CONTAGION IN EXPERIMENTAL FINANCIAL MARKETS

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Abstract

We experimentally study the possibility that news of a crisis in one market may cause a contagious crisis in another market though there are no links between those markets. Literature provides models of contagion in which news of a crisis may cause contagion in Bandwagon and Strategic risk channels; however, these models lack empirical evidence. The reason may be that it is difficult to isolate the effect of news of a crisis in real data, as markets are linked in many ways. To our knowledge this is the first research into contagious effects of the news of a crisis. We modify the influential experimental design of Smith et al. (1988) to construct an environment in which two separate markets are traded simultaneously, and there is no link between these markets other than possibility of observing prices in the other market. We create a crisis in one market by simulating a price drop in that market and observe whether prices in the other market drop in a contagious manner. Our results show that news of a crisis is a significant source of contagion and the Bandwagon channel is significant, while the Strategic risk channel is not. Further, news of a crisis may cause contagion in channels other than Bandwagon and Strategic risk; however, we do not identify which channels in the present study, leaving it for future research.

JEL classification: C92, G12,

Keywords: asset market, contagion, experiment

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1. Introduction

This study uses a financial market experiment to study the role of news of a crisis effect (NCE) in contagion. NCE is the contagious effect in which news of a crisis may transfer a crisis across markets. News of a crisis in one market may affect the sentiments of agents in another market, inducing them to change their trading strategies, resulting in a crisis in the other market as well, even when there are no links between those markets. We use a double auction financial market experiment in which two assets are traded simultaneously, and news of a crisis in one market may cause a crisis in the other market. The experimental design allows us to isolate NCE and test whether it has a significant role in contagion. We use an experiment because in real life it is impossible to isolate NCE from the effects of many links connecting markets such as common traders, common shocks, fundamental links, etc.

News of a crisis in one market may affect the behavior of agents in the other market through different channels. The present study considers two of the possible channels: Bandwagon (Calvo and Reinhart, 1996) and Strategic risk (Ahnert and Bertsch, 2013) channels. The Bandwagon channel transfers NCE from one market to another when agents in one market think that two markets are similar, and if a crisis happens in one market it is likely to happen in the other market as well. The Strategic risk channel transfers NCE from one market to another when there is no common knowledge of others' information. When each agent has information that markets are not similar but they do not know if all the agents in their market have the same information, they face strategic risk about the others' information. Each agent may think that others might not have the information about non similarity of markets and that they may create a crisis by trading as if a crisis is likely to happen in their market too. Thus, for each agent it is safer to trade as if there should be a crisis in their market too, though each agent knows that the markets are not similar. If some critical number of agents chooses to trade safely when facing strategic risk, a self-fulfilling contagious crisis may occur.

We construct four treatments which allow us to test for the significance of NCE in general, and particularly in Bandwagon and Strategic risk channels of NCE. We control Bandwagon and Strategic risk channels in our experiment by eliminating them from one treatment to another. In one treatment, we eliminate both Bandwagon and Strategic risk channels, nevertheless there is still NCE. We realize it is possible that there are channels of NCE other than Bandwagon and Strategic risk. For example, a crisis in one market might have a sunspot effect on traders in

another market and result in a crisis there as well. Because our design does not allow us to separate possible other channels from one another, we group them in "channels other than Bandwagon and Strategic risk" (OBSR).

The experiment is designed so that the two markets have different parameters. We believe knowledge about the differences between markets and whether this knowledge is public can control for Bandwagon and Strategic risk channels respectively. When subjects do not know that markets have different parameters, they may think that markets are similar, and if prices drop in one market they are likely to drop in the other as well. Giving information to subjects about differences between markets should eliminate the Bandwagon channel. Further, if it is not common knowledge that all the subjects know about the differences between markets, there is a Strategic risk channel, as subjects do not know how other subjects will react to price changes in the other market. Making this knowledge public eliminates the strategic risk channel of NCE, as there is no more uncertainty about others' information about the similarities between markets.

We have a section labeled "Additional Information" in our instructions with which we control Bandwagon and Strategic risk channels of NCE. In two of four treatments there are only baseline instructions which do not include "Additional Information" section and do not give subjects information about differences between markets. In the other two treatments there is the "Additional Information" section in the instructions which gives information about differences between markets in addition to the information about the experiment provided to subjects in baseline instructions. Having "Additional Information" in a treatment eliminates the Bandwagon channel, and making it public knowledge that all the participants have "Additional Information" eliminates the Strategic risk channel.

Our results show that NCE is a significant cause of contagion. Our findings compliment the study of Calvo and Reinhart (1996) by showing that the Bandwagon channel is significant. We do not find support for the model of Ahnert and Bertsch (2013), as in our experimental setting, the Strategic risk channel is insignificant. After eliminating the Bandwagon and Strategic risk channels we find that NCE can still be significant, which implies that at least one of possible OBSR channels is significant.

The paper further is organized in the following way: Section 2 provides relevant empirical and experimental literature. Section 3 describes the experimental design. Section 4 describes

data obtained from the experiment. Section 5 describes methodology and results, and section 6 concludes the paper.

2. Literature Review

Many studies discuss contagion channels which are connected to the links between countries (Kaminsky, 1998; Kodres and Pritsker, 2002; Kyle and Xiong, 2001; Goldstein and Pauzner, 2004; Aloui et al., 2011). However, there are few studies related to the role of news of a crisis in contagion, and those studies fail to provide evidence which would prove the significance of NCE. Calvo and Reinhart (1996) study the incidences of crises in Latin America and Asia after the Mexican crisis of 1994 and examine the possibility of contagion. They find co-movement between weekly returns to bonds in Latin American countries in the wake of the Mexican crisis. According to the authors, a possible explanation would be that the co-movement is caused by herding behavior. Calvo and Reinhart's explanation is in accordance with the hypothesis that news of a crisis may cause contagion, as herding behavior across countries may occur when agents receive news about market performance in the other countries. However, the authors argue that a contagion may also be caused by the decision of a few large investors to liquidate assets in different markets. Thus, the results of Calvo and Reinhart (1996) do not allow us to identify news of a crisis as a cause of contagion.

Eichengreen, Rose and Wyplosz (1996) examine large panel data from 1959-1993 in order to find evidence of contagion. The authors control for macroeconomic fundamentals and still find that the incidence of crises in one country increases the probability of crises in another country. Thus, news of crises in other markets may be a cause of contagion. However, Eichengreen, Rose and Wyplosz do not control for common shocks, which does not allow us to identify the role of news of a crisis in contagion. Thus, few empirical studies which discuss whether news of a crisis may cause contagion do not provide enough evidence to conclude that it does.

The present study contributes to the literature by providing evidence from an experimental laboratory. There has been no experiment conducted with the same objectives as the current research to the best of my knowledge. There are some experiments which study contagion or correlation between markets (Fisher and Kelly (2000), Ackert, Mazzotta, Qi (2011), Qi and Ochs (2009)); however, they do not relate to the current study closely as they focus on the arbitraging across markets and transfer of information from one market to another.

We use a financial market experiment which is a modification of the Smith, Suchanek, Williams, (1988) financial market experiment. The experiment is not constructed to replicate the model of Calvo and Reinhart (1996) or Ahnert and Bertsch (2013); however, it allows us to test whether the news of a crisis may cause a contagion in any of possible channels and further, it allows us to test for the Bandwagon and Strategic risk channels considered by Calvo and Reinhart, and Ahnert and Bertsch.

In their influential experimental research, Smith et al. (1988) constructed a double auction financial market experiment to test the Efficient Market Hypothesis, according to which prices in the market should reflect all the available information. In Smith et al.'s experiment, subjects trade stocks which have constantly declining fundamental value (FV). Theory predicts that prices in each period should equal the FV; however, the results of the experiment of Smith et al. show that prices have an inverse U shape and they form a bubble. Figure 1 shows an arbitrary example of FV and a price line which is similar to the results of Smith et al. The green-curved line is the average of prices of each trading period. The blue straight line is the FV of a stock in each period. Prices increase above the FV and start decreasing closer to the end of trading creating bubble.

Figure1: Example of price development in Smith et al.'s experiment.

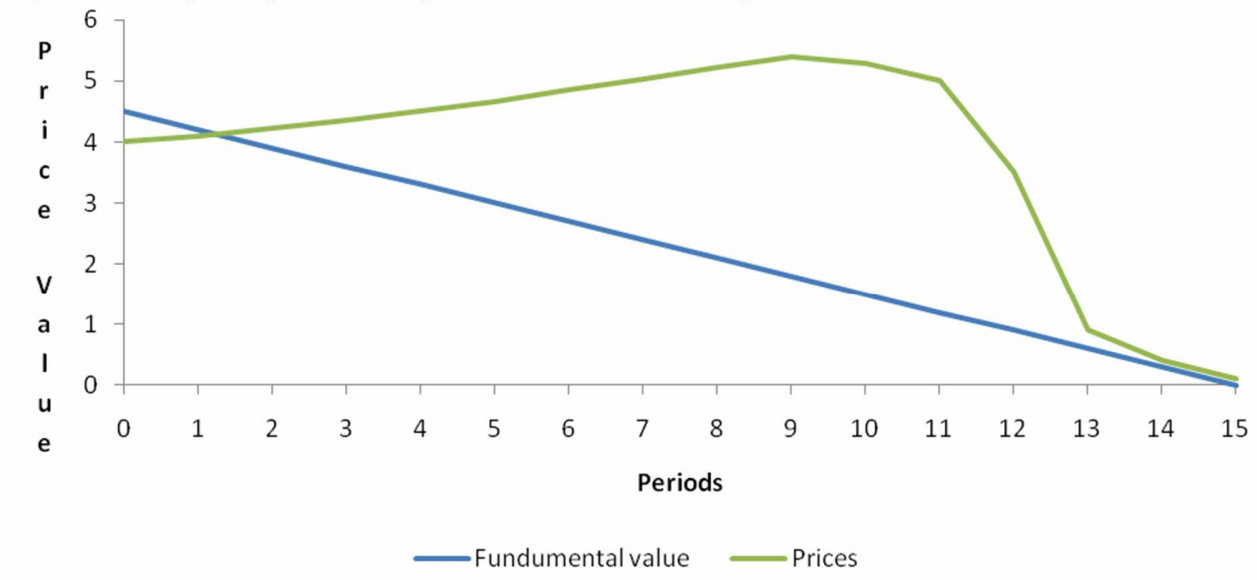


Figure 1 depicts an example of the usual pattern of prices in Smith et al.'s experiment. The blue line is the fundamental value of a stock and the green curve is the average traded prices in a period.

