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CAN RUMORS AND OTHER UNINFORMATIVE MESSAGES CAUSE ILLIQUIDITY?

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Abstract

This paper analyzes whether false information, rumors and other uninformative messages can *cause* illiquidity. In the model, a group of investors are invited to participate to a high-yield collective project. The project succeeds only if a minimum participation rate is reached. Before taking their decision, investors receive an uninformative but emotion loaded message. If investors believe that the message has an impact on the beliefs of the others, the problem can be analyzed as a typical global game. We solve the model for the critical message separating the success / fail states of the project. It turns out that lesser investors will participate to the collective project when they receive a negative message as compared to the case when they receive a positive message. Predictions of the theoretical model are corroborated by data provided by an Online and a Lab experiment. Insights apply to contagion and market manipulation episodes.

Keywords: Illiquidity; Rumors; Market panic; Global games; Strategic uncertainty, Experiments.
JEL Classification: G01; G11; C91; D84.

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1 Introduction

The 2007-2009 Great Recession and the recent 2010-2012 turmoil in the Euro sovereign debt markets were dramatic reminders of how disruptive financial crises can be. Both of them carried the mark of illiquidity: in a short lapse of time and without any premonitory alert, investors in various short-term assets (bank commercial paper, CDOs, MBSs or "EU peripheral countries" public debt) just vanished. In turn, the sudden asset liquidation puts at risk the survival of the borrowers, be them large banks or governments. In an influential book written in the aftermath of the 2007-2009 crisis, Akerlof and Shiller (2010, p. 82) point out that "in the same way that nineteenth-century bank depositors fled into currency in times of panic, every short-term lender may want to be the first in line not to renew its loans to investment banks, bank holding companies, and hedge funds".

Economists' explanations to financial crises are often grouped in two main classes (Goldstein, 2011; Goldstein and Razin, 2012). The first class focuses on the "real factors": according to these theories, slow and undetected deterioration in fundamentals ultimately brings about a large swing in the equilibrium values of output and employment. The second class of explanations emphasizes the instability of private agents' beliefs about the state of the economy; a sudden deterioration of these beliefs would prompt them to consume or to invest less, thus engineering a self-enforcing process shifting the economy from a "good" to a "bad" equilibrium.[1]

Quite often, journalists but also some economists, refer to financial crises as market panics, with a vocabulary borrowed from psychology that emphasizes the "irrational" component of some financial trades.[2] Bracha and Weber (2012, p. 2) describe market panics as "emotional reaction with adverse consequences that is not (entirely) justified by existing market information". According to Kindleberger and Aliber (2005, p. 104), a financial panic is "a sudden fright without cause". *The Economist* on February 13, 2010 acknowledges that illiquidity is "the most emotional

[1] That sudden changes in investors' beliefs can have substantial consequences on financial markets and ultimately on the real economy could be traced back at least to the General Theory by John Maynard Keynes in 1936.

[2] The origin of the word panic comes from the god Pan, known for causing terror (Kindelberger and Liber (2005). A medical perspective on panics can be found in the US "Diagnostic and Statistical Manual of Mental Disorders", whose fifth version was published on May 2013. Main emotions associated to panic are "intense fear or discomfort".

of risks".

Actually, as noticed by Goldstein (2011), during financial crises emotional responses do combine their effects with rational decision-making where deteriorating beliefs and negative real consequences are tied together. This paper aims to study whether a rumor-type "uninformative message" can bring about a generalized "sell" movement or illiquidity, even if in the first stage fundamentals were invariant.

As a representative example, when the *Daily Mail* – a middle market UK tabloid with modest record in economic analysis – commented on August 7, 2010 that the French bank *Société Genérale* might be in big financial troubles, the bank's share price fell by 22.5% during one single trading day, although investors gave little credit to the journal's expertise in financial accounting. As it turned out one day later, the journalist who wrote the paper did not use any serious information and the journal had to present formal apologizes. The next day the share price went up by 13%; furthermore, the normal performance of the bank in the second half of the year confirmed that the bank faced no major problem.[3]

Another example is provided by Orléan (1989) in what he refers to as the "Reagan effect". Taking stock on a story reported in the *New York Times* of December 12, 1987, he notices that in response to a journalist' query, the President Ronald Reagan commented that the dollar "has depreciated enough". Nobody believed the President, the article relates, since operators in the financial markets all have doubts about the President's knowledge of economics. Yet the next day all traders bought dollars, probably because everyone believed that the others will believe the President's statement. The dollar ended up by appreciating in a significant way.

In the first part of the text we develop a simple investment coordination game inspired by the classical bank-run paper by Diamond and Dybvig (1983). There is a constant, large number of investors. Each can either invest a fixed amount in a safe, low-yield project or in a high-yield, collective investment project. The collective project succeeds only if the participation rate exceeds an exogenously given threshold. If the project succeeds, investors get a high positive payoff, if not,

[3] A formal investigation was opened by the French financial market regulator (AMF), but no proof of intentional market manipulation or inside trading was found. See: "French regulator warns UK paper over SocGen story", *Reuters News*, January 22, 2013, Online at www.reuters.com.

they get nothing. Since the success of the project depends on many persons' individual decision, the project presents a specific risk stemming from investors' legitimate doubts about the ability of the other investors to coordinate on the most favorable outcome. As an original development in this paper, investors must take their decision after getting a message conveying a piece of information unrelated to the fundamentals, but having an emotional loading that impacts the motivation to invest. While such emotions can be quite various, in the theoretical part we consider that we can extract a common factor and use a real number scale to rate any of these messages, from the most negative to the most positive. However, a given message can be interpreted differently by various investors, depending on their psychological biases. More in detail, a positive message can be seen as bad by a pessimistic person, while a negative message can be read as a good one by an optimistic person. Investors do not know the bias of their colleagues, but have the right idea about the distribution of biases in the population of investors.

