RATIONAL REASONING OR ADAPTIVE BEHAVIOR EVIDENCE FROM LABORATORY EXPERIMENT

Helena Chytilova, Ing., M.A.
University of Economics, Faculty of Economics, Prague, Czech Republic

Abstract:

Many studies deal with experimental investigation of rational behaviour, which might deviate from initial concepts under particular conditions, where subjects follow rather adaptive behaviour. The aim of this study is to verify whether adaptive behaviour might be prevalent in environment of nominal values characterized by uncertainty. Our hypothesis is verified with help of the experiment based on n-player pricing game with monopolistic competition and strategic complementarity inspired by experimental design of Fehr and Tyran, (2001), where players have to cope with environment of real or nominal values. Results confirm our initial assumption that in case of nominal treatment, subjects tend to behave rather in adaptive way, since the size of expectation correction is close to simulated case of adaptive player together with substantial deviation from equilibrium. On the other hand, subjects in the real treatment behave in less adaptive and even more rational way, where the size of expectation correction is far away from the case of adaptive player and deviation from equilibrium substantially smaller. Prevalence of adaptive players under the nominal treatment has also implications in terms of slower convergence to equilibrium at aggregate level, as opposed to the real treatment where more rational players are present. Furthermore, this is in line with our illustrative simulations carried out at economy´s level.

Key Words: Adaptive player, rational player, experiment, expectations, convergence

Introduction

Many studies deal with analysis of rational and adaptive behavior on experimental basis under particular conditions, for instance Williams (1987), Marimon, Sunder (1988), Hey (1994), Van Huyck (1997) with recent resurrection in studies of Bornstein, (2004), Nagel, Grosskopf (2007), Terracol (2009) or Fehr and Tyran (2008). It was shown that subjects do not necessarily behave in line with game theoretic assumptions based on rationality, but may deviate as opposed to initial concepts and switch rather to adaptive behavior as emphasized by Nagel, Grosskopf (2007). This raises question under what conditions might individuals behave in adaptive or rational way. The main aim of this study is to evaluate behavior of players under two different environments and detect whether rational or adaptive behavior prevails in case of each treatment. Hypothesis will be examined with help of the experiment based on n-player pricing game with monopolistic competition and strategic complementarity inspired by experimental design of Fehr and Tyran, (2001), where players have to cope with environment of real or nominal values. We expect that in nominal treatment, subjects will tend to adaptive rather than rational behaviour due to the factor of uncertainty and also due to rational player´s conjectures about other players playing rather in adaptive way. In contrast, the real treatment should exhibit prevalently rational behaviour, since under the real frame subjects have no reason to behave adaptively and no reason to suppose that others will behave adaptively, since cognitive barrier related to nominal values is absent.

First section outlines initial hypothesis followed by description of basic experimental design. The second section provides our simulations related to individual adaptive or rational behavior together with simulations at aggregate level, which provide support for results gained on the basis of experiment. The last section reveals experimental results which are in line with our initial expectations.

Hypothesis and Experimental Design

We assume that if subjects face different environment related to their pricing strategy, they may exhibit different behavior. Under conditions of uncertainty, which require solution of cognitive task, we assume individuals to apply rather adaptive behavior, which is simply the best option. In other words, subjects under uncertainty consider rationality too costly, thereby they prefer to switch to adaptive behavior, which enables to collect at least average rewards with some certainty. This means that although only small number of adaptive individuals was present in environment of certainty, the share of adaptive individuals will significantly increase under uncertain environment. It is assumed that subjects, which would be rational under standard conditions, assess the situation in uncertain environment as untenable and switch to less costly adaptive behavior as emphasized by Smith (2002, 2003). Moreover, they may doubt if others stay rational in this uncertain environment, which is another reason for the change in their behavior.