Many studies[1] have used different modifications of the experimental designed by Smith et al. (1988) in order to understand why the prices form bubbles and do not follow the theoretical prediction. Unlike those studies, the goal of present research is not to understand the reasons for bubble formation as in Smith et al., but to understand how a crisis can be transferred from one market to another. However, it is important for the present study to ensure that the price formation process in the experiment is similar to the price formation process in real life financial markets and that it is not particular to the experimental design. Otherwise, the results would not be informative as they could have been driven by particularities of experimental design.

Smith et al. explain bubbles in their experiment by speculative trading: the subjects understand that the prices are higher than the FV; however, they do not know if the other subjects understand it as well. They speculate by buying assets with higher price than the FV in hope that they can sell it latter at an even higher price and thus gain capital profit. A more recent study by Kirchler et al. (2012) argues that bubbles in Smith et al.'s financial market experiments are purely a result of confusion connected with the declining nature of the fundamental value. In contrast Kirchler et al., Akijama et al. (2013), and Cheung et al. (2014) show that the price pattern in Smith et al.'s (1988) experiments is not only caused by confusion but also by uncertainty of the subjects about other subjects' behavior, which results in speculative trading.

The possibility of confusion in the experimental design of Smith et al. mentioned by Kirchler et al. is not desirable in the design of the proposed study because any result may be driven by confusion which is a particularity of the experimental design of Smith et al. and does not reflect reality. To avoid confusion, we adopt the design of one of the treatments of Cheung et al.

Cheung et al. argue that the results of Kirchler et al. are biased by the fact that Kirchler et al. *publicly* provide information about the declining nature of FV. As a result, elimination of confusion also eliminates the uncertainty about others' behavior because it is common knowledge that all agents have more information about FV, which makes others' behavior easier to predict. Cheung et al. eliminate confusion by training subjects about FV; however, unlike Kirchler et al., they do not eliminate the uncertainty about others' behavior as they *do not make*

[1]Boening et al. (1993), Noussair et al. (2001), Kirchler et al. (2012), Akijama, Hanaki, Ishikawa (2013), Cheung (2014).

it common knowledge that all subjects have training. The results show that mispricing is almost as large as without training. This shows that the price developments in Smith et al.'s experiment are caused not only by confusion connected to the design of the experiment, which is not natural in real life. The price pattern in Smith et al.'s experiment is also caused by traders' expectations of how other traders will act, which is natural in real life. I present below the details of Cheung et al.'s experiment that are important for the design of our experiment.

There are 4 treatments in Cheung et al.'s experiment. We give details for 2 of them. In the first treatment, 20 participants all are trained about the FV of the asset, and it is common knowledge that everyone is trained. This is Public Knowledge (PK) treatment. Further subjects are divided into 2 groups of 10 and each group trades in one benchmark Smith et al. experiment. The second treatment is Non Public Knowledge (NPK). In this treatment, 20 subjects are gathered in the lab; however, only 10 receive training. After training is complete, subjects are divided into 2 groups of 10, one group consisting of trained and the other untrained subjects. Each group trades in one Smith et al. market; however, the subjects in the group of trained subjects are not told that everyone in their group has been trained. Thus, in the NPK treatment, there is no confusion in the group of trained subjects and at the same time there is uncertainty about others' behavior as it is not common knowledge that all had training.

The results show that mispricing in NPK is not significantly different from the base treatment of Smith et al., and PK is significantly different. Further, PK is different from NPK, at 10 percent significance. Based on these results, Cheung et al. conclude that reducing individual confusion alone cannot account for the observed mispricing, but the uncertainty about others' behavior does.

We use the NPK treatment design of Cheung et al.'s experiment, as the confusion about the declining nature of FV, is thus eliminated and the uncertainty about others' behavior, which is a natural factor, is preserved. Similar to the NPK treatment of Cheung et al., in all treatments of the current experiment, subjects are divided into two groups which trade in two separate markets, and in one group all the subjects are trained about FV; however, it is not common knowledge that among the group all the subjects had training.

Another important financial market experiment for the current study is that of Bostian, Goeree, and Holt (BGH) (2005). Though their conclusions do not concern the present research, two aspects of their experiment are used. First, prices of one of the two markets traded

simultaneously are controlled in such a way that there is a drop in prices. The drop represents a crisis in that market, and it allows us to observe how the prices of the second market react. In order not to create artificial numbers in the market realized prices of two sessions from BGH's experiment are used (Figure 2).

Second, the BGH experiment has significant differences from Smith et al.'s (1988) design: the FV of a stock in the BGH experiment is constant, unlike in Smith et al., where FV is decreasing. One of the two markets in the current experiment is a Smith et al. type, and the other is a BGH type. The information about these differences is used to control the Bandwagon and Strategic risk channels of NCE. If the subjects are not given the information about differences between markets, they may think that the markets are similar; this is the condition for existence of Bandwagon channel, similar to the model of Calvo and Reinhart (1996). In two treatments the Bandwagon channel is eliminated by making the information about differences between the two markets available to traders. Further, the strategic risk channel is controlled by making it common knowledge that information about the differences between markets is available to all agents. If the subjects are given information about the differences between markets, yet, they do not know that everyone has the same information, there is strategic risk related to other's information, similarly to the model of Ahnert and Bertsch (2013). If it is common knowledge that all agents have the same information, there is no strategic risk.

3. Experimental Design

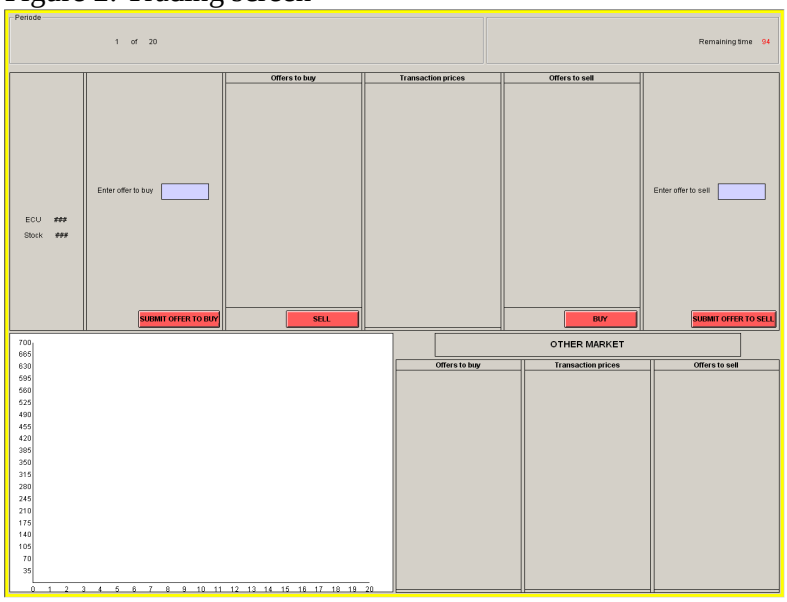
3.1. Main features of the experiment

Two stock markets are traded simultaneously in the current experiment. Both operate for 20 periods, each lasting 100 seconds, and the trading opens and closes simultaneously in each period. Because NCE affects beliefs and sentiments of subjects, it is important to have a trading environment closely resemble a natural trading environment. Therefore, we design the experiment with two markets traded simultaneously, rather than with possible alternatives in one market. For example, there could be one market and in the end of each period subjects could be given information about realized prices of a similar experiment conducted previously. Such a design would not be similar to natural environment in which contagion occurs. There may be other effects than NCE present. Subjects might disregard this information, thinking that the realized prices of other experiments from the past are irrelevant to the present trading, or they

may think that, as they are given this information there should be some use to it, which would lead to the experimenter demand effect.

The trading is computerized, and the markets are constructed with Z-tree software. Each subject trades only in one market and there are no links between markets other than the possibility to observe trading in both markets on computer screen. Subjects trading in one market can observe trading in the other market on their computer screen in two ways: First, they can observe "offer to buy", "offer to sell" and "traded" prices in the current period (lower right corner of Figure 2) and second, they can observe the history of the average prices in each period on a diagram for all periods *preceding* the current period, so that the average price of the current period appears on the diagram with a one period lag (lower left corner of Figure 2).

Figure 2: Trading screen



The average price of each market is given on a diagram with price lines. The average price line of a subject's own market is labeled "Your market" and average price line of the other market is labeled "Other market". Subjects can see drastic changes in average prices in the other market on the diagram; thus, the diagram transfers information about substantially large drops in prices without any effort from subjects creating NCE.

3.2. Market environment

One of the two markets in our experiment plays a passive role because we control the prices in that market in order to generate price drops whenever convenient for the purposes of

the experiment and observe how the prices in the other market react. The markets are called respectively Originate and Follower in the text for convenience: we want to see if and how a shock from the Originate market transfers to the Follower market prices. These names are not in the instructions for subjects. As the prices in Originate market are controlled, we consider only the prices of Follower market.

3.2.1. Controlling prices in the Originate market

Controlling prices in the Originate market is aimed to minimize the costs of the experiment and to make the identification process of NCE attainable. If we did not control prices in the Originate market, we might not have a significantly large drop of prices in each session in any of the markets. As a result, there would be no news of a crisis and we would not be able to use the results. Even if there were price drops in one market, most likely the prices of the market experiencing the price drop would take different paths, and drops might occur in different periods of trading in different sessions. Testing for NCE would be cumbersome in the latter case.