If investors discard this message, this coordination game presents two trivial Nash equilibria, the high-risk, Pareto dominant one where all investors participate to the collective project, and the zero-risk, Pareto dominated one where no investor participates (Bryant, 1983). However, investors might use the non-informative message as a coordination device. If they admit that the message influence the decision to invest of the other members of the group, then beliefs are no longer common knowledge and the problem can be framed as a typical global game (Carlson and Van Damme, 1993). Morris and Shin (1998) have developed an original method for determining a coordination equilibrium in n-player global games. They applied this method to various contexts, such as currency crises, bank runs, credit risk and illiquidity debt default (Morris and Shin, 2001; 2002; 2004; 2009). In these papers, investors observe the fundamental state of the economy with a noise; in our paper, investors interpret a message *unrelated to fundamentals* with a psychological bias. We will show that, when messages and biases are normally distributed, this game presents a non-trivial coordination equilibrium defining a critical message below (above) which the project fails (succeeds). We can show that the equilibrium participation rate to the high risk collective project is neither zero, nor one; furthermore, the participation rate will be low when the received message is negative and vice-versa. Which one of the tree equilibria prevails is actually an empirical

issue.

What makes the empirical analysis of illiquidity crises difficult is just the fact that bad news, negative emotions, deteriorating beliefs and deteriorating fundamentals all come together; it is therefore extremely difficult to infer from the data which was the "original shock". One way to bypass these empirical difficulties is to resort to Lab experiments, wherein we can control for the message conveyed to participants, while keeping fundamentals invariant. There is an impressive experimental literature on coordination games as surveyed by Camerer (2003) and Devetag and Ortmann (2007). One established result is that the Pareto dominated equilibrium is rather resilient in games with complete information, a finding firstly put forward by Van Huyck et al. (1990). On the other hand, there are many devices – such as "cheap talk" (costless non-binding pre-play communication), introduction of leaders, former experience with coordination, feed-back information, etc. – that can help engineering coordination on the higher payoff equilibrium.[4]

In coordination games with imperfect information, experiments tend to show that the Morris and Shin equilibrium dominance prevails, with players adopting a "go/no go" threshold strategy (Heinemann et al., 2004; 2009). Cornand and Heinemann (2013) test a coordination game with strategic complementaries. In one treatment agents receive private and public signals unrelated to "fundamentals"; they show that individuals use the public information to coordinate their actions.

We develop two controlled experiments to test our theoretical model. A first experiment was administered on-line. Subjects, self-selected from the ESSEC Business School student population, were matched in groups of five and were given the opportunity to invest a marketing grade bonus point into a collective project. The project succeeds if at least three out of five students invest. If the project succeeds, the bonus is doubled, if not the bonus is canceled. All subjects in the same group received the same message through the computer's interface. Half of the groups received a "neutral" message, and half of the groups received a "negative message". The second experiment is a variant of the study by Heinemann et al. (2009). They show that strategic uncertainty in coordination games is addressed by individuals in similar ways that they address risk in elementary

[4] The paper is closest to the "cheap talk" literature (e.g. Cooper et al. 1992, Farell and Rabin, 1996, Charness, 2000) where players themselves engage in pre-play costless, unbinding communication, as well as the analysis of the impact of an external advice on cooperation by Van Huyck at al. (1992) and Bangun et al. (2006).

lottery choices. To analyze individuals choice under strategic uncertainty, they developed a choice problem where the individual must choose between a certain payoff and the random payoff of a coordination game. By varying the certain amount along a monotonous scale, they can determine the individual-specific thresholds where the certain payment becomes a more attractive choice than the risky option. We use the same framework, but introduce two treatments: some groups will receive a positive message, some groups will receive a negative one. It will be shown that negative messages disturb coordination on the high payoff equilibrium of the coordination game. Finally, in both our experiments, messages are delivered through the computer interface. This corresponds to an "almost common knowledge" setup, as defined by Bangun et al. (2006), as compared to a "common knowledge" variant where the information would have been displayed on a blackboard that could be observed by everyone simultaneously, as in Van Huyck et al (1992).

The theoretical analysis and the experiments corroborate the intuition provided by real life examples according to which rumors and other uninformative messages can trigger illiquidity in asset markets. The majority of models of contagion in financial markets take into account "common shocks" or a hidden correlation in fundamentals between two distinct markets via trade or financial linkages (Summers, 2000). Our paper points to another source of contagion, where bad news about one market (country) can have devastating effects on investors in a different market (country) even if fundamentals of the two economies are strictly independent.

The paper is organized as following: In the next section we develop our simple theoretical model. Section 3 introduces the two experiments. Section 4 presents our conclusions.

2 Theory

2.1 Assumptions and definitions

There is a large, given number of identical risk-neutral investors, normalized to 1.[5] Each individual investor can invest a fixed amount Z either in a in *a safe, individual project*, or in a *high-yield, riskier collective investment project*. The safe project will bring him S (with $S > Z$), the high-yield collective project will bring W in case of success ($W > S$) or nothing in case of

[5] The assumption of risk neutrality is not essential, the model could be solved for any type of preference toward risk.

failure.

Table 1 summarizes the possible payoffs of an investor, depending on his strategy (invest in the collective project / invest in the safe individual project) and the final state of the collective project (fail / success):

	Collective project: fails	Collective project: succeeds
Invest in collective project	$-Z$	$W - Z$
Invest in safe project	$S - Z$	$S - Z$

Table 1. The payoff matrix

To simplify notations, we can normalize these payoffs:

	Collective project: fails	Collective project: succeeds
Invest in collective project	0	1
Invest in safe project	λ	λ

Table 2. The normalized payoff matrix

with $\lambda = S/W \in]0,1[$ being the relative net gain in the safe compared to the risky project.

