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# CAN RUMORS AND OTHER UNINFORMATIVE MESSAGES CAUSE ILLIQUIDITY?

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## Abstract

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 a vague statement about the outcome of a past investment decision. 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 and would present a threshold equilibrium. If not, in theory both an equilibrium where all invest and an equilibrium where no one invests can occur. In a Lab experiment, a large number of subjects adopt switching strategies consistent with the threshold equilibrium and appear to respond to the orientation of the message. 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 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, 2013). 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.<sup>1</sup>

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.<sup>2</sup> 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 of risks".

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<sup>1</sup> 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.

<sup>2</sup> The origin of the word panic comes from the god Pan, known for causing terror (Kindleberger 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".

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 Générale* 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 apologies. 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.<sup>3</sup>

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 analyze in a theoretical perspective how messages bringing no additional information about fundamentals can modify the outcome of an investment coordination game. The structure of the problem is 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

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<sup>3</sup> 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](http://www.reuters.com).

project succeeds, investors get a high, positive payoff, if not, they get nothing. Since the success of the project depends on many persons' individual decision, the project involves a form of strategic risk stemming from investors' legitimate doubts about the willingness 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 making some vague statement about chances that the good (bad) equilibrium has occurred in the past. 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 have the right idea about the distribution of biases in the population of investors, but do not know the individual bias of each other investor.

If investors discard the vague 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. In keeping with the standard result, when messages and biases are normally distributed, the 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 two 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 difficulties is to resort to Lab experiments. 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.<sup>4</sup> 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).

In order to test the implications of the theoretical model, a controlled experiment was conducted at the ESSEC Experimental Lab with subjects who answered a call for paid decision experiments. The experiment extends the analysis by Heinemann et al. (2009) by allowing the administrator of the experiment to provide different messages. Heinemann et al. (2009) asked subjects to choose between a certain payoff and the uncertain payoff of a coordination game (strategic uncertainty). By varying the certain amount along a monotonous scale, they can determine the individual-specific threshold where the certain payment becomes a more attractive choice than the risky option. They show that strategic uncertainty in coordination games is addressed by individuals in a similar way to risk in elementary lottery choices. We use the same framework, but introduce two treatments: some groups will receive a positive message, some groups will receive a negative one. A significant number of subjects (12 out of 95) will invest whatever the safe payoff, as if they discard the message and coordinate on the Pareto dominant equilibrium. A larger number of subjects (71 out of 95) will nonetheless adopt switching strategies as if they use the message as a coordination device. It will be shown that negative messages are associated to a lower participation rate to the collective investment project than positive message.

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<sup>4</sup> The paper is closest to the "cheap talk" literature (e.g. Cooper et al. 1992, Farrell 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 et al. (1992) and Bangun et al. (2006).

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 continuum of identical risk-neutral investors, with a mass normalized to 1.<sup>5</sup> Each individual investor can invest a fixed amount  $Z$  either in a in a *safe, individual project*, or in a *high-yield, risky 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 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	$\lambda$	$\lambda$

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<sup>5</sup> The assumption of risk neutrality is not essential, the model could be solved for any type of preference toward risk.



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

Following Diamond and Dybvig (1983), 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:

$$\text{The collective project: } \begin{cases} \text{Succeeds if } \ell \geq v \\ \text{Fails if } \ell < v \end{cases} . \quad (1)$$

Prior to making their decision, investors receive a message providing a relatively vague comment about the type of equilibrium that occurred at an undefined past moment. A positive message will claim the Pareto dominant equilibrium prevailed in the past, a negative message will claim that the Pareto dominated equilibrium prevailed. The message does not provide any information about the "fundamentals" of the project, i.e., it does not change or further clarify the rule of the game, nor brings any additional information about the strategies or preferences of the subjects involved in that decision. In this respect, we consider that the message is "uninformative". True, if subjects have higher order beliefs about how the others will interpret this message, the message cannot be discarded by rational players, and, without being informative in our narrow sense, it must be taken into account.