The prices in the Originate market are controlled by fake subjects. There are 12 subjects participating in each session. 10 are genuine subjects who are invited to participate only for one session and whose trading behavior we want to study. 2 are fake subjects who control prices in Originate markets in order to create price drops which represent crises in the context of the experiment[2]. In all 16 sessions the 10 genuine subjects trade in the Follower market, and 2 fake subjects trade in the Originate market, so that genuine and fake subjects do not interact throughout the experiment.

Because we are using fake subjects to simulate prices in the Originate market, we are cautious in our instructions and throughout the experiment to avoid deception. At the end of the instructions for all 16 sessions the participants are told:

"The group of participants is divided into two groups.

One group will trade in one market; the other group will trade in the other market.

None of the participants can trade in both markets"

Thus, the subjects are not told how the two groups are formed, how many participants are in each group, or who is in their group. One group consists of 10 genuine subjects who trade on

[2]The fake subjects are two students from CERGE-EI who participated in all sessions of the experiment.

the Follower market and the second group consists of 2 fake subjects who trade on the Originate market. Genuine subjects also are not told that the subjects trading in the Follower market are fake subjects who will control prices. We do not inform genuine subjects about the fake subjects because it might affect their reaction to price drop in the Originate market and bias our identification. For example, they might pay too much attention to the Follower market prices because of the experimenter demand effect.

Genuine subjects may by default assume that the prices they observe in the Originate market are formed by profit seeking behavior, as they are not given information that subjects trading in the Originate market are fake subjects. Ortmann and Hertwig (2002) discuss deception in their paper and suggest that violations of possible default assumptions should be avoided. To avoid these violations, we instruct fake subjects to simulate realized prices of two sessions of the BGH experiment. Because the subjects in the BGH experiment were genuine, the prices were formed by profit seeking behavior. Consequently, by simulating realized prices of the BGH experiment in the Originate market of our experiment, we do not violate any possible default assumption of genuine subjects that prices in the Originate market are formed by profit seeking behavior.

The realized prices of two sessions of the BGH experiment, which fake subjects replicate in our Originate market, are given in Figure 3. There are 4 treatments in the current experiment. One control (Ctrl) treatment which is constructed in order to observe how prices in the Follower market develop when there is no price drop (in the absence of NCE) in the Originate market, and three main treatments (M1, M2, M3) which are constructed in order to observe how the prices of the Follower market react to price drop in the Originate market (in the presence of NCE). The treatments are described in detail in the section Treatments. The “No crisis” price line in the Figure 3 depicts the prices on the Originate market in Ctrl treatment and the “Crisis” price line depicts prices in the Originate market for three main treatments.

The prices of these two particular sessions of the BGH experiment are chosen for two reasons: First, price patterns are similar until the 9^{th} period; as a result, prices on the Originate market have the same effect on the Follower market until the 10^{th} period in both main and Ctrl treatments. Thus, observing differences in price changes of the Follower market in period 10 between main and control treatments can legitimately show if a drop of prices in the main treatments is due to NCE. Second, usually in Smith et al.’s experiments, prices are relatively

more volatile in the early periods, and are more affected by FV in the later periods. As the price drop in the Originate market in the present experiment occurs in the 9th period of trading, the described patterns of prices in Smith et al. type experiments in the early and late periods of trading do not affect the identification of NCE.

Figure 3: Prices on the Originate market for control and main treatments

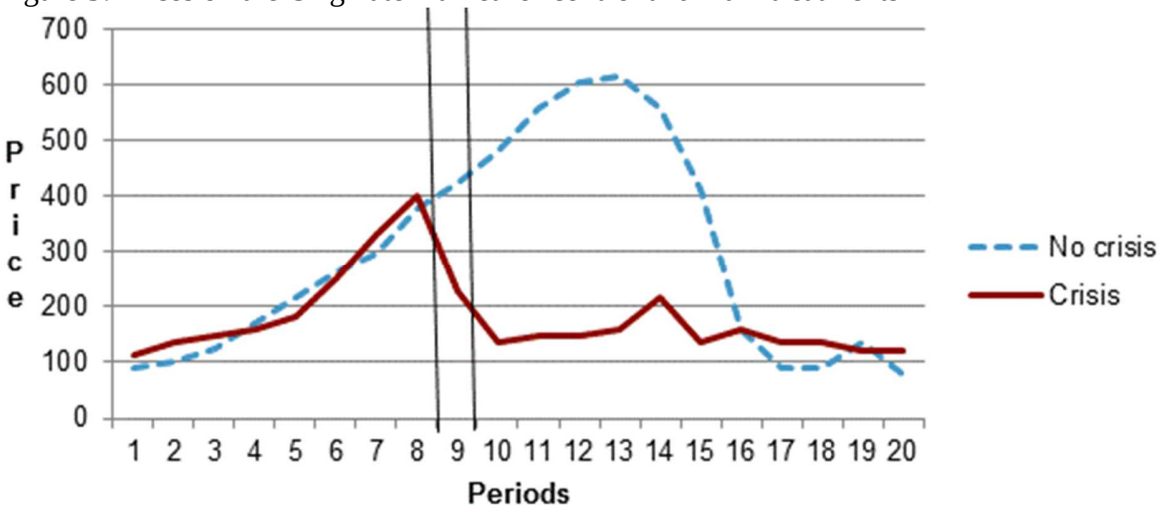


Figure 3 depicts the prices according to which the fake subjects trade in the Originate market. "No crisis" depicts the Originate market prices in Ctrl treatment and, "Crisis" depicts the Originate market prices in treatments M1, M2 and M3. The prices are taken from the results of BGH's (2005) experiment. The original BGH prices are scaled up and adjusted to match the parameters and goals of our experiment.

The prices for the Originate market are chosen from the BGH experimental results not only because of their suitable pattern for our experiment, but also because the design of the financial market in the BGH experiment is substantially different from the Smith et al. type design. The information about these differences is used in the section "Additional Information" of our instructions in order to control Bandwagon and Strategic risk channels.

3.2.2. Originate market parameters

The parameters of the Originate market replicate the parameters of the BGH experiment market and are scaled up with the same scaling as realized prices in Figure 3 for convenience. The subjects in the beginning of trading receive portfolio of experimental currency units (ECU) and stocks. Cash holdings carried over from one period to another pay interest of 20%. Each stock pays dividend from set {13, 19} with equal probability and the expected dividend is 0.5*13+0.5*19 = 16 ECU. Each stock has terminal value of 80 ECU at the end of the

experiment. FV is constant for each period and equals 80 ECU (expected dividend/interest rate = 16/0.2 = 80).

3.2.3. Follower market parameters

The parameters of the Follower market replicate those of Cheung et al.'s (2014) experiment, which is a Smith et al. type and are scaled up for the convenience of the present research. In the beginning of the first period, each subject is given a portfolio of stocks and experimental currency units (ECU). If all subjects were given the same portfolio in the beginning of the experiment with equal amounts of stocks and cash, they might employ similar trading strategies in the first period, which might result in a low number of trades. To avoid this possibility, the 10 subjects are given 3 different portfolios, similar to Cheung et al.'s experiment. The portfolios have equal initial value of 1665 ECU, but different composition of stocks and ECU. The initial endowments are as follows:

- 3 subjects have 2 assets and 1185 ECU
- 4 subjects have 4 assets and 705 ECU
- 3 subjects have 6 assets and 225 ECU

Cash holdings do not earn interest. Each stock yields a dividend in the end of each period from distribution {0; 4; 14; 30} with equal probability and expected dividend is 0.25*0 + 0.25*4 + 0.25*14 + 0.25*30=12. The terminal value of a stock at the end of the experiment is 0. The FVs of stocks are decreasing, and in any given period are equal to the sum of expected dividends across all the remaining periods. The FV of the Follower stocks in the first period are equal to the number of periods (20) multiplied by the expected dividend (0.25*0 + 0.25*4 + 0.25*14 + 0.25*30 =12). This is equal to 20*12=240. The FV decreases in each period by 12 and in the last (20^{th}) period equals 12*1=12. At the end of the experiment, the subjects receive their ECU holdings converted to CZK at an exchange rate of 1 ECU=0.18CZK as a reward.

Thus, the parameters of the Originate and Follower markets have considerable differences. We believe that knowledge of this may eliminate the Bandwagon channel. Unlike the Follower market, in the Originate market, cash holdings earn interest at the end of each period, stocks have positive terminal value, and the FV of stocks is constant for each period and equal to the termination value. Furthermore, the dividends of stocks in the Follower and Originate markets are from different sets; this shows that besides the structural differences in the two markets there

is also no correlation between them in terms of dividend realizations. In other words, good and bad states in the two markets are not correlated.

3.3. Additional information about the Originate market

The objective of giving "Additional Information" about the Originate market is to inform the subjects that the markets are different and not correlated. Subjects are given the description of the Originate market, which shows that the Originate market differs from the Follower market in four ways:

- The ECU holdings in the Originate market earn interest.
- The stocks in the Originate market have termination value.
- The stocks in the Originate market yield dividends from different distribution.
- The stocks in the Originate market have fixed FV in each period.

Further, subjects are informed that dividend realizations are independent.

After subjects are acquainted with the details of the Originate market, they are asked eight questions about the two markets which stress the differences between the two markets. For example, subjects are asked:

1. How much interest do cash holdings earn in the First market in each period?
   (The correct answer is 0%)
2. How much interest do cash holdings earn in the Second market in each period?
   (The correct answer is 20%)

Subjects cannot pass to the next question until they give the right answer. The answers to the two questions above show that the two markets are different in terms of interest earnings of ECU holdings. The other six questions are composed in a similar manner to highlight the differences in terminal value, FV in each period, and correlation of dividend realization.