Let γ denote the frequency of investors who invest in the collective project, with $\gamma \in [0,1]$.

In the line of the Diamond and Dybvig (1983) model, we admit that the collective project succeeds if a "critical participation rate" is reached, and fails if else. Many investment projects require a critical mass in order to succeed. Let v denote the "critical participation rate", with $v \in]0,1[$ being known and exogenously determined. Formally:

$$\text{The collective project: } \begin{cases} \text{Succeeds if } \gamma \geq v \\ \text{Fails if } \gamma < v \end{cases} . \tag{1}$$

Prior to making their decision, investors receive an uninformative message, where "uninformative" means that the information provided in the message is not related to the fundamentals of the project, i.e., it does not alter the payoffs or the rule of the game, nor brings additional information about the players' strategies.

However, the information can generate a spectrum of emotions related to the project, ranging from least to the most positive ones, such as optimism, trust, enthusiasm, and so on. We admit

that these multiple facets have a common factor, and that factor can be given a grade ρ on a real number scale.[6] For instance, a positive ρ is can be associated to a message such as: "in the past, all such projects have been successful". A negative ρ would then correspond to: "in the past, none of these projects have succeeded". We admit that the statistical distribution of the message grades is known, and is characterized by the c.d.f. $F(\rho) : \mathbb{R} \to [0, 1]$. The ex-ante mean value of ρ, denoted by $\bar{\rho}$, is representative of the general investors' mood. In this paper we consider that the distribution of ρ is predetermined. In a more powerful model, the distribution itself can change, with a higher $\bar{\rho}$ in good times than in times of crisis.

When Nature (journalists) picks a message from the set of messages, investor i interprets it with a psychological bias, $q_i = \rho + \epsilon_i$, where ϵ_i is also a random variable with $E[\epsilon_i] = 0$ and known c.d.f. $H(q)$. We refer to q_i as the "perception" of ρ by an individual i.

Investors might rationally decide to discard the non-informative message. In this case, the game present two trivial Nash equilibria (see Bryant, 1983):

- The first is the Pareto dominant one where all invest in the collective project: because $\gamma = 1 > v$, the risky collective project succeeds and all investors get 1, thus validating their choice ($1 > \lambda$); the investor who would opt for the investment in the safe project would regret his choice.

- The second is the minimum risk Pareto dominated equilibrium where all would-be investors prefer the safe project and get λ; as $\gamma = 0 < v$, the collective project fails. Should one individual decide to invest, his contribution does not allow the project to succeed, thus his payoff would be $0 < \lambda$.

However, these are not the only equilibria of the game. We will show that there is a "non-trival" equilibrium where investors take into account the possible response of the other investors to the message. In this case, the participation rate is positive, lower than one, and depends on the message.

[6] Alternatively, we can consider that the message just conveys some information about the chances of the project to succeed, but this information is not relevant since it tells nothing new about the actual game. In this case, ρ measures the intensity of the statement, along a negative to positive scale.

2.2 Non-trivial equilibrium: the general solution

If investors take into account their own perception of the message, and the perception of the message by of the others, the problem can be analyzed as a standard $n-$player global game, firstly introduced and solved by Morris and Shin (1998). As Atekson (2001) emphasizes, there are two important distributions:

- The first is the distribution of perceptions q_i across agents, conditional on the realization of the message ρ. The c.d.f. of this distribution is denoted by $H(q, \rho)$; its mean value is ρ itself.
- The second is the posterior distribution over ρ of an agent who perceives q_i. This is obtained from Bayes rule and has the c.d.f. $F(\rho, q_i)$; its mean value will be a weighted average between the mean of the ex-ante distribution ($\bar{\rho}$) and the perception q_i.

If the group of investors receives a very poor message (such as "investing in this project is the worst thing you will do today"), it is highly probable that even the most optimistic investors will chose the safe project, and that all other investors are aware of this and do the same. To the contrary, a very positive message ("smile, today is your lucky day"), might prompt even the most pessimistic investors to participate to the collective project, so all the other realize this and participate as well. We admit that there exist a "critical message" ρ^* along our negative to positive emotion scale, such that:

$$\begin{cases} \text{For } \rho \geq \rho^* \text{ the collective project succeeds } (\gamma \geq v) \\ \text{For } \rho < \rho^* \text{ the collective project fails } (\gamma < v) \end{cases} . \tag{2}$$

In this case, an investor i (who perceives q_i) will adopt a "threshold strategy", such that he will:

$$\begin{cases} \text{Invest in the collective project if } q_i \geq q^* \\ \text{Invest in the safe project if } q_i < q^* \end{cases} . \tag{3}$$

where q^* is a "critical perception".

In this game, q^* and ρ^* will be determined simultaneously as equilibrium (endogenous) values.

1. The critical message equation

For a given critical perception q^*, the frequency of investors who prefer the safe project conditional on realization of message ρ is $\Pr[q_i \leq q^* | \rho] = H(q^*, \rho)$. For symmetric, single peaked

statistical distributions, this function is decreasing in ρ. It is also increasing in q^*. The participation rate to the risky collective project is $1 - H(q^*, \rho)$. We know the collective project will succeed as long as this participation rate is larger than v. For a given q^*, equation:

$$H(q^*, \rho) = 1 - v \tag{4}$$

implicitly defines ρ^* such that if $\rho < \rho^*$, then $H(q^*, \rho) > (1 - v)$ and the project fails; if $\rho \geq \rho^*$, then $H(q^*, \rho) \leq (1 - v)$, the project succeeds. We can write $\rho^* = \rho^*(q^*, v)$, with $\frac{\partial \rho^*}{\partial q^*} > 0$ and $\frac{\partial \rho^*}{\partial v} > 0$.

