely effects rational investors' payoffs in Stage 1, but then in Stage 2 the irrational investors' hatred towards the issue causes an increase in welfare relative to Stage 1.

By comparison to Stage 3 welfare, we can also see that this is not as large as Stage 2 welfare. From this we can conclude that the hatred factor causes a positive externality to the rational investors in Stage 2, since the crash in price increases their ex post expected payoff in comparison to an environment with no irrational investors. In such a sequential system, the price crash caused by irrational hatred for the issue could be seen as a compensation for the inflated share price in Stage 1, since this price crash does not discourage rational investing, but rather encourages it and results in a higher expected ex ante payoff.

Overall, we conclude that the irrational investors at first cause a negative externality to the rational investors in the economy. But, when love turns to hatred for the issue, the price crash now encourages investing and increases ex post expected payoffs for the rational investors.

As far as the irrational investors are concerned, the sequence of emotions that overwhelm them causes every one of them to receive a negative ex post expected payoff. Not only does this irrationality inversely affect them, but also the rational investors in Stage 1.

2.6. Conclusion: Possible Extensions To the Model

We now consider some extensions to this model, which would take into account conditions better suited in Financial Markets and also alternative ways of modeling economies with both rational and irrational investors.

(i) Underpricing: In order to be consistent with the empirical findings of Stoll and Curley (1970), Reilly (1973), Logue (1973), Ibbotson (1975) and Ritter and Welch (2002) we could introduce an underpricing factor to the initial share price. This would involve multiplying the fundamental share price by, say 0.8, to account for

20% underpricing. This would initially have a similar effect as the price crash in Stage 2, however when the price inflates, rational investors would have to consider both inflation and underpricing by the issuer in their expected payoff equation.

(ii) Instead of assuming that after the price crash the share price remains fixed below its fundamental value, we could carry over the inflation from Stage 1 into Stage 2 but with an additional term that now takes into account hatred towards the issue by the irrational investor. Such a term would counteract the inflation from Stage 1 and thus rational investors would have to consider the effects of both inflation and deflation simultaneously when calculating their expected payoff. For example, the second rational investor would be faced with a payoff equation:

$$\Pi_{R_5}|(S_4 = S_G, S_5 = S_G) =$$

$$\frac{1}{N}(\dot{p}V_H + (1-\dot{p})V_L) - \frac{V_H + V_L}{2N}(1+3\Delta_{LOVE})(1-\Delta_{HATE}) \qquad (57)$$

this implies that:

$$\dot{p} \geq \frac{(V_H+V_L)(1+3\Delta_{LOVE})(1-\Delta_{HATE}) - 2V_L}{2(V_H-V_L)} \qquad (58)$$

is needed for R_5 to invest. The numerator in (58) indicates the ambiguity concerning the current share price since, if the inflation outweighs the deflation, we will see similar results in Stage 2 as in Stage 1.

(iii) Our analysis has shown that, in the presence of irrational investors, the investment decision of rational investors rely heavily on the strength of the signal

q. Following the work of Chenmaur (1993), we could impose a condition that allows an investor to increase the strength of their signal (increase q) at a price. In other words they would be marginally increasing their information set. Then they would have to consider if the increase in the strength of their signal is beneficial when irrational investors have inflated the share price above its fundamental value.

(iv) We could introduce some form of social learning to the irrational investors by adding in a second IPO with the same irrational investors in the economy. In this second IPO, the Δ_{LOVE} term would be smaller than in the first period, to account for irrational investors realisation that their emotions had clouded their judgment and resulted in negative payoffs. Since the term is still included, it means that irrationality, and in particular, phantasy, is still present. This would strengthen the likelihood of Rationals investing relative to the first IPO. Furthermore, in such a case, the price crash in Stage 2 would be less drastic and thus q would need to be higher relative to the first IPO for Rationals to invest.

(v) An alternative way of modeling an economy with both rational and irrational investors could be to use the Lotka-Volterra Competition equations (Lotka, 1910). In mathematical biology, these are used to model the dynamic behaviour of multiple species and determine if co-existence between the species is possible. For the purpose of extending our research, instead of the looking for co-existence, we can determine if there are such states when all types of investors in the economy can have positive payoffs. After briefly developing a simple model with three types of investors in the economy (love investors, hate investors and fully rational investors) where, consistent with our findings so far, the love investors inversely affect the Rationals' payoff and the hate investors positively, there was no steady state where all three types of investors receive a positive payoff. We could add in other relationships between the three types, as well as use some of our parameters in our model as the rates and coefficients in the Lotka-Volterra equations. For example, the Δ_{LOVE} could be the term that inversely the rational investor’s payoff. Also, love and hate investors could inversely affect each others’ payoffs as well.

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