3.4. Treatments

The three of four treatments where there is NCE we designate main treatments (M1, M2, M3) and one treatment where there is no NCE we designate control (Ctrl). The treatments differ from each other in three respects:

- Whether there is a price drop in the Originate market or not; synonymously, whether there is NCE or not. This feature is controlled by simulating either "No crisis" or "Crisis" prices in the Originate market.

- Whether subjects know that the two markets are different; synonymously, whether there is a Bandwagon channel. This feature is controlled by either having the section "Additional Information" in our instructions or not.
- Whether it is common knowledge that all the subjects trading on the Follower market know that the markets are different; synonymously, whether there is a Strategic risk channel. This feature is controlled by whether it is common knowledge that all agents have the section "Additional Information" of instructions or not.

Ctrl: There is no "Additional Information" and "No crisis" prices are used in the Originate market. Thus there is no NCE for subjects in the Follower market in period 10.

M3: "Crisis" prices are used in the Originate market so there is NCE in period 10. All the subjects have "Additional information" and they are told that *all of them* have "Additional information." Thus, there is neither a Bandwagon nor a Strategic risk channel in treatment M3, as all agents know that the markets are different, and this is common knowledge. Nevertheless, as there is news of a crisis, there are OBSR channels of NCE.

M2: "Crisis" prices are used on the Originate market, so there is NCE in period 10. Subjects are told that *some of them* have "Additional Information" and others do not. They are not told how many have "Additional information," and later when they are divided into two groups they are not told whether the subjects in their group have "Additional information" or not. Ten genuine subjects receive "Additional information" and two fake subjects do not. Ten genuine subjects trade on the Follower market and two fake subjects trade on the Originate market. Thus, in the M2 treatment, all the subjects in the Follower market know that the two markets are different, so there is no Bandwagon channel, but they do not know if others know that the markets are different, so there is a Strategic risk channel. Further, as there is NCE there are also OBSR channels.

M1: "Crisis" prices are used in the Originate market, so there is NCE in period 10. Subjects are not given "Additional Information" so all possible channels of NCE including the Bandwagon channel are present.

Table 1: Characteristics of treatments

Treatment	Period of price drop on the Originate market	Additional information about the Originate market	Common knowledge that all have additional information	News of a crisis in period 10	OBSR channels	Strategic risk channel	The Bandwagon channel
M1	9	-	n/a	+	+	+	+
M2	9	+	-	+	+	+	-
M3	9	+	+	+	+	-	-
CTRL	14	-	n/a	-	-	n/a	n/a

In all the treatments after instructions and "Additional Information" (in M2 and M3 treatments), subjects are told that they are divided into two groups and each group trades on one of the markets. They are not told how many participants are in each group and they are not told who is in their group. The characteristics of treatments are summarized in Table 1.

3.5. Hypothesis

The four treatments of the current experiment allow us to test two sets of hypotheses: The first set asks whether NCE is significant given that there are none zero number of NCE channels. As the number of NCE channels differs across treatments we have four hypotheses stating that within each treatment NCE is significant.

As there is no NCE in the Ctrl treatment, there should be no unusual price drop in the Ctrl treatment.

Hypothesis 1: *There is no significant drop in prices in period 10 in Follower market in the Ctrl treatment.*

As in treatment M3 there are only OBSR channels of NCE significant, drop in the Follower market prices in 10^{th}period should indicate that NCE is significant in OBSR channels.

Hypothesis 2: *There is a significant drop in Follower market prices in period 10 in the M3 treatment, which indicates that NCE is significant in OBSR channels.*

As in the M2 treatment there are Strategic risk and OBSR channels of NCE, significant drop in prices in period 10 in Follower market should indicate that NCE is significant in the Strategic risk and OBSR channels.

Hypothesis 3: *There is a significant drop of Follower market prices in period 10 in the M2 treatment which indicates that NCE is significant in Strategic risk or/and OBSR channels.*

As we do not control for any channel of NCE in theM1 treatment, a significant drop in prices of Follower market in period 10 would mean that generally NCE is significant.

Hypothesis 4: *There is a significant drop in Follower market prices in period 10 in the M1 treatment, which indicates that NCE is significant.*

The second set of hypothesis asks which channels of NCE are significant. The number of channels of NCE decreases across four treatments from M1 to Ctrl. Assuming that NCE as well as the Bandwagon, Strategic risk and OBSR channels of NCE are significant, it should be that the magnitude of the effect of NCE on Follower market prices should decrease across treatments from M1 to Ctrl as the number of channels of NCE decrease in the same manner. Thus, we have the following three hypotheses:

The difference between treatments M3 and Ctrl is that in M3 there are OBSR channels of NCE while in Ctrl there is no NCE channel. If prices on the Follower market in period 10 drop more in treatment M3 than in treatment Ctrl it must be that the OBSR channels of NCE are significant.

Hypothesis 5: *The drop in prices in period 10 on the Follower market in treatment M3 is larger than in treatment Ctrl, indicating that the OBSR channels of NCE are significant.*

The difference between treatments M2 and M3 is that in M2, in addition to OBSR channels, there is also the Strategic risk channel of NCE, while in M3 there are only OBSR channels. If the Follower market prices in period 10 drop more in treatment M2 than in treatment M3, it must be that the Strategic risk channel of NCE is significant.

Hypothesis 6: *The drop in Follower market prices in period 10 in treatment M2 is larger than in treatment M3, indicating that the Strategic risk channel of NCE is significant.*

The difference between treatments M1 and M2 is that in M1, in addition to the Strategic risk and OBSR channels, there is also the Bandwagon channel of NCE, while in M2 there are only Strategic risk and OBSR channels. If Follower market prices in period 10 drop more in treatment M1 than in treatment M2 it must be that the Bandwagon channel of NCE is significant.

Hypothesis 7: *The drop in Follower market prices in period 10 in treatment M1 is larger than in treatment M2, indicating that the Bandwagon channel of NCE is significant.*

3.6. Procedure

A group of twelve subjects consisting of ten genuine subjects and two fake subjects are invited to the LEE[3]experimental laboratory at VSE[4]. Each picks a table number randomly. They fill a participation consent form. Afterwards, subjects are given ten minutes to read the first part of written paper instructions "Instructions A" (Appendix A), which gives general information about the experiment and computerized trading. After reading "Instructions A," subjects have "practice period" of trading for two hundred seconds, in which they practice how to insert "offer to buy" and "offer to sell" prices, and how to accept them. After the "practice period," the second part of the paper instructions "Instructions B" (Appendix B) is distributed and subjects are given five minutes to read. "Instructions B" describes the Follower market on which genuine subjects trade. After subjects read "Instructions B," the experiment continues on the computer screen.

After "Instructions B," subjects have training about FV on their computer screens. Though FV training does not play an important role in identification of NCE in our design, it is necessary to eliminate confusion about the declining nature of FV in the Follower market. This would ensure that our results are not driven by confusion is connected to the design of the experiment and irrelevant for real markets. On the screen, subjects read that some participants receive FV training and others not. Ten genuine subjects receive training and two fake subjects do not. Note that in the BGH experiment, subjects did not receive training about FV. In our experiment, two fake subjects also do not have FV training, and they trade on the Originate market, which is a replica of the BGH experimental parameters and price realizations.

In all four treatments the procedure is the same until the end of the FV training. After the training, the experiment in different treatments continues in the following ways:

1. In treatments Ctrl and M1 subjects are divided into two groups after FV training and trading begins. Subjects read information on the screen saying that all subjects are divided into two groups and one group will trade on one market and the other on the

[3] Laboratory of experimental economics at University of Economics, Prague
[4] University of Economics, Prague

other market. Subjects are not told how many participants are in each group or who is in their group. Ten genuine subjects are assigned to the Follower market, and two fake subjects are assigned to the Originate market and the trading starts.

Because the ten genuine subjects who trade in the Follower market know that only some of the subjects had FV training and they do not know who is trading with them in the same market, they do not know that everybody had FV training. Thus, there is uncertainty about others' knowledge of FV, which creates uncertainty about others' behavior. This uncertainty is present in all the treatments in a similar way.

2. In treatments M2 and M3, subjects are given "Additional Information" after the FV training. The difference between M2 and M3 treatments is the following:

- In the M2 treatment, subjects read on their screens that some of them receive "Additional Information" and others do not. Ten genuine subjects have "Additional Information" and two fake subjects do not.
- In the M3 treatment, subjects read on their screens that all participants receive "Additional Information". All the subjects have "Additional Information".

After receiving "Additional information" in both treatments M2 and M3, subjects are told that they are divided into two groups and they are told in which market they will trade. Because in treatments M2 and M3 there is "Additional Information" about the Originate market which says that the two markets are different, the subjects are informed in which market they will trade after the instructions end. Two fake subjects trade in the market described in the "Additional Information" (the Originate market). Ten genuine subjects are told that they trade in the market described in the "Instructions B" (the Follower market). However, they are not told how many or which subjects trade with them in the same market. Because in the M2 treatment not all the subjects have "Additional Information" and they do not know whether all the subjects trading with them in the same market have "Additional information," there is strategic risk about others' knowledge of the differences between the Originate and Follower markets. In theM3 treatment, all subjects know that everybody has "Additional Information", thus there is no strategic risk about others' knowledge about differences between the Originate and the Follower markets.

After the end of trading in the 20^{th} period, subjects are given a questioner for their feedback about the effect of prices in the Originate market on their decision making. After filling in the questionnaire subjects receive their rewards and the experiment ends.

3.7.FV training

The training is about the FV of the Follower market assets. The training is done in all four treatments and minimizes possibility of confusion about fundamental value among subjects.

The FV training is similar to the training done in Cheung et al. (2014). The process of training subjects in FV consists of two sets of control questions: one framed from the perspective of buying an asset, and the other from the perspective of selling an asset. There are 5 questions in each frame:

In the buyer frame, subjects are asked, for t = {20; 16; 12; 8;4}:

Suppose that you buy one stock in period t and that you keep it until the end of the market (i.e. until period 20). What is the average total dividend that you will receive from this stock?