2. The critical perception equation

For a given critical message ρ^* the probability that an individual assigns to the event that the project fails, contingent upon his perception q_i is $\Pr[\rho \leq \rho^* | q_i] = F(\rho^*, q_i)$. The probability is assessed according to the ex-post distribution of the ρ; the mean value of the ex-post distribution is an increasing function in the individual's perception q_i. Thus the function $F(\rho^*, q_i)$ is decreasing in q_i and is increasing in ρ^*.

We know that an individual i will invest in the collective project if the expected gain exceeds his certain gain from investing in the safe project (λ), and vice versa.

Thus equation:

$$\begin{aligned} & 1 \times (1 - \Pr[\rho \leq \rho^* | q_i]) = \lambda \\ \Leftrightarrow & \Pr[\rho \leq \rho^* | q_i] = 1 - \lambda \\ \Leftrightarrow & F(\rho^*, q_i) = 1 - \lambda \end{aligned} \tag{5}$$

implicitly defines, for a given ρ^*, the critical perception q^* such that an individual who records it is indifferent between investing in the collective or in the safe project. We can write $q^* = q^*(\rho^*, \lambda)$, with $\frac{\partial q^*}{\partial \rho^*} > 0$ and $\frac{\partial q^*}{\partial \lambda} > 0$.

As can be seen, the critical message ρ^* depends on the critical perception q^* and vice versa. Hence, an *equilibrium* is a couple (q^*, ρ^*) that simultaneously fulfills the two equations:

$$\Pr[q_i \leq q^* | \rho^*] = 1 - v \tag{6}$$

$$\Pr[\rho \leq \rho^* | q^*] = 1 - \lambda. \tag{7}$$

Under general statistical distributions, the system can have no solution, one solution or more than one solution. In the next section we show that with normal distributions for ρ and ϵ, the system has one solution. This defines an equilibrium where depending on the message, the project will be either in the success or the fail state.

2.3 Non-trivial equilibrium with normal distributions

From now on we assume that Nature chooses the message from a normal distribution, $\rho \rightsquigarrow N(\bar{\rho}, \sigma_\rho^2)$, where $\sigma_\rho^2 = 1/\alpha$ denotes the variance of the message state along the measured characteristic (α is the precision).

We also assume that the psychological bias follows a normal distribution: $\epsilon_i \rightsquigarrow N(0, \sigma_\epsilon^2)$ with $\sigma_\epsilon^2 = 1/\beta$.

We know that when Nature picks right the equilibrium critical message ρ^*, the distribution of q_i has mean ρ^* and precision β. We can write:

$$\Pr[q_i \leq q^* | \rho^*] = \Phi\left(\sqrt{\beta}(q^* - \rho^*)\right), \tag{8}$$

where $\Phi()$ denotes the standard normal c.d.f.

We then remark that the posterior distribution over ρ of an agent who perceives q_i has a mean:

$$E[\rho | q_i] = \frac{\alpha}{\alpha + \beta}\bar{\rho} + \frac{\beta}{\alpha + \beta} q_i, \tag{9}$$

and a precision $(\alpha + \beta)$.

For an individual that perceives exactly the critical q^*, the conditional probability that the project will fail is:

$$\begin{aligned}
\Pr[\rho \leq \rho^* | q^*] &= \Phi\left(\sqrt{\alpha + \beta}\,(\rho^* - E[\rho | q^*])\right) \\
&= \Phi\left(\sqrt{\alpha + \beta}\left[\rho^* - \frac{\alpha}{\alpha + \beta}\bar{\rho} - \frac{\beta}{\alpha + \beta} q^*\right]\right) \\
&= \Phi\left(\sqrt{\alpha + \beta}\left[\frac{\alpha}{\alpha + \beta}\,(\rho^* - \bar{\rho}) - \frac{\beta}{\alpha + \beta}\,(q^* - \rho^*)\right]\right).
\end{aligned} \tag{10}$$

Our system of two equations (Eq. (6) and Eq. (7)) that characterize the equilibrium becomes:

$$\Phi\left(\sqrt{\beta}(q^* - \rho^*)\right) = 1 - v \tag{11}$$

$$\Phi\left(\sqrt{\alpha + \beta}\left[\frac{\alpha}{\alpha + \beta}\,(\rho^* - \bar{\rho}) - \frac{\beta}{\alpha + \beta}\,(q^* - \rho^*)\right]\right) = 1 - \lambda. \tag{12}$$

The first equation (Eq. 11) provides, for a given critical perception (q^*), the threshold message that separates the success / fail states of the collective project[7] :

$$\rho^* = q^* + \frac{\Phi^{-1}(v)}{\sqrt{\beta}}, \tag{13}$$

The higher the participation threshold v, the higher ρ^* and the higher chances that the project fails.

The second equation (Eq. 12) indicates, for a given critical threshold message, what is the perception that makes the individual indifferent between investing in the safe or in the risky project:

$$q^* = \left(1 + \frac{\alpha}{\beta}\right)\rho^* - \frac{\alpha}{\beta}\bar{\rho} + \frac{\sqrt{\alpha+\beta}}{\beta}\Phi^{-1}(\lambda). \tag{14}$$

For a given ρ^*, the higher the payoff associated to the safe project (λ), the higher the critical perception q^* and the larger the frequency of investors who prefer the safe project.