In order to verify whether subjects tend to adaptive rather than rational behavior under uncertainty, hypothesis will be examined with help of the experiment based on n-player pricing game with monopolistic competition and strategic complementarity, (Fehr and Tyran, 2001). Individuals are setting prices, where returns are affected by their selling price and price level, determined by prices set by other firms in experimental economy. Subjects aim to maximize profits, defined as a function of their individual price and the average price level. Subjects are expected to select profit-maximizing price, which should be consistent with the total general equilibrium of the economy, if other subjects choose the correct price as well. The game has 40 rounds plus one trial period, with a group size of n=4. 80 subjects participated in the experiment, which was conducted in the Laboratory of Experimental Economics, University of Economics, Prague. Experiment is divided into a pre-shock and a post-shock phase. Fully anticipated negative monetary shock is implemented during the game, which is common knowledge to participants.

In order to determine whether adaptive type of players are present in uncertain environment, treatment groups are endowed by different pay-off functions, which provide them with information about their pricing strategy. Experimental treatment is represented by subjects, which receive pay-off information in nominal terms, whereas control treatment by subjects which receive pay-off information in real terms. In order for subject in the nominal environment to decide correctly about the price of his product, he needs to re-count nominal pay-off into the real pay-off. The nominal pay off is given by $P_{-i}. \pi_i$, therefore in order to compute real payoff, individuals have to divide their nominal payoffs $P_{-i}. \pi_i$ by P_{-i}.

The real pay-off of subject i is given by:

$\pi_i = \pi_i (P_i, P_{-i}, M)$ i=1,.... n

where P_i stands for nominal price, P_{-i} is the average price of the other n-1 group members, and M is nominal shock variable. Subjects are informed about payoffs of other subjects in the group, since x and y types players are present in both treatments, (For more detailed specification of nominal and real payoffs see Fehr, Tyran (2000).

Since experimental group of nominal treatment requires to make distinction between nominal and real values, its environment represents higher level of uncertainty compared to the real control treatment. This will enable to examine whether phenomenon of adaptive behaviour prevails in uncertain nominal environment, after fully anticipated negative monetary shock is implemented during the game.

In experimental nominal treatment we expect behaviour, where majority players are presumed to be closer to the situation of adaptive player. Firstly, nominal frame plays the role, where subjects after the shock find themselves in uncertain situation ,unable to familiarize and rather switch to adaptive behaviour in order to minimize costs. But also strategic complementarity (Haltiwanger, Waldmann, 1989) contributes to the fact that even rational players switch to adaptive behaviour, since it is optimal for them. This is caused by the fact that they believe that others will not behave rationally under nominal frame as well and thus may maximize rewards better by joining suboptimal adaptive path of behaviour. This will be reflected in character of coordination, where the size of expectation correction will be close to zero after the negative shock and distance from the equilibrium after the shock will be rather substantial. Additionally, lower speed of the adjustment to equilibrium is expected at aggregate level, since coordination effort required in order to adjust adequately is slowed down by prevalence of backward-looking individuals.