Similarly, in the seller frame subjects are asked, for t = {19; 15; 11; 7;3}:

Suppose that you sell one share in period t and that you do not buy it back. What is the average total dividend that you give up on this stock?

The questions are asked in descending order of periods.

4. Data

16 sessions of the experiment were conducted in the LEE experimental lab at VSE in Prague in spring and fall of 2015. 4 sessions of each of the 4 treatments were conducted. A total of 156 subjects participated in the experiment. There were 10 participants in 13 sessions, 9 participants in 2 sessions and 8 participants in one session. Most participants were economics students, and some students from the Business Administration and Computer Sciences departments were also invited.

We have individual level data on “traded”, “offer to buy” and “offer to sell” prices. However, in our analysis we use average traded prices of a given period of a given session as a unit of observation. Because trades by one subject affects the trades of all other subjects participating in the same session, individual level data does not add information compared to average traded price data.

Figure 4 depicts the average price development across treatments. As the drop in prices in the Originate market occurs in period 9, and subjects in the Follower market see this drop in period 10, we analyze price behavior in period 10 to test for the significance of NCE. We do not take into account the price developments starting from period 11 for analyses of NCE because it

would be hard to differentiate NCE from effect of a bubble bursting. If there is a bubble drop of prices in period 10 may be cascaded by drop in prices in the following periods as well not because of NCE from the Originate market in period 10 but because the bubble in the Follower market burst in period 10.

Figure 4: Average traded prices on treatment level.

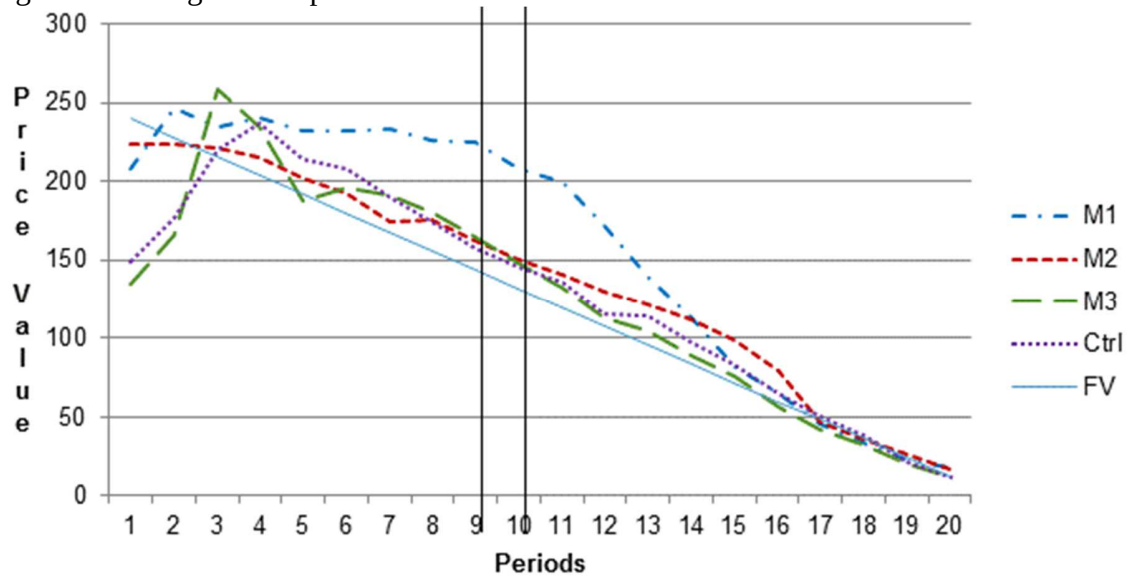


Figure 4 depicts treatment-level-average-prices. M1, M2, M3, and Ctrl are average traded prices in a given period for 4 sessions of respective treatments. FV is the fundamental value of a stock in each period.

As subjects in theFollower market receive news of a crisis in period 10, we are interested to see howthe average prices of each treatment change from period 9 to 10. Plain observation of changes of treatment-level-average-prices from period 9 to 10 shows that NCE may be significant. In treatments M2 and Ctrl, the drops are very similar (-11.3 and -11.8 respectively), suggesting that inthe M2 treatment there is no unusual drop due to NCE. However, in theM1 and M3 treatments, the drops (17.4 and 17 respectively) are about 1.5 times larger than in theCtrl treatment which is a sign that NCE may be significant. Deeper analysis of price changes and NCE are provided in the next section.

5. Methodology and Results

We construct two tests to analysis the two sets of our hypothesis. The first test analyzes our first four hypotheses. We call it a Within-treatment test as it tests whether there is a significant drop in the Follower market prices in period 10 within each of four treatments separately. The second test analyzes our last three hypotheses. We call it Between-treatment

test as it tests whether NCE and its different channels are significant by comparing the drop in Follower market prices in period 10 across four treatments.

Within-treatment and Between-treatment tests are to some extant robustness checks for each other. The pitfall of the Within-treatment test is that we have to assume that usually prices do not follow a particular trend which results in a significant drop in period 10. If this assumption is wrong, we would find false significant results with a Within-treatment test. In such a case, a Between-treatment test would provide more objective results, as comparison between treatments would cancel out the trend. The pitfall of the Between-treatment test is that if sessions of one treatment appear to be more volatile then sessions of another treatment it is possible that treatment with more volatile sessions will result in significant NCE. In this case, a Within-treatment test would provide more objective conclusions as it would account for thevolatility of a session. Thus it would be safe to conclude that NCE is significant if it is significant in both tests.

5.1. Within-treatment test

The Within-treatment test tests whether prices experience a relatively higher drop in period 10 compared to periods 2 to 9 within each of four treatments. We look at the rank of price changes in period 10 among price changes in periods 2 to 10 to see how price changes in period 10 compare to price changes in other periods. The ranks take values from [1, 9]. The higher the rank the lower (relatively more negative) is the price change, with rank 1 (rank 9) meaning relatively more positive (negative) price change.

As we have four sessions of each treatment, our elements of observation are the average ranks of price changes of a given period across four sessions of the treatment (ARPC). Thus, for each treatment, we have nine observations for periods 2 to 10. We construct the theoretical distribution of ARPC and compare the observed ARPC with the theoretical distribution to test whether the observed ARPC is significantly different from the expected ARPC in a given period.

We assume that price changes do not follow any particular trend[5] in order to construct the theoretical distribution of ARPC. The assumption implies that the rank of price changes in each

[5]Note that while declining FV might cause price trends, there is less reason to expect that declining FV may also imply trend in price changes.

period is a random variable uniformly distributed in [1, 9] and each value has 1/9 probability of occurrence. The four sessions of each treatment are independent of each other and ARPC is the average of the rank of price changes in a given period across four sessions of a given treatment and the theoretical distribution of ARPC is the distribution of the mean of four independent draws from the later uniform distribution. The distribution is given in Appendix C. The p-value of ARPC is the probability of the mean of four independent draws being higher or equal (lower or equal) to the observed ARPC for upper tail (lower tail). The results of the Within-treatment test are given in Table 2.

Panel A of Table 2 reports ARPCs and their p-values when considering periods 2 to 10. First we check whether our assumption that prices do not follow trend holds or not. The "*" ("**") indicates that ARPC is in the lower (upper) 10-percentile[6]. In the 2nd and 3rd periods, 6 out of 8 ARPCs are in the lower 10-percentile, which indicates an upward trend in prices in these periods. The observation that ARPCs in early periods are in the lower tail of the distribution is consistent with the results of existing literature that prices in the starting periods are more volatile. There are no similar indications of trends in other periods. In both periods 7 and 10, 2 out of 4 ARPCs are in the upper 10-percentile; however, this might be caused by the upward price trend in starting periods.

We analyze periods 4 to 10 to avoid the effect of trend in periods 2 and 3. In the same fashion as for periods 2 to 10, we construct distribution of ARPC for periods 4 to 10 (Appendix D). The ARPCs and respective p-values are reported in Panel B of Table 1. In this case, ARPCs are more consistent with the assumption of no trend in prices and we can discuss the ARPCs of period 10 (ARPC10) to analyze news of a crisis.

[6]We use p-value <=0.1084 for 10-percentile as we conduct a non parametric test and, this is the p-value closest to 10%.

Table 2: Within-treatment test

Panel A: 9 periods						Panel B: 7 periods					
		ARPC						ARPC			
Treatment		M1	M2	M3	Ctrl	Treatment		M1	M2	M3	Ctrl
Period						Period					
2		3*	3.5	2*	2.5*	4		3.25	4.5	3.75	1.5*
		0.0754	*0.1495*	*0.0107*	*0.032*			*0.273*	*0.359*	*0.452*	*0.006*
3		6	3.25*	2.5*	3.25*	5		4.25	3.5	4.5	5.75**
		0.256	*0.108*	*0.032*	*0.108*			*0.452*	*0.359*	*0.359*	*0.053*
4		4.25	5.75	5.5	2.5*	6		3.5	3	3.25	4
		0.320	*0.320*	*0.390*	*0.032*			*0.359*	*0.198*	*0.273*	*0.548*
5		5.5	5	6.5	7.5**	7		2.75	5.25	2.5*	5.25
		0.390	*0.537*	*0.150*	*0.032*			*0.136*	*0.136*	*0.088*	*0.136*
6		4.5	4.5	4.75	5.5	8		4.25	3.25	4	3.75
		0.390	*0.390*	*0.463*	*0.390*			*0.452*	*0.273*	*0.548*	*0.452*
7		3.75	7*	4.25	7*	9		4.25	4.25	4.5	4
		0.199	*0.075*	*0.320*	*0.075*			*0.452*	*0.452*	*0.359*	*0.548*
8		5.5	4.5	5.75	5.5	10		5.75**	4.25	5.5**	3.75
		0.390	*0.390*	*0.320*	*0.390*			*0.053*	*0.452*	*0.088*	*0.452*
9		5.5	6	6.25	5.75						
		0.390	*0.256*	*0.199*	*0.320*						
10		7**	5.5	7.5**	5.5						
		0.075	*0.390*	*0.032*	*0.390*						

Table 1 reports ARPCs of each treatment for periods 2 to 10. P-values are given in italics. P-values are given for upper (lower) tail if the average rank is higher (lower) than the expected ARPC. Panel A reports ARPCs for periods 2 to 10 and the expected ARPC is 5. Panel B reports ARPCs for periods 4 to 10 and the expected ARPC is 4. The "*" ("**") shows that p-value is lower than 0.1084 and the ARPC is in lower (upper) tail of the distribution.