The two functions can be represented in the $(O\rho^*, Oq^*)$ space as two straight lines with a different positive slope. They can cross only once, at the equilibrium critical values (ρ^*, q^*). Hence, in this simple framework, the equilibrium is unique, whatever the variance of ρ and ϵ.[8] The only case where the non-trivial equilibrium does not exist is if $\beta \to \infty$, i.e. there is no bias in interpreting the message (no bias), or if $\alpha \to 0$, i.e. the variance of ρ tends to infinity (the distribution of ρ looks like an uniform distribution on $(-\infty, +\infty)$). We will not consider these extreme cases.

Solving the system, we obtain firstly the equilibrium critical message:

$$\rho^* = \bar{\rho} - \frac{\sqrt{\alpha+\beta}}{\alpha}\Phi^{-1}(\lambda) - \frac{\sqrt{\beta}}{\alpha}\Phi^{-1}(v). \tag{15}$$

If the group of investors receive a message $\rho_0 < \rho^*$, then the project will fail because less than v investors will participate, and if they receive a message $\rho_1 > \rho^*$, then the project will succeed. It is interesting to remark that for some values of λ and v (for instance, if both are lower than 0.5), we have $\rho^* > \bar{\rho}$.[9] In this case, there is a set of "good messages" – in the sense that they are rated

[7] Recall that $\Phi^{-1}(1-x) = -\Phi^{-1}(x)$.

[8] In all other applications of the Morris and Shin (1998), the uniqueness of the equilibrium relies on strict conditions about the variances of the two key random variables (state of the economy and noise).

[9] The necessary and sufficient condition for $\rho^* > \bar{\rho}$ is $(\alpha/\beta + 1)^{0.5}\,\Phi^{-1}(\lambda) + \Phi^{-1}(v) < 0$.

above the expected rating, $\rho \in [\bar{\rho}, \rho^*]$ – where default can still happen.

Next, the equilibrium critical perception is:

$$q^* = \bar{\rho} - \frac{\sqrt{\alpha+\beta}}{\alpha}\Phi^{-1}(\lambda) - \left(\frac{\beta+\alpha}{\alpha\sqrt{\beta}}\right)\Phi^{-1}(v). \tag{16}$$

We have denoted by γ the frequency of investors who participate to the collective project. Thus, if nature picks a message $\rho = \rho_0$, the signal distribution will be centered around ρ_0; all persons with $q_i \geq q^*$ will participate and all those with $q_i < q^*$ will prefer the safe project. The participation rate is:

$$\gamma = 1 - \Phi\left(\sqrt{\beta}(q^* - \rho_0)\right). \tag{17}$$

First, we notice that this frequency is neither zero, nor one as it is in the trivial Nash equilibria with ignored information. Second, this frequency increases with the position of the message along the negative to positive emotion scale. For the equilibrium q^*, if the message is more positive, more investors will participate to the collective project: $\partial\gamma/\partial\rho_0 > 0$.

To sum up this theoretical section, this game present two trivial Nash equilibria, one involving a participation rate $\gamma = 1$, and the other involving a participation rate $\gamma = 0$. In the third, non-trivial equilibrium, $\gamma \in (0, 1)$. While intuition would suggest that the most plausible case is the latter, theory only does not allow to select one of them. It it therefore a sensible research strategy to try to observe how human subjects play this game in the Lab, and see what of the tree equilibria tend to prevail.

3 Experimental evidence

We implemented two experiments in order to test the implications of our theoretical model. In particular, we are interested in the impact of the uninformative message on the frequency of investors. Should the frequency of investors respond to the message, this would suggest that the non-trivial equilibrium is at work; hence investors take into account the potential impact of the message on the beliefs of the other investors.

3.1 An online test

A first experiment was performed online. An interactive survey was delivered through the ESSEC Sona system to the whole population of ESSEC students enrolled in graduate marketing classes on October 22-26, 2012 and February 25-28, 2013. Students who answered at the first survey wave did not receive the second call. It is important to underline that the population of students is relatively homogenous in terms of education, age and GMAT scores.

- **Experimental design**

The experiment comprises two distinct stages. In the first stage, subjects were asked to perform a simple real effort task (to count 7s in a table of figures). This test was quite simple: it took students on average 60 seconds to answer, and only 3 out of 213 failed. All those who got the right answer got a 0.1 bonus point, that they can add to the final grade of a marketing class of their choice. The purpose of this first task was to provide students with a feeling that they "earned" their bonus point by undertaking some kind of "work".

In the second stage, all the students (who earned the 0.1 bonus) were matched at random in groups of five persons. They were given the opportunity to participate to a collective investment project under the following rule: if three or more students invest their bonus point, the project succeeds; if two subjects or less participate, the project fails. When the project succeeds, all those who invested their 0.1 bonus point will get the double, i.e. 0.2 bonus points; those who did not participate keep their initial 0.1 bonus point. If the project fails, all those who invested their 0.1 bonus will end up with nothing (see Table 3). Instructions are provided in a Web Appendix.[10]

	Project fails	Project succeeds
Invest in collective project	0	0.2
Opt-out	0.1	0.1

Table 3. The bonus payoff matrix in the Online experiment

Notice that the payoff matrix in Table 3 is similar to the payoff matrix in the theory section (Table 2); by dividing everything by 0.2, we get a payoff 1 if the project succeeds and the opt-out

[10] Web address: http://behavioralresearchlab.essec.edu/research/research-topics/results

payoff $\lambda = 0.5$.

The rule of "at least three out of five investors for the project to succeed" is tantamount to a critical participation threshold $v = 0.6$.

Before taking their decision whether to invest or not, all subjects in a group received a same message through the computer interface; they were informed that all subjects in their group received the same message.