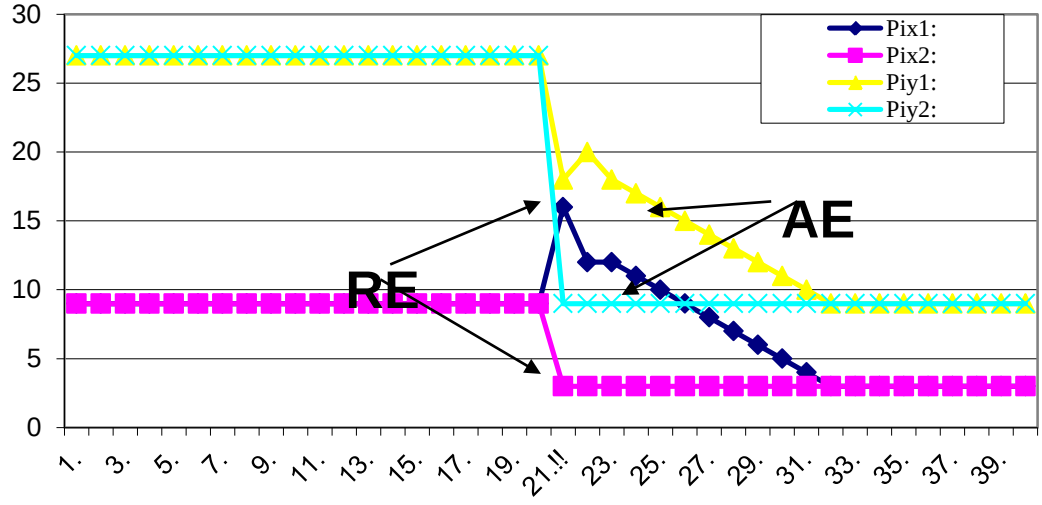
In the real treatment, which serves as a control group, we assume that more players tend to the situation of rational player, since real values are directly available for subjects without the need to distinguish between nominal and real values, which significantly reduce the level of uncertainty. Not only under the real frame more intensive expectation correction takes place, but also lower distance from the equilibrium after the shock is present under the real frame. We also predict that subjects on aggregate level will converge more quickly to economy's equilibrium, since coordination effort is higher also due to the prevalence of rational subjects, which do not have any reason to consider behaviour of other subjects to be adaptive under the real frame.

Simulations of Adaptive and Rational Behavior

Basic simulations are addressed before discussion related to the main results of experiment. These simulations aim to introduce examples of representative behaviour of particular strategies (adaptive versus rational), which players follow in ideal cases with respect to artificial economy examined. As a result, it may provide a good benchmark in comparison with the real data gathered on experimental basis. In other words, we may evaluate easily, how closely the characteristic of players in our experimental economy is to the simulated case and thereby determine type of rational or adaptive player prevailed in particular treatment. Additionally, simulations may provide information regarding the speed of convergence in the economy, affected by the type of players prevailed. This may be further compared to the actual results gained.

We have simulated the situation of experimental subjects from different games, which behave half in adaptive and half in rational way, (See Figure 1 below). It makes also distinction according to the type of player (x or y). Monetary shock is implemented in period 21, which is a common knowledge. The simulation shows that prices differ significantly in period of the shock, with regards to whether the player is adaptive or rational one. Player of type x_1, who behaves in adaptive way, changes the price after the shock from $P_i^* = 9$ to $P_i^* = 16$. In contrast, player x_2 with rational expectations changes the price after the shock from $P_i^* = 9$ to $P_i^* = 3$. Player y_1 with adaptive expectations changes price from $P_i^* = 27$ to $P_i^* = 18$ after the shock. Lastly, player y_2 with rational expectations changes price from $P_i^* = 27$ to $P_i^* = 9$. The adjustment to the equilibrium price is significantly slower for adaptive players after the shock and they converge only to equilibrium in the period 32. In contrast, rational players x_2 and y_1 head smoothly towards equilibrium immediately after the shock in period 21, since prices selected after the shock reflect equilibrium prices. In addition, behaviour of player x_1 after the shock might seem to be non-standard, since the price increased. We would expect movement in direction of lower prices, which is exactly the behaviour of player y_1 in the first period after the shock. However, the setting of pay-off table of player x implies that he should increase the price after the shock if he behaves in adaptive way with respect to the size of the average price in the economy given by experimental design above.

Figure 1: Simulation of the Development of Prices for Adaptive and Rational Players from Different Games.