The ARPC10 of Ctrl treatment has p-value 0.4519 lower-tail, indicating that without NCE the prices in period 10 do not have a negative trend. This result supports *Hypothesis 1*. The ARPC10 of M3 is 0.0875 upper-tail, indicating negative NCE through channels other than Bandwagon and Strategic risk (OBSR channels). This result supports *Hypothesis 2*. The

ARPC10 of M2 is 0.4519 upper-tail, indicating no NCE when the Bandwagon channel is eliminated and all the other channels are present. This result rejects *Hypothesis 3*. The ARPC10 of the M1 treatment has p-value 0.0525 upper-tail, indicating sizably negative NCE on price formation when all the channels of NCE are present. This result supports *Hypothesis 4*.

The results of the M2 and M3 treatments contradict one another. M1 and M2 together imply that there is a sizable negative NCE exceptionally through the Bandwagon channel; while M1 and M3 together imply that there is NCE exceptionally through OBSR channels. This can be interpreted as implying that the Bandwagon and OBSR channels may play an important role in transferring NCE interchangeably, and the Strategic risk channel does not transfer NCE. Thus the Within-treatment test shows that there is sizable negative NCE which can be transferred either through Bandwagon or OBSR channels.

5.2. Between-treatment test

Abnormal price change (APC) in period 10 is used as a unit of observation for the Between-treatments test. APC is the difference of price change in a given period from the average price change for some length of historical price changes. We do not have any criteria for how many periods before period 10 for calculating the historical average price change is optimal in the context of our experiment. Therefore, we calculate APCs for eight possible lengths of history and report results for all eight.

Abnormal price changes in period 10 for the given length of history are calculated using the following formula:

$$\boldsymbol{APC(j)} = \boldsymbol{\Delta P(10)} - \frac{\Sigma_{\boldsymbol{i=j}}^{\boldsymbol{9}} \boldsymbol{\Delta P(i)}}{\boldsymbol{10-j}} \qquad \text{for j=2, …, 8} \qquad (1)$$

where: APC(j) is abnormal price change in period 10 which equals the difference of the price change in period 10 and the average price change of 10-j periods preceding period 10 and ΔPi = average price of period i – average price in period (i-1), is price change in period i.

The number of channels of news of a crisis is decreasing from treatment M1 to Ctrl in the following manner: M1-all channels, M2-all but Bandwagon channels, M3-OBSR channels, Ctrl-no channel - no news of a crisis. This implies that APC(j) must increase from treatment M1 to Ctrl in the spirit of *Hypothesis 5-7*:

$$\boldsymbol{APC(j)(M1) < APC(j)(M2) < APC(j)(M3) < APC(j)(Control)} \qquad (2)$$

The significance of NCE, and Bandwagon and Strategic risk channels of NCE are tested in three steps: First, it is assumed that NCE, and particularlythe Bandwagon and Strategic risk channels of NCE are not significant. This implies that APC(j)-s across treatments must not differ significantly and inequalities in equation (2) must hold with equality signs. Moreover, APC(j)-s must be from same distribution. Second, the bootstrap distribution of the mean of APC(j)-s across sixteen sessions of all treatments together is constructed. Third, the positions of treatment mean APC(j)-s (the average APC(j) across four sessions of the treatment) is checked with respect to the bootstrap distribution constructed in step two. If NCE, and Bandwagon and Strategic risk channels of NCE are not significant, the means of APC(j)-s of each treatment must be close to the mean of the bootstrap distribution. In the opposite case, the means of treatment APC(j)-s of treatments must be positioned in bootstrap distribution with the sequence of equation (2) with APC(j)(M1) in the lower tail and APC(j)(Ctrl) in the upper tail of the distribution. The results of the Between-treatments test are reported in Table 3.

Table 3: Between-treatment test

Panel A Bootstrap of 16 APC(j)-s across 4 treatments						Panel B Treatment average APC(j)			
APC(j)	Observed Coef.	Bootstrap Std. Err	Normal-based [95% Conf. Interval]			M1	M2	M3	Ctrl
APC(2)	-14.2	3	-20.1	-8.4		-19.5	-3.6	-20.8**	-13
APC(3)	-10.7	2.6	-15.8	-5.6		-14.4	-2.5	-16.7**	-9.1
APC(4)	-5	3	-11	0.9		-15.8**	-1.5	-1.3	-1.6
APC(5)	-3.5	2.8	-8.9	1.9		-14.4**	-0.7	-3.1	4.0*
APC(6)	-6.4	3.5	-13.3	0.5		-15.5**	-1.1	-11.1	2.2*
APC(7)	-4.5	3.2	-10.7	1.8		-15.2**	-1.1	-6.4	4.8*
APC(8)	-4.5	3.7	-11.8	2.9		-13.0**	-5.3	-3.9	4.4*

Panel A of Table 2 reports the observed mean of APC(j)-s across 16 conducted sessions of 4 treatments, the standard error and the 95 % confidence interval of the bootstrapped mean of 16 APC(j)-s. Panel B of Table 2 reports the observed mean of APC(j) across 4 sessions for each treatment. The "*" ("**") shows that the observed mean of APC(j) of a treatment is in upper (lower) 2.5% tail of the bootstrapped distribution of the mean of APC(j)-s of 16 sessions.

Panel A of Table 2 reports the observed means of APC(j)-s across sixteen sessions, their bootstrap standard errors and 95% confidence intervals. Panel B of Table 2 reports the observed means of APC(j)-s for given treatment. All the APC(j)-s of main treatments are negative, while APC(5)-APC(8) of Ctrl treatment are positive. This can be a signal of NCE present in main treatments. By looking closer at thePanel B comparison of APC(2) and APC(3) to APC(4)-APC(8) across treatments shows an average upward trend in prices in periods 2 and 3 as is also shown in the Within-treatment test section. As a result of this trend APC(2) and APC(3) across treatments does not show support for the significance of NCE.

APC(4)(M1) is in lower 2.5% while APC(4)(M2), APC(4)(M3) and APC(4)(Ctrl) are close to each other and to the mean of the distribution. This might indicate that NCE is significant. Further, the Bandwagon channel is a significant channel through which NCE is transferred, as after eliminating the Bandwagon channel in treatment M2, NCE became insignificant.

M1 is in the lower 2.5% and Ctrl is in the upper 2.5% tail of the distribution while M2 and M3 are closer to the mean of the distribution for APC(5)-APC(8). This is closer to our hypothesized sequence of APC(j) across treatments in equation (2). The only difference is that APC(j)(M2) and APC(j)(M3) for all j-s except for j=8 are in opposite order than hypothesized: APC(j)(M2)> APC(j)(M3).

APC(j) of the M1 and Ctrl treatments are in the lower and upper 2.5% tails, which implies that NCE is significant. Further, APC(j) of M2 is closer to the mean of the distribution, implying that eliminating the Bandwagon channel from M1 to M2 decreases NCE but does not eliminate it completely as APC(j)(M2) < APC(j)(Ctrl). This implies that the Bandwagon channel transfers NCE; however, it is not the only channel through which NCE is transferred: Strategic risk and OBSR channels may transfer NCE as well. Eliminating the Strategic risk channel from M2 to M3 treatment does not decrease NCE as APC(j)(M2) > APC(j)(M3) in most cases; this implies that Strategic risk channel is not significant. Further, as APC(j)(M3) is closer to the mean of the distribution rather than to the APC(j)(Ctrl) it implies that OBSR channels transfer NCE as well. Thus, results of the Between-treatment test show that NCE is significant and can be transferred through Bandwagon and OBSR channels, and that the Strategic risk channel is not significant. These results support *Hypotheses 5 and 7* and reject *Hypothesis 6.*

The results of the Within-treatment and Between-treatment tests are very similar. In both cases the NCE is sizable and the Bandwagon and OBSR channels transfer NCE and Strategic risk channel is insignificant. The difference is that in the Within-treatment test in one case the Bandwagon channel is significant and other channels are not (M2), and in the other case OBSR channels are significant and the Bandwagon channel is not significant (M3), which is contradictory. In the Between-treatment test, there is no such contradiction; elimination of the Bandwagon channel in treatment M2 decreases NCE but does not eliminate it completely, leaving room for OBSR channels to be significant.

The reason for these differences between the results of the Within- and Between-treatments tests may be that the Within-treatment test does not take into account the magnitude of price changes because ranks of price changes are used. For example, if a difference between price changes in two periods in one case is -5 and in the other case is -15, the ranks in both cases are the same, though, obviously, the two cases are different. Thus, because the Between-treatments test takes into account the magnitude of price changes and its results do not contradict the results of the Within-treatment test, we conclude that the Between-treatment test describes the nature of NCE properly: NCE is significant and can be transferred through the Bandwagon and OBSR channels, and the Strategic risk channel is not significant.