We run two treatments in a between subjects design. In Treatment A, half of the groups received a "neutral" message:

"*In the last period, weather forecasts have greatly improved*"

and, in Treatment B, the other half received the "negative" message

"*Last time the game was played, none of the investors won anything*"

Compared to Message A, Message B conveyed negative feelings about the game; both were uninformative in the sense that they did not carry any new, relevant information about the rule, payoffs, type and strategy of the players, etc.

- **Results**

A total of 210 subjects (42 groups) got the 0.1 bonus point and were offered to participate to the collective investment project. Half of them received Message A and half Message B.

Table 4 presents the rough data. A total of 105 subjects got the message A, and 105 subjects got the message B. Among the 105 students who received the "neutral" message, 92 chose to invest the bonus point in the collective project. Only 63 of the 105 students who got the "negative"message invested their bonus point.

Message	Opt-out	Invest in coll. project	Total
Neutral	13	92	105 (21 groups)
Negative	42	63	105 (21 groups)

Table 4. Results of the Online experiment

Even under a neutral message, and although this set of students is very homogenous and naturally trustful, the participation rate is lower than one (the Pareto dominant Nash equilibrium was not implemented). The participation rate responds to the message, as suggest the analysis of the non-trivial equilibrium. Compared to the "neutral" message, in the case where subjects received the "negative" message, the participation rate to the collective project declined from 87.6% to 60%; the change in behavior is statistically significant, as shown by the χ^2 test (significant at the $p<0.01$ level).

While under the neutral message only one out of 21 groups was in a situation of default, under the negative message 7 out of 21 groups defaulted (the difference is statistically significant; the F-test is significant at $p<0.04$).

3.2 A Lab experiment

- **Experimental design**

We also implement a lighter variant of the experiment used by Heinemann et al. (2009) to measure aversion to strategic uncertainty; we adapt it in order to study the consequences of irrelevant messages on the decision of the subjects to participate to a coordination game.

We run three sessions, two of them being performed at the LESSAC (the Experimental Lab of ESC Dijon) on March 29, 2013 and a third one at the ESSEC Experimental Lab on April 23, 2013 with a total of 75 subjects. Subjects were recruited from the student population of the schools, who answered to a call for paid decision experiments. Instructions were presented via computer interface and all interactions were computerized. The program was written in z-Tree (Fischbacher, 2007). Each subject was assigned at random with a PC terminal. We make sure that no subject has participated more than once in this experiment.

The average time spend in the Lab was 20 minutes; on average they earned 16.30 euros including a 5 euros show-up compensation.

At the outset of the experiment, subjects were matched at random in groups of five. There were more than two groups in each session, to prevent students to identify each other. Before starting the experiment, subjects were required to answer several questions, to makes sure that

they understood the rules. The experiment started after all subjects provided correct answers to these questions.

In the test, subjects face 20 independent choices (situations), organized in two distinct blocks of 10 situations each. The first block tests is the most important because it tests the coordination game; the second block tests an elementary lottery used for a robustness check. In each situation, the subject must chose between an option A and an option B. Option A provides a certain payoff, varying from 1.50 euros to 15 euros, in increments of 1.50 within each block. The payoff for option B is either 0 or 15. In the coordination game the 15 euro payoff is delivered provided that at least three subjects out of five chose option B; remark that the same participation threshold was required in the Online experiment.[11] In the elementary lottery, the probability of the 15 euro payoff is 0.5. In order to make sure that there is no carry-over effect from the lottery to the coordination game which is central to our analysis, we asked subjects to play firstly the coordination game, and then the lottery. Instructions are provided in a Web Appendix.[12]

Figure 1 presents the basic decision screen for the coordination game, identical to the decision screen used by Heinemann et al. (2009). Option B is invariant from one situation to the other; option A is the safe bet, whose payoff is increasing from 1.5 to 15 from decision 1 to decision 10. The decision screen for the lottery is similar, except that option B is the lottery (0;15) with 0.5 winning chances.

At the end of the experiment, one of the 20 options is drawn at random by the computer and subjects are paid according to the actual choices they made in the experiment. In the random lottery, the computer performs a random draw with the 0.5 probability.

Such a "multiple price list" provides an incentive for subjects to determine a threshold strategy (Heinemann et al. 2004). Subjects make up their mind about the payoff in the uncertain (risky) choice, and compare it with the certain payoff. Normally they should switch only once, having a preference for the risky choice if the certain payoff is low, and vice versa. When individuals present such threshold strategies, the number of times they choose option B can be interpreted as

[11] Heinemann et al. (2009) test the game for groups of various sizes and for different participation theresholds.

[12] Web address: http://behavioralresearchlab.essec.edu/research/research-topics/results