To be more specific, depending on the strength of the claim, messages can be ranked on a real number scale, according to a message grade  $\rho$ . For instance, a positive  $\rho$  is associated to a message such as: "in a past experiment, a close investment project has been successful". A negative symmetric message would then state: "in a past experiment, a close investment project has failed". A higher grade (positive) message would be more assertive: "in many similar past experiments, the Pareto dominant equilibrium occurred systematically". We assume that the statistical distribution of the message grade is known, and is characterized by the c.d.f.  $F(\rho) : \mathbb{R} \rightarrow [0, 1]$ . The ex-ante mean value of  $\rho$ , denoted by  $\bar{\rho}$ , is representative of the general investors' mood.

When Nature (journalists) picks a message from the set of messages and delivers it, investor  $i$  will have his own specific understanding of what the message actually means, given his own psychological biases. More precisely, a message of a grade  $\rho$  as delivered by Nature, will be interpreted by the individual as a statement  $q_i = \rho + \epsilon_i$ , where  $\epsilon_i$  is assumed to be a random variable distributed on the set of investors, with  $E[\epsilon_i] = 0$  and a known c.d.f.  $H(\epsilon_i)$ . We further refer to  $q_i$  as the "perception" of  $\rho$  by an individual  $i$ .

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

- The first is the Pareto dominant equilibrium where all invest in the collective project: because  $\ell = 1 > v$ , the 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 investors prefer the safe project and get  $\lambda$ ; as  $\ell = 0 < v$ , 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 exist a "nontrivial" equilibrium where investors use the message as a coordination device. In this case, the participation rate is positive, lower than one, and depends on the message.

## 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 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  $\rho$ . The c.d.f. of this distribution is denoted by  $H(q_i, \rho)$ ; it is obtained from the

distribution of  $\epsilon_i$  around the mean value  $\rho$ .

- The second is the posterior distribution over  $\rho$  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" negative message (such as "there is substantial evidence that this type of collective investment has never succeeded"), 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 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"  $\rho^*$  along our negative to positive grade scale, such that:

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

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

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

where  $q^*$  is the "cut-off perception".

In this game,  $q^*$  and  $\rho^*$  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  $\rho$  is  $\Pr[q_i \leq q^* | \rho] = H(q^*, \rho)$ . For symmetric, single peaked statistical distributions, this function is decreasing in  $\rho$ . 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:

$$H(q^*, \rho^*) = 1 - v \quad (4)$$

implicitly defines  $\rho^*$  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  $\rho^*$  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  $\rho$ ; 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  $\rho^*$ .

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 ( $\lambda$ ), and vice versa.

Thus equation:

$$1 \times (1 - \Pr[\rho \leq \rho^* | q^*]) = \lambda$$

implicitly defines, for a given  $\rho^*$ , 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  $\rho^*$  depends on the critical perception  $q^*$  and vice versa. Hence, an *equilibrium* is a couple  $(q^*, \rho^*)$  that simultaneously fulfills the two equations:

$$\Pr[q_i \leq q^* | \rho^*] = 1 - v \tag{5}$$

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

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  $\rho$  and  $\epsilon$ , 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 ( $\alpha$  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  $\rho^*$ , the distribution of  $q_i$  has mean  $\rho^*$  and precision  $\beta$ . We can write:

$$\Pr[q_i \leq q^* | \rho^*] = \Phi\left(\sqrt{\beta}(q^* - \rho^*)\right), \quad (7)$$

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

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

$$E[\rho | q_i] = \frac{\alpha}{\alpha + \beta} \bar{\rho} + \frac{\beta}{\alpha + \beta} q_i, \quad (8)$$

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

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

$$\begin{aligned} \Pr[\rho \leq \rho^* | q^*] &= \Phi\left(\sqrt{\alpha + \beta}(\rho^* - E[\rho | q^*])\right) \\ &= \Phi\left(\sqrt{\alpha + \beta}\left[\frac{\alpha}{\alpha + \beta}(\rho^* - \bar{\rho}) - \frac{\beta}{\alpha + \beta}(q^* - \rho^*)\right]\right). \end{aligned} \quad (9)$$