6. Conclusion

We address the question whether the news of a crisis in one market can result in a contagious crisis in another market in an environment where there are no links between markets. Further, we test for two of the possible channels through which news of a crisis in one market can affect another market; the Bandwagon and Strategic rick channels. To do so we apply a novel methodology which, to the best of my knowledge, has not been applied before. Taking into account that it is almost impossible to isolate the NCE in empirical data, I construct an experiment which allows us to isolate NCE. It is a financial market experiment in which two markets are traded simultaneously. In one market there is a simulation of price drop which represents crisis. It is possible to isolate the NCE due to the design of the experiment which does not allow any links between two markets other than the possibility to observe the prices on the other market. Further, the information about differences between designs of two markets is used to control for Bandwagon and Strategic risk channels across four treatments.

The current paper is the first attempt to test for the significance of NCE to the best of my knowledge, and it complements the theoretical models in which news of a crisis is shown to be a significant factor in contagion. The results of the current experiment show that the NCE is significant and robust to both Within-treatment and Between-treatments tests. The Within-treatment test tests if NCE is significant in each treatment separately given that there are a positive number of channels of NCE. Between-treatment test tests whether NCE and Bandwagon and Strategic risk channels are significant by comparing four treatments.

Further, the results allow us to say distinctly that the Strategic risk channel is not significant, while the Bandwagon and OBSR channels can be significant, though this significance is weak in the sense that in one treatment they are significant, while they are not in the other. This result, though contradictory, is still logical, as news of a crisis may cause contagion by affecting the sentiments of subjects. As sentiments are not constant, it is intuitive that some channel of NCE may play a significant role in one case and not be significant in another.

Our results compliment the work of Calvo and Reinhart (1996) who suggest that beliefs that two markets are similar can be the cause of contagion. Further, our results do not support the theory suggested by Ahnert and Bertsch (2013), according to whom strategic risk about other agents' information may result in contagion.

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Appendix A: Instructions A

(are the same for all treatments)

Instructions A

Dear Participant! We welcome you to this experimental session.

This is an experiment on decision making in markets. If you follow the instructions carefully and make good decisions, you may earn on average 400 CZK which will be paid to you privately in cash at the end of the experiment.

At the end of the experiment you will be asked to complete a questionnaire, after which you will receive your payment. The entire experiment will last approximately two hours, including half an hour for instructions and practice.

Please, do not talk to each other for the duration of the experiment or your participation will be terminated without any payment. If you face any difficulties or have any questions, please raise your hand and we will answer it privately.

General Information

In this part of theinstructions you will receive **general information about the experiment** and you will **learn how to use computerized market.** You will get more detailed information later.

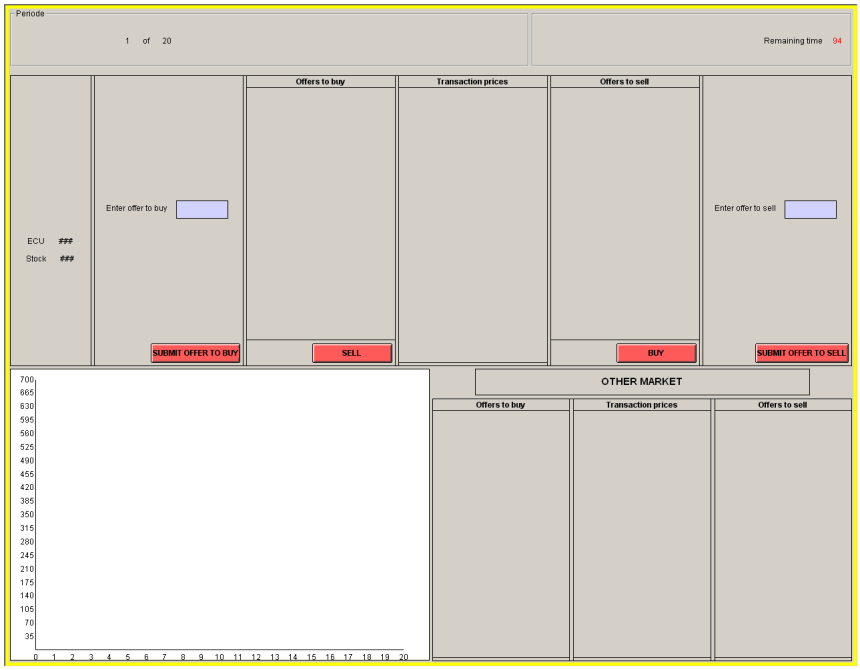
This experiment is about an asset market on which traders can trade the stocks of a fictitious company for 20 consecutive periods. Each period will last 100 seconds. There will be two asset markets operating simultaneously. Each of you will trade in one and only one market during the entire experiment. There will thus be no subject who will trade in both markets. However, you will be able to see the trading in the other market.

Trade is organized in the form of a double auction, *i.e.*, each trader can appear as buyer and seller at the same time. At the beginning of the first trading period you will be given some amount of Experimental Currency Unit (ECU) and some number of stocks for trading.ECU is the currency which will be used for trading during this experiment and at the end of the experiment your ECU holdings will be converted to Czech Koruna (CZK) using an exchange rate of CZK/ECU=0.18. At the end of each period, each stock will yield some dividend. In every period you can sell and/or buy stocks. The ending balance of your stock and ECU holdings at the end of each period becomes your beginning balance of your stock and ECU holdings in the next period.

How to use the computerized market

1. The number of the current period and time left till the end *of the current period*

In the top right corner of the screen you will see how much time is left in the current trading period. In the top left corner of the screen you can see the number of the current period.



2. *Trading*

Below the first row on the top of the screen there are six columns next to each other. The first column to the left shows how much cash and how many stocks you have. Each time you make a trade your balance of cash and stocks in this column will adjust accordingly.

The other five columns are used for trading. You can participate in the market in one of four ways.

Making an offer to sell a share, by entering the price at which you would like to sell:

To offer to sell a share, enter the price at which you would like to sell in the box labeled 'Enter offer to sell' on the right of the screen, then click on the button 'Submit offer to sell'.

The second column from the right will show a list of offers to sell, each submitted by a different participant. The lowest offer-to-sell price will always be on the bottom of the list. Submitting a new offer will replace your previous one. You can submit only offers-to-sell lower then already submitted offers-to-sell.

Making an offer to buy a share, by entering the price at which you would like to buy:

To offer to buy a share, enter the price at which you would like to buy in the box labeled 'Enter offer to buy' on the left of the screen, then click on the button 'Submit offer to buy'.

The third column from left will show a list of offers to buy, each submitted by a different participant. The highest offer-to-buy price will always be on the bottom of the list.

Submitting a new offer will replace your previous one. You can submit only offers-to-buy which is higher than already submitted offers-to-buy.

Buying a share, by accepting an offer to sell:

You can select an offer to sell in the second column from right by clicking on it. If you click the 'Buy' button at the bottom of this column, you will buy one share at the price that you selected. However, you are not allowed to buy a share from yourself.

When you accept an offer-to-sell, it will disappear from the list. If you had also placed an offer-to-buy, it will disappear from the offers to buy list because you have just bought a share.

Selling a share, by accepting an offer to buy:

You can select an offer-to-buy in the third column from the right by clicking on it. If you click the 'Sell' button at the bottom of this column, you will sell one share at the price that you selected. However; you are not allowed to sell a share to yourself.

When you accept an offer-to-buy, it will disappear from the list. If you had also placed an offer-to-sell, it will disappear from the offers to sell list because you have just sold a share.

Transaction prices

When you buy a share your money decreases by the price of the purchase. You can only buy a share if you have enough money to pay for it.

When you sell a share, your ECU holdings increase by the price of the sale. You can only sell a share if you owned one to begin with.

In the fourth column from right of the screen, labeled 'Transaction prices', you will see the prices at which shares have traded in the current period.

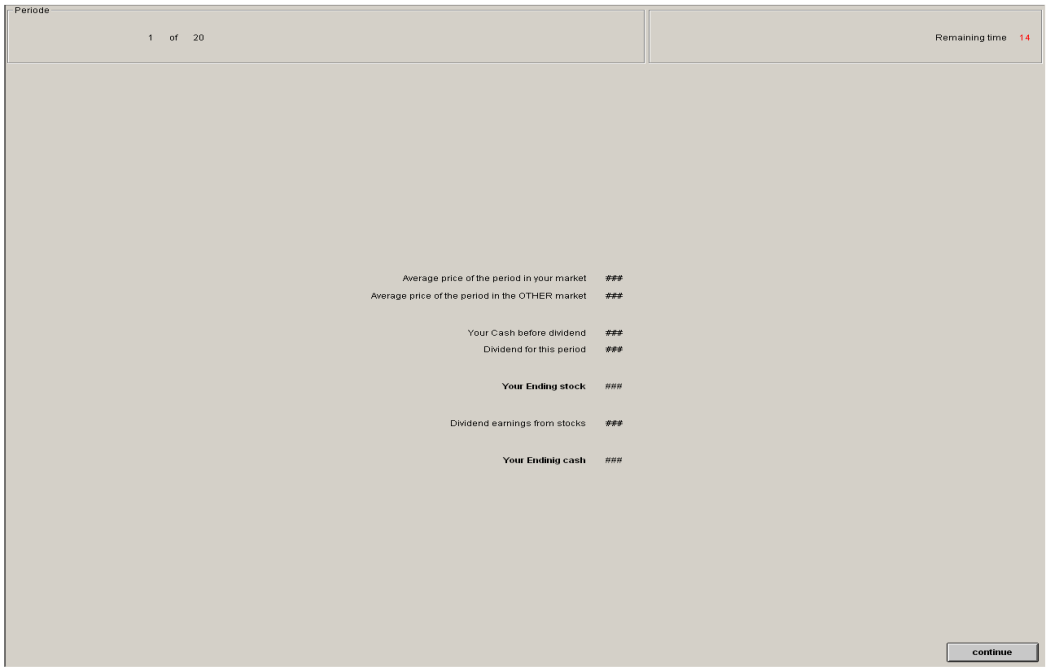
3. *Information about other market and average prices*

The lower half of the screen consists of a diagram to the left of the screen and three columns to the right of the screen. The three columns will show offers to buy, transaction prices, and offers to sell in the other market in the current period. You cannot trade in the other market, so you cannot accept offers to buy or offers to sell of the other market.