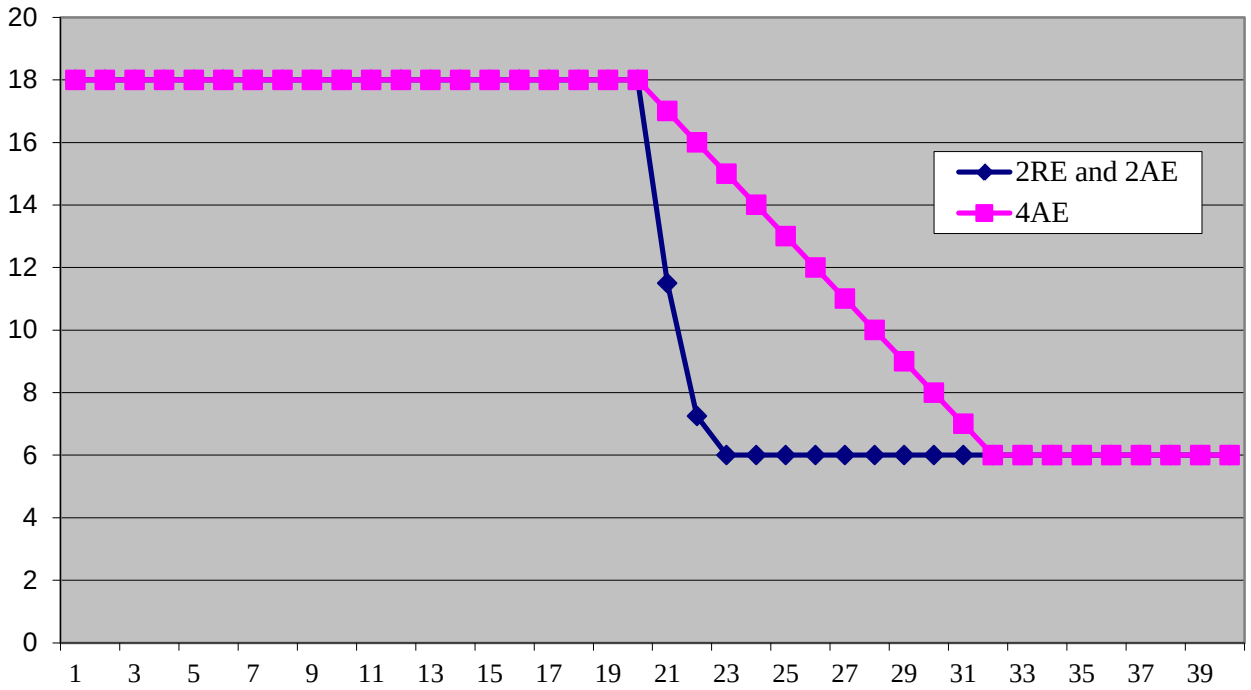
Further, we have simulated the size of expectation correction and deviation from the equilibrium directly after the shock depending on whether the player is rational or adaptive one.

Expectations of adaptive player were computed as the average price of the other n-1 players in the pre-shock period, where prices of these other n-1 players are individual pre-shock equilibrium prices given by experimental design, since behaviour of naive adaptive player is delayed and based on prices of the previous pre-shock period. When getting values for type of x and type of y of adaptive player (the size of expectation correction is 0 for both types), the average size of expectation correction equals 0. Similarly, based on experimental design, we computed for the average deviation from equilibrium directly after the shock, which is 11 for adaptive player, (deviation for player x is 13, deviation for player y is 9 consecutively).

Expectations of rational player were computed as the average price of other n-1 players in the post-shock period, where prices of other three players are their individual post-shock equilibrium prices, since he is no longer interested in the past price development. After getting values for type of x and type of y of rational player (the size of expectation correction is 14 and 10 consecutively), the size of expectation correction yields 12, which suggests that rational player adjusts substantially his expectations with immediate movement towards equilibrium after the shock. Similarly we computed for deviation of rational player from equilibrium directly after the shock, which is 0, (for player x deviation equals 0, for player y also 0).