The system of two equations (Eq. (5) and Eq. (6)) that characterize the equilibrium becomes:

$$\Phi\left(\sqrt{\beta}(q^* - \rho^*)\right) = 1 - v \quad (10)$$

$$\Phi\left(\sqrt{\alpha + \beta}\left[\frac{\alpha}{\alpha + \beta}(\rho^* - \bar{\rho}) - \frac{\beta}{\alpha + \beta}(q^* - \rho^*)\right]\right) = 1 - \lambda. \quad (11)$$

The first equation (Eq. 10) provides, for a given critical perception ( $q^*$ ), the cut-off message that separates the success / fail states of the collective project<sup>6</sup> :

$$\rho^* = q^* + \frac{\Phi^{-1}(v)}{\sqrt{\beta}}, \quad (12)$$

The higher the participation threshold  $v$ , the higher  $\rho^*$  and the higher chances that the project fails.

The second equation (Eq. 11) 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

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<sup>6</sup> Recall that  $\Phi^{-1}(1 - x) = -\Phi^{-1}(x)$ .

project:

$$q^* = \left(1 + \frac{\alpha}{\beta}\right) \rho^* - \frac{\alpha}{\beta} \bar{\rho} + \frac{\sqrt{\alpha + \beta}}{\beta} \Phi^{-1}(\lambda). \quad (13)$$

For a given  $\rho^*$ , the higher the payoff associated to the safe project ( $\lambda$ ), 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  $(\rho^*, q^*)$ . Hence, in this simple framework, the equilibrium is unique, whatever the variance of  $\rho$  and  $\epsilon$ .<sup>7</sup> The only cases where the non-trivial equilibrium does not exist are  $\beta \rightarrow \infty$ , i.e. there is no bias in interpreting the message, and  $\alpha \rightarrow 0$ , i.e. the variance of  $\rho$  tends to infinity (the distribution of  $\rho$  looks like an uniform distribution on  $(-\infty, +\infty)$ ). We will not consider these extreme cases.

Solving the system, we obtain firstly the equilibrium cut-off message:

$$\rho^* = \bar{\rho} - \frac{\sqrt{\alpha + \beta}}{\alpha} \Phi^{-1}(\lambda) - \frac{\sqrt{\beta}}{\alpha} \Phi^{-1}(v). \quad (14)$$

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  $\lambda$  and  $v$  (for instance, if both are lower than 0.5), we have  $\rho^* > \bar{\rho}$ . In this case, there is a set of "good messages" – in the sense that they are rated above the expected rating,  $\rho \in [\bar{\rho}, \rho^*]$  – where default can still happen.

Next, the equilibrium critical perception is:

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

We have denoted by  $\ell$  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  $\rho_0$ ; 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:

$$\ell = 1 - \Phi\left(\sqrt{\beta}(q^* - \rho_0)\right). \quad (16)$$

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<sup>7</sup> 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).

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 message grade. For the equilibrium  $q^*$ , if the message is more positive, more investors will participate to the collective project:  $\partial\ell/\partial\rho_0 > 0$ .

To sum up the theoretical section, this game presents two trivial Nash equilibria, one involving a participation rate  $\ell = 1$ , and the other involving a participation rate  $\ell = 0$ . In the third, non-trivial equilibrium, the participation rate is strictly positive, but lower than one:  $\ell \in (0, 1)$ . While intuition would suggest that the most plausible case is the latter, theory only does not allow to select one of them. It is therefore a sensible research strategy to observe how human subjects play this game in the controlled environment of the Lab.

## **3 A Lab experiment**

### **3.1 Experimental design**

The experiment can be seen as 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. 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. 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).

We run four sessions: two were performed at the LESSAC (the Experimental Lab of ESC Dijon) on March 29, 2013 and two were realized at the ESSEC Experimental Lab on April 23, 2013 and Mai 15, 2014 with a total of 95 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. At the end of

the experiment subjects were paid in cash (one of their multiple choices was selected at random). The average time spend in the Lab was 25 minutes; on average they earned 16.30 euros including a 5 euros show-up compensation.<sup>8</sup>

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.<sup>9</sup> 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.<sup>10</sup>

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

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<sup>8</sup> This generous compensation was somehow imposed by the payoff structure - similar to the experiment by Heinemann et al. (2009).