The diagram will show the average prices of both markets in each of previous periods. The diagram will be updated after each period.

4. *Summary screen*

After the end of each period you will be given summary statistics of the period in the following screen:



a) Where you will be given information about:
b) Average price of the period in your market,
c) Average price of the period in the other market,
d) ECU holdings before dividend –your ECU balance before adding dividend earnings,
e) Dividend for this period –realized dividend for the period,
f) Dividend earnings from stocks –Dividend for the period multiplied by your ending stocks of the period.
g) Ending ECU –your ECU holdings including dividend earnings for period. This will be your beginning ECU balance in the next period.
h) Ending stock –your ending number of stocks for the period. This will be your beginning stock balance in the next period.

5. *Practice interface*

You now have 180 seconds to practice buying and selling stocks. Your actions in this practice period will not influence your earnings or your position later in the experiment. The only goal is to master the use of the interface.

Please make sure that you successfully submit offers to buy and offers to sell. Also make sure that you successfully accept other people's offers to buy and sell shares.

If you have any questions, please raise your hand and an experimenter will assist you.

Appendix B: Instructions B

(text in //... // for treatments Main 2,3)

Instructions B

In this part of the instructions you will learn about the *//First of//* experimental asset markets that will be operating during this experiment**.**

The market lasts for 20 consecutive periods. Each period lasts for 100 seconds.

In the beginning of the market participants are given some amount of ECU and a number of stocks for trading. You will find out what are your initial **holdings of ECU and stocks in the beginning of the first trading period in the first column from the left**.

Each stock has a 0 value in the end of the market, i.e. after the period20.

//No interest is paid for ECU holdings.//

Each stock at the end of each period pays a dividend from the following outcome set {0; 4; 14; 30}. Dividends are realized randomly each period. The probability of each outcome to be realized is the same and is equal to 0.25. The expected dividend of a stock for each period can be calculated by

Expected Dividend = 0.25*0 + 0.25*4 + 0.25*14 +0.25*30=12

Fundamental Value (FV)

The table below may help you to make decisions.

A. Ending period	B. Current period	C. Number of Holding Periods	X	D. Average Dividend Value per Period	=	E. Fundamental Value per Unit of Inventory
20	1	20	X	12	=	240
20	2	19	X	12	=	228
20	3	18	X	12	=	216
20	4	17	X	12	=	204
20	5	16	X	12	=	192
20	6	15	X	12	=	180
20	7	14	X	12	=	168
20	8	13	X	12	=	156
20	9	12	X	12	=	144
20	10	11	X	12	=	132
20	11	10	X	12	=	120
20	12	9	X	12	=	108
20	13	8	X	12	=	96
20	14	7	X	12	=	84
20	15	6	X	12	=	72
20	16	5	X	12	=	60
20	17	4	X	12	=	48
20	18	3	X	12	=	36
20	19	2	X	12	=	24
20	20	1	X	12	=	12

Column *A* in Table 1 indicates the Ending Period of the market. Column *B* indicates the Current Period for which the Fundamental Value is being calculated. Column *C* gives the Number of Holding Periods from the Current Period to the Ending Period.

Column *D* gives the Average Dividend per Period for each share that you hold. Column *E* gives the Average Fundamental Value per Share that you hold from the Current Period until the end of the market.

That is, for each stock that you hold for the rest of the market, you will earn on average the amount listed in column *E*. The value in column *E* is calculated by multiplying the values in columns *C* and *D*.

Calculating Your Earnings

Your earnings for a period are given by the actual dividends received at the end of a period, plus revenues for assets sold, minus expenditures for purchases.

YOUR EARNINGS FOR A PERIOD=

DIVIDEND PER UNIT × NUMBER OF UNITS IN INVENTORY (AT THE ENDOF THE PERIOD) + REVENUES –EXPENDITURES (WHICH YOU HAVE IN THE COURSE OFTRADING).

Your total profit at the end of the experiment is equal to the initial cash endowment plus the sum of earnings acquired in all 20 trading periods.

YOUR TOTAL EARNINGS IN THE EXPERIMENT=

INITIAL CASH ENDOWMENT+EARNINGS FOR PERIOD 1 + EARNINGS FOR PERIOD 2 + EARNINGS FOR PERIOD 3 + EARNINGS FOR PERIOD 4 + EARNINGS FOR PERIOD 5 + EARNINGS FOR PERIOD 6 + EARNINGS FOR PERIOD 7 + EARNINGS FOR PERIOD 8 + EARNINGS FOR PERIOD 9 + EARNINGS FOR PERIOD 10 + EARNINGS FOR PERIOD 11 + EARNINGS FOR PERIOD 12 + EARNINGS FOR PERIOD 13 + EARNINGS FOR PERIOD 14 + EARNINGS FOR PERIOD 15 + EARNINGS FOR PERIOD 16 + EARNINGS FOR PERIOD 17 + EARNINGS FOR PERIOD 18 + EARNINGS FOR PERIOD 19 + EARNINGS FOR PERIOD20

Appendix C: PDF and CDF functions of ARPC considering periods 2 to 10 (9 periods)

N	ARPC	PDF	CDF	
			p-value lower tail	p-value upper tail
1	1	0.000	0.000	1.000
2	1.25	0.001	0.001	1.000
3	1.5	0.002	0.002	0.999
4	1.75	0.003	0.005	0.998
5	2	0.005	0.011	0.995
6	2.25	0.009	0.019	0.989
7	2.5	0.013	0.032	0.981
8	2.75	0.018	0.050	0.968
9	3	0.025	0.075	0.950
10*	3.25	0.033	0.108	0.925
11	3.5	0.041	0.150	0.892
12	3.75	0.049	0.199	0.851
13	4	0.057	0.256	0.801
14	4.25	0.064	0.320	0.744
15	4.5	0.070	0.390	0.680
16	4.75	0.073	0.463	0.610
17	5	0.075	0.537	0.537
18	5.25	0.073	0.610	0.463
19	5.5	0.070	0.680	0.390
20	5.75	0.064	0.744	0.320
21	6	0.057	0.801	0.256
22	6.25	0.049	0.851	0.199
23	6.5	0.041	0.892	0.150
24**	6.75	0.033	0.925	0.108
25	7	0.025	0.950	0.075
26	7.25	0.018	0.968	0.050
27	7.5	0.013	0.981	0.032
28	7.75	0.009	0.989	0.019
29	8	0.005	0.995	0.011
30	8.25	0.003	0.998	0.005
31	8.5	0.002	0.999	0.002
32	8.75	0.001	1.000	0.001
33	9	0.000	1.000	0.000

The table gives the PDF and CDF functions for possible values of ARPC for a given period when considering periods 2 to 10.

ARPC is the average rank of price changes of the same period across four sessions of a treatment. The ARPC in the table shows the possible values that ARPC may obtain. There are 33 possible values of ARPC (N=33). Analytically these values are obtained as the average value of four draws with replacement from set {1, 2, 3, 4, 5, 6, 7, 8, 9}. This set of values corresponds to the ranks that price changes in periods 2 to 9 may have among price changes of periods 2 to 9.

PDF shows the theoretic frequency (probability) of each value of ARPC. It is calculated the ratio of the number of combinations of four draws which have the same average value over the number of all possible combinations.

CDF p-value lower tail (upper tail) shows probability of ARPC to have value lower or equal (higher or equal) to the corresponding value of ARPC.

* (**) indicates 10 (5) % lower or upper tail threshold.

Appendix D: PDF and CDF functions of ARPC considering periods 4 to 10 (7 periods)

N	ARPC	PDF	CDF	
			p-value lower tail	p-value upper tail
1	1	0.000	0.000	1.000
2	1.25	0.002	0.002	1.000
3	1.5	0.004	0.006	0.998
4	1.75	0.008	0.015	0.994
5	2	0.015	0.029	0.985
6**	2.25	0.023	0.053	0.971
7*	2.5	0.035	0.088	0.948
8	2.75	0.048	0.136	0.913
9	3	0.062	0.198	0.864
10	3.25	0.075	0.273	0.802
11	3.5	0.086	0.359	0.727
12	3.75	0.093	0.452	0.641
13	4	0.096	0.548	0.548
14	4.25	0.093	0.641	0.452
15	4.5	0.086	0.727	0.359
16	4.75	0.075	0.802	0.273
17	5	0.062	0.864	0.198
18	5.25	0.048	0.913	0.136
19*	5.5	0.035	0.948	0.088
20**	5.75	0.023	0.971	0.053
21	6	0.015	0.985	0.029
22	6.25	0.008	0.994	0.015
23	6.5	0.004	0.998	0.006
24	6.75	0.002	1.000	0.002
25	7	0.000	1.000	0.000

The table gives the PDF and CDF functions for possible values of ARPC for a given period when considering periods 4 to 10. The parameters are defined similar to the ones in Appendix C.

Abstrakt

Experimentálně ověřujeme domněnku, že zpráva o krizi na jednom trhu způsobí krizi na druhém trhu, přestože tyto trhy nemají společné ekonomické fundamenty. Stávající modely nákazy mezi trhy mluví o možnosti nákazy díky módním vlnám nebo strategickému přenosu rizika, nicméně tyto modely nebyly empiricky testovány, pravděpodobně díky obtížnosti testování na datech z reálných trhů, které jsou výjimečně zcela izolovány. Náš experimentální design modifikuje Smith et al. (1988) a obsahuje dva současně probíhající trhy, jež jsou propojeny pouze díky možnosti pozorovat ceny na obou trzích. Po vytvoření krize na jednom z trhů pozorujeme ceny na druhém trhu a potenciálně nákazu krize. Naše výsledky ukazují, že zpráva o krizi na jednom trhu je signifikantním zdrojem nákazy na druhém trhu díky efektu módní vlny, nikoliv díky strategickému přenosu rizika.

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