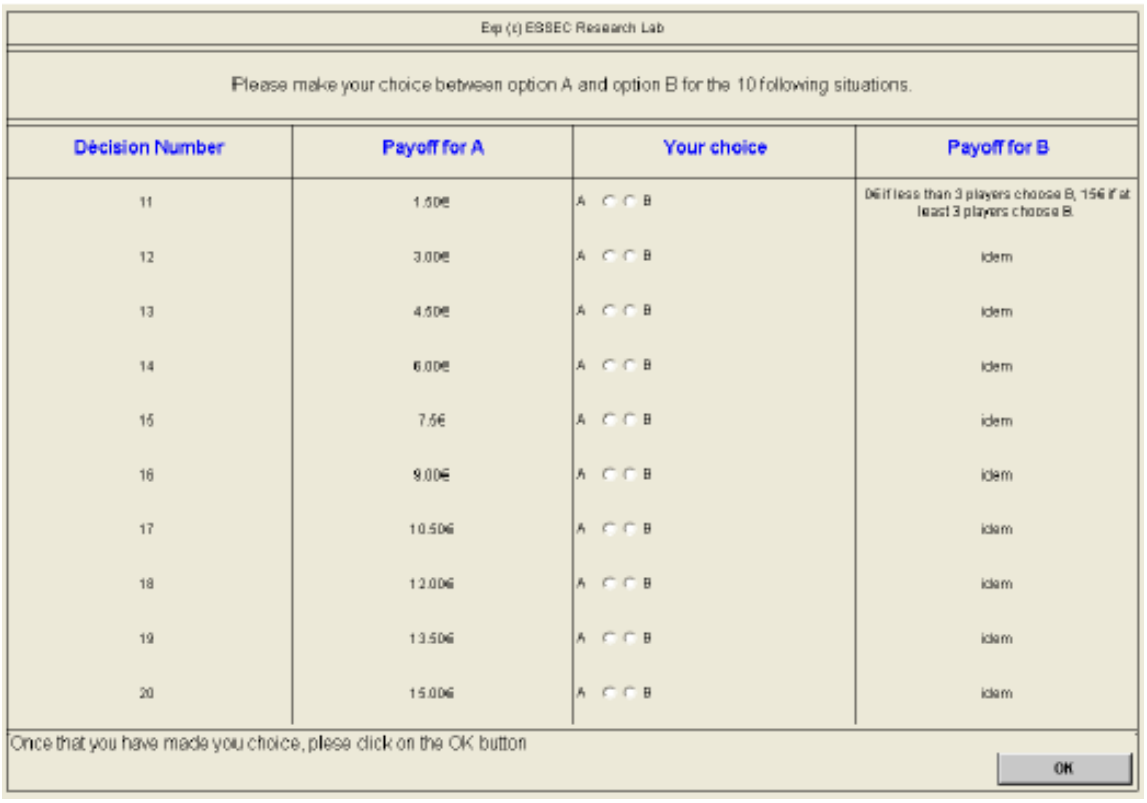


Figure 1: Main decision screen: Coordination game (based on Heinemman et al. 2009)

a measure of their preference toward risk.

Table 5 presents the individual payoff for each situation k, where s_k is the secure payoff, $s_k \in [1.5; 3; 4.5; ...; 15]$. This payoff structure is similar to the payoff matrix in the theoretical section, with $\lambda_k = s_k/15$.

	Collective project fails	Collective project succeeds
Invest in collective project	0	15
Take the safe option	s_k	s_k

Table 5. The payoff matrix in the Lab experiment

At difference with Heinemann et al. (2009), we split the population in two randomly selected subgroups. Before the decision screens were displayed, one group received through the computer interface a "positive" message, and the other group received a "negative" message. It was made clear from the outset that a message will be provided prior to any investment decision, and that all members of the group will receive the same message.

The "positive" message:

"*In a past experiment, subjects that had chosen the risky option were satisfied with their choice*"

The "negative" message:

"*In a past experiment, subjects that had chosen the risky option were disappointed by their choice*"

It is of course difficult to find messages that convey positive/negative emotions related to the situations under scrutiny, but do not directly orient the choice. Worlds such as "satisfaction" and "disappointment" seem to be sufficiently vague to open the door for individual interpretations of its meaning for himself and for the others. While they have a clear positive / negative ordering, they are not excessive. The fact that they refer to a past experiment, make them irrelevant for the current one.

- **Results**

Over the 75 subjects, 10 of them presented inconsistent choices in the coordination game (switched twice). Heinemann et al. (2009) report on rates of inconsistent choices between 1 to 15% depending on the place where experiments were run. In the following we present data only pertaining to the 65 subjects with consistent choices in the coordination game.[13]

Message	Nb. subjects	Av. nb. B-choices Coordination game	Av. nb. B-choices Elementary lottery
Positive	34	7.38	4.76
Negative	31	6.45	4.55

Table 6. Average number of B-choices

The coordination game appears to be more appealing to investors than the lottery given that, whatever the message, they make more B-choices in the coordination game than in the lottery game (these are within-subjects observations). Remark that in the lottery case, when a player

[13] In addition, four players presented inconsitent behavior only in the lottery; we choose to keep them in the analysis.

chooses option B for the last time at decision 4, he is preferring the lottery to a certain 6 euros payoff but is not preferring the lottery to a certain 7.5 euros payoff. He is a risk-averse or risk neutral player. When a player chooses option B for the last time at decision 5, he is preferring the lottery to a 7.5 euros certain payoff, he is a moderate risk loving player. According to the elementary lottery figures, in general subjects are risk neutral or risk averse.

As implied by the analysis of the non-trivial equilibrium, in the coordination game subjects that receive the negative message are more reluctant to participate to the collective project than subjects that receive a positive message (in a between-subjects comparison). On average, the number of B-choices is as low as 6.45 in the first treatment as compared to 7.38 in the second treatment. A Mann-Whitney U test confirms that the difference between the number of B-choices in the coordination game is statistically significant from one treatment to another (P-value$<$ 0.09). As expected, the difference in B-choices is not statistically significant in the lottery choice where beliefs about the others no longer mater.

In the context of our analysis, the most interesting information pertains to the frequencies of individuals who decide to invest in the collective project, for varying λ_k and depending on the type of message (Figure 2).

When the safe project brings little, all investors prefer the collective project, whatever the message. Yet whenever the safe project brings more than 4.5 euros, some players will chose it; the frequency of players investing in the collective project is declining when the safe payoff increases. This tells us that different individuals reach their critical q^* for different safe payoffs (it does not tell us how two groups of identical individuals, one playing with a high safe payoff and the other with a low safe payoff will chose their respective q^*)

In line with the prediction of the theoretical model, more subjects will prefer the collective projects if the message is positive as compared to the case when the message is negative; this pattern holds for all lambdas. Actually, the highest gap is obtained for relatively large values of lambda.