<sup>9</sup> Heinemann et al. (2009) test the game for groups of various sizes and for different participation thresholds.

<sup>10</sup> Web address: <http://behavioralresearchlab.essec.edu/research/research-topics/results>



Exp (c) ESSEC Research Lab			
Please make your choice between option A and option B for the 10 following situations.			
Decision Number	Payoff for A	Your choice	Payoff for B
11	1.50€	A <input type="radio"/> B <input type="radio"/>	0€ if less than 3 players choose B, 15€ if at least 3 players choose B
12	3.00€	A <input type="radio"/> B <input type="radio"/>	idem
13	4.50€	A <input type="radio"/> B <input type="radio"/>	idem
14	6.00€	A <input type="radio"/> B <input type="radio"/>	idem
15	7.5€	A <input type="radio"/> B <input type="radio"/>	idem
16	9.00€	A <input type="radio"/> B <input type="radio"/>	idem
17	10.50€	A <input type="radio"/> B <input type="radio"/>	idem
18	12.00€	A <input type="radio"/> B <input type="radio"/>	idem
19	13.50€	A <input type="radio"/> B <input type="radio"/>	idem
20	15.00€	A <input type="radio"/> B <input type="radio"/>	idem

Once that you have made you choice, please click on the OK button

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

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 a measure of their preference toward risk.

Table 5 presents the individual payoff for each situation  $k$ , where  $s_k$  is the secure payoff,  $s_k \in [1.5; 3; 4.5; \dots; 15]$ . 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"*

Messages bring no additional objective information about the game subjects must play. It states something about a vague "past experiment" (not necessarily identical), and comment about "satisfaction / disappointment", without any precise information about the actual outcome of the game. It provides no information about other past experiments that might have delivered a different outcome. 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.

#### • Results

Overall the experiment was played by 95 subjects.

Five of them presented inconsistent choices, i.e. shifted from B to A more than once, either in the coordination game or the lottery choice.<sup>11</sup>

Two participants are not rational given that they refuse the lottery when the safe payoff is small and prefer the lottery when the safe payoff is large. Six participants prefer the lottery whatever

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<sup>11</sup> Heinemann et al. (2009) report on rates of inconsistent choices between 1 to 15% depending on the place where experiments were run.

the safe payoff; their behavior is not rational either given that they also prefer the lottery (0;15) to the safe payoff 15.

Then 12 subjects will always prefer the coordination game (0;15); among them, 7 have received the positive message, 5 the negative message. They present various degrees of risk aversion; the average number of B-choices in the lottery condition is 5.41 (standard deviation 3.00); two of them refused the lottery even against the smallest safe payoff. This extremely cooperative behavior, including on behalf of subjects who received a negative message, suggests that some of them discard the non-informative message and settle on the Pareto-dominant equilibrium.

The other 71 subjects implemented clear switching strategies in the coordination game (the Morris and Shin solution) as if they were using the message as a coordination device; they also shift only once in the lottery.

	Typical coordination choice	Typical lottery choice	Number
Inconsistent	BBAABAABBB	BBAABAABBB	5
Lottery: Not rational	BBBBAAAAA	AAABBBBBBBB	2
Lottery: Not rational	BBBBBBBBBBB	BBBBBBBBBBB	5
Always coordinate; risk aversion	BBBBBBBBBBB	BBBBBAAAAA	12
Switching strategy; risk aversion	BBBBBBAAAAA	BBBBBAAAAA	71

Table 6. Distribution of subjects according to the nature of the decisions

In the following the analysis focuses on these 71 subjects playing switching strategies in the coordination game. Table 7 presents the average number of B-choices for each condition (coordination and lottery), depending on the message:

Message	Nb. subjects	Av. nb. B-choices Coordination game	Av. nb. B-choices Elementary lottery
Positive	34	6.82 (6.17–7.47)	4.38 (3.84–4.92)
Negative	37	6.13 (5.45–6.81)	4.55 (4.18–4.89)

Table 7. Average number of B-choices for subjects who play switching strategies

(between brackets: the 95% confidence interval)

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

Within each treatment, investors were more averse to the pure risk as generated by the lottery than to the strategic risk specific to the coordination game (p-value of the Kruskal-Wallis test is 0.99).

The average number of B choices in the lottery is very close in the two treatments (4.38 vs. 4.55): the message has little impact on the lottery choice. In the coordination game, the positive message is associated with a higher average number of B-choices as compared with the negative message (6.82 vs. 6.13), but we cannot confirm that the difference is statistically significant - the p-value of the Kruskal-Wallis test is 0.20.

In the context of our analysis, an interesting result pertains to the frequency of individuals who decided to invest in the collective project, for varying payoffs  $\lambda_k$  and depending on the type of message (Figure 2).

When the safe project brings little (less than 3 euros), 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. At 13.5 euros for the safe project, there are still 38% who prefer the collective project under the positive message, and 20% who prefer the collective project under the negative message. 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 except the very low ones.

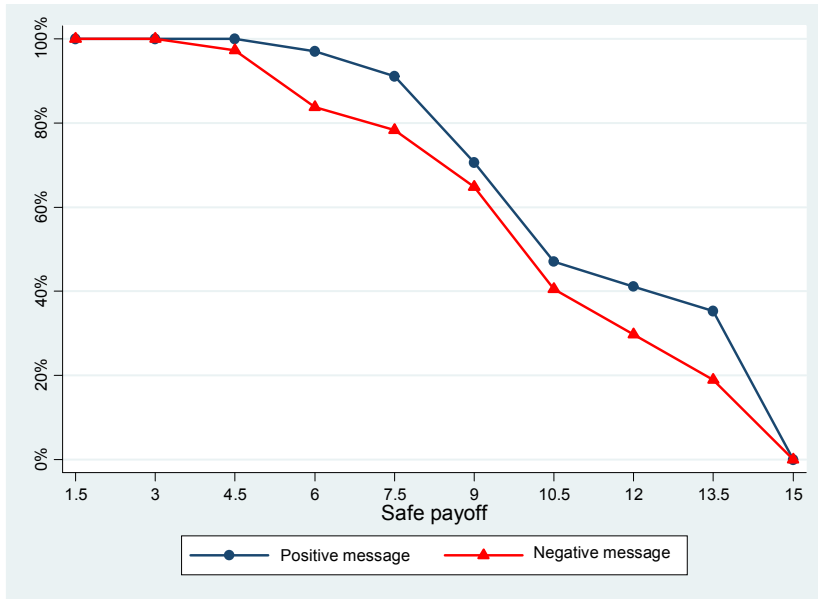


Figure 2: Frequency of individuals who opt for the collective project (choose the B option)

## 4 Conclusion

This paper analyses whether more or less vague messages about the past outcome of an investment game have "real" consequences on the way subjects coordinate on a current investment decision. In a narrow sense these messages can be referred to as uninformative insofar as they bring no additional information about the fundamentals of the current game. Some people may rationally choose to discard them.

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 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 threshold value of the message above which the critical participation is achieved. 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, the participation rate is larger for positive messages as compared to negative messages.

We implement a controlled experiment to study which of the three equilibria prevails. 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 message.

While 12 out of 95 subjects presented an inconsistent or irrational behavior, 12 subjects behaved as if they discarded the message and coordinated their decision so as to support the Pareto dominant equilibrium. A much larger number (71 subjects) implemented a clear switching strategy, suggesting that individuals use the non-informative message as a coordination device. The frequency of individuals who choose the collective project is lower in groups that receive a negative non-informative message as compared to groups that receive a (symmetric) positive message.

Tests were conducted 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. We considered only two messages, one conveying a positive and the other a symmetric negative assessment. 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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