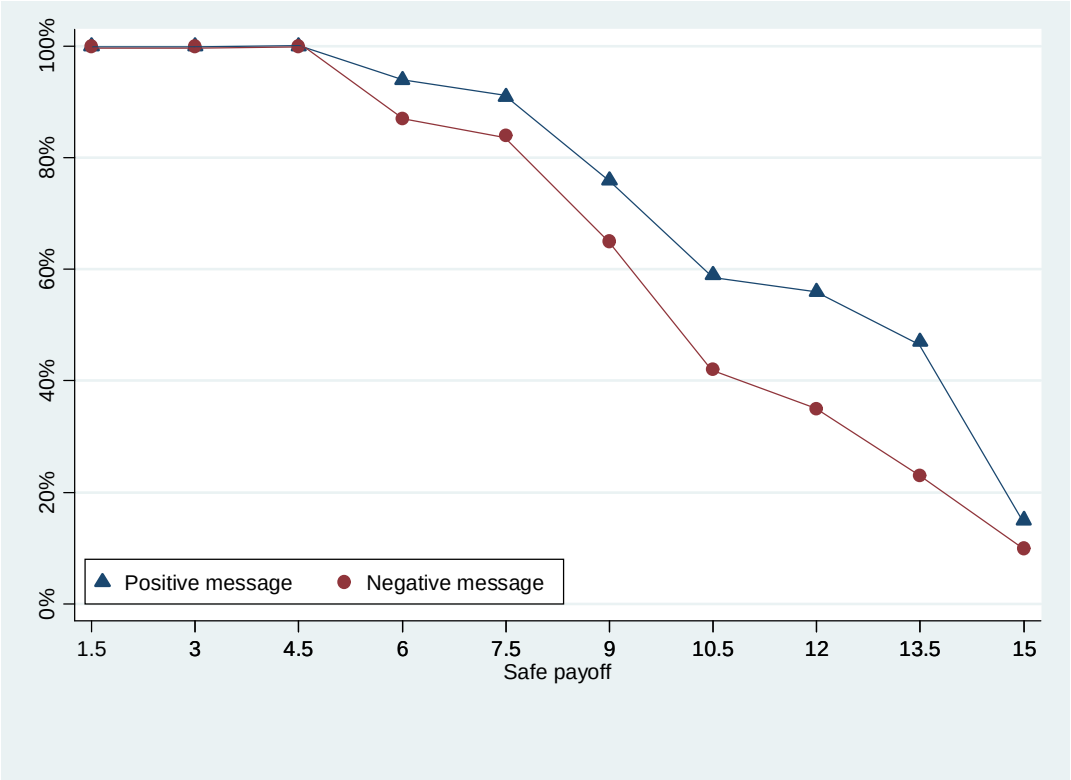


Figure 2: Frequency of investors in collective project, depending on the safe payoff and message.

4 Conclusion

This paper aims to investigate whether rumor-type uninformative messages can cause illiquidity in financial markets. The original contribution of the paper was to study the impact of an uninformative message on the participation rate to a project involving coordination risk.

We first study a theoretical problem where investors have the choice between a safe, low-yield project, and a high-yield collective investment project. The collective project succeeds only if a critical mass of investors participate. The game has almost all the characteristics of a full information game: the rule and the payoffs are common knowledge. However, individuals receive a message, common to all, unrelated to the fundamentals of the game, that can be interpreted by participants in a different way depending on their psychological biases. If subjects discard the uninformative message, the game presents two trivial Nash equilibria, the high-risk, Pareto dominant one where all individuals participate, and the low-risk, Pareto dominated one where nobody invests in the collective project. If subjects use the non informative message to coordinate

their actions, the game presents a "non-trivial" threshold strategy equilibrium as shown by Morris and Shin (1998); we solve the problem for the critical threshold value of the message above which the critical participation is achieved. At difference with the trivial equilibria, in the non-trivial equilibrium the frequency of investors who choose to participate is a positive number lower than one. Furthermore, when this equilibrium is at work, rumors, false and uninformative messages can have substantial implication on investors' decision to participate to collective projects. More precisely, the participation rate is larger for positive messages as compared to negative messages.

We then implement two controlled experiments to study which of the three equilibria prevails. A first experiment was administered online, using bonus point incentives; the second is a standard Lab experiment with money incentives. In both experiments, individuals were matched in groups and were asked to choose between a safe bet and the outcome of a coordination game that delivers a large payoff only if a critical mass of investors participate. Half of the groups received a negative message, half of the groups received a positive or neutral message. In both experiments, the frequency of participants is a positive number lower than one, suggesting that individuals use the non-informative message as a coordination device. In both experiments the frequency of individuals who choose the riskier collective project is much lower in groups that receive a "negative" non informative message as compared to groups that receive "neutral or positive" messages.

The tests were performed with no variation in the critical participation threshold or group size, as extensively tested by Heinemann et al. (2009). Further research might extend the analysis in this direction. In both experiments we considered only two messages, one conveying positive (neutral) and the other negative emotions. It would be interesting to test the game for a wider range of messages. Another extension of the model would consider messages that convey both some relevant information about the fundamentals and irrelevant information.

Such a simple theoretical model backed by experimental evidence sheds its own light on a given type of market panics. It emphasizes that "cheap but emotional talk" might have strong consequences on financial trades. In particular, the mechanism outlined in this paper provides an explanation to a specific form of contagion, where bad news in one market can cause trouble in another market, even if fundamentals of the two markets are strictly independent.

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