Till now, we have simulated individual behaviour of particular players, which may emerge in our economy. This individual behaviour may have serious implications for convergence at aggregate level, depending on type of the player prevailed. Therefore, we have also simulated two economies, where the first one is composed of two rational players (REx and REy) and two adaptive players (AEx and AEy) and the second one is purely adaptive economy (4AE), (See Figure 2 below). The adjustment to the equilibrium price is for the first economy significantly faster than for purely adaptive economy. Moreover, the inclusion of only two rational players is sufficient in order to ensure smooth and relatively fast adjustment to economy´s equilibrium. In contrast purely adaptive economy, which relies solely on backward-looking behaviour, is characterized by slow convergence to new equilibrium after the shock and converges in period 32. In contrast, the first economy converges in period 23, which is relatively fast adjustment if the share of rational and adaptive players is comparable. This suggests that smooth convergence might be achieved even in case of the economy, which consists only partly of rational players.

Figure 2: Development of the Average Price in two economies: 2 RE, 2AE and pure AE



Results of Experiment

Simulations above suggest that adaptive player in ideal case corrects expectations in no way in the first post-shock period and deviates by 11 directly after the shock, with consequent pricing path, which reflects only slow backward-looking adjustment to new equilibrium in following post-shock periods. On the other hand ideal rational player corrects expectations significantly by 12, with zero deviation from equilibrium directly after the shock, with relatively fast convergence towards equilibrium even in the first post-shock period. Based on simulations, this is reflected also on aggregate treatment´s level as illustrated above. Following section will reveal whether adaptive behaviour will be present under the nominal treatment with less frequent expectations correction and slow adjustment to equilibrium, compared to the control group of the real treatment, where subjects are assumed to be rather rational with substantial expectation correction and relatively fast adjustment to equilibrium.

Following test enables to detect not only whether subjects follow rather adaptive behaviour in uncertain environment of the nominal treatment compared to the real one, but also whether they get acquainted with experimental instructions and whether they reflected this consistently into consequent behaviour. In other words, the aim is to evaluate how far subjects corrected their expectations about the price in the first post-shock period with consequent pricing strategy after the shock. This will be evaluated with help of the following regression:

$$(P_i - P^*) = \alpha + \beta * (\bar{P}_{-i} - \bar{P}^{\,e}_{-i}) + \varepsilon \qquad (1)$$

Where $(\bar{P}_{-i} - \bar{P}^{\,e}_{-i})$ is deviation of player´s expectations for the post-shock period to the pre-shock actual price level (i.e. the size of his expectations correction) and $(P_i - P^*)$ is distance of subject´s individual price from equilibrium in the first post-shock period. The coefficient β measures, how the size of expectations correction is reflected into consequent distance of the subject with his individual price from equilibrium. If the coefficient β=0, then the size of expectation correction has no effect on distance of the subject from equilibrium, which reflects non-consistency of decisions. If the coefficient β<0, then two situations may arise where the player is consistent with his decision-making. Either consistent adaptive player is the case, where the closer the expectations to the past pre-shock price, the higher the deviation of individual price from the optimum in the post-shock phase. Or consistent rational player is the case, where the higher the expectations correction, the lower is the deviation of individual price from the optimum in the post-shock phase.

Based on simulations applied on the player of type x, the case of consistent adaptive player looks as follows: the past pre-shock average price was $\bar{P}_{-i} = 9$, where zero expectation correction takes place and thus expectations are in line or very close the past pre-shock average price, i.e. $\bar{P}_{-i} = 9 = \bar{P}^{\,e}_{-i}$. The equilibrium price, which reflects perfect adjustment for type of player x is however $P^* = 3$. Difference between individual price and optimum is higher, the most inertial being $(P_i - P^*)$=6, which is our simulated case. Similarly we would apply our considerations on player of type y.

Behaviour of consistent rational is described as follows: high expectation correction takes place and therefore expectations are much further from the past pre-shock average price, i.e. $\bar{P}_{-i} > \bar{P}^{\,e}_{-i}$. After the shock individual price of player of type x is in line with equilibrium post-shock price, i.e. $\bar{P}_{-i} = 3 = P^*$. Difference between individual price and optimum is very low, in ideal simulated case $(P_i - P^*)$=0. Similarly we would apply our considerations on player of type y.

Thus, for the consistent behaviour it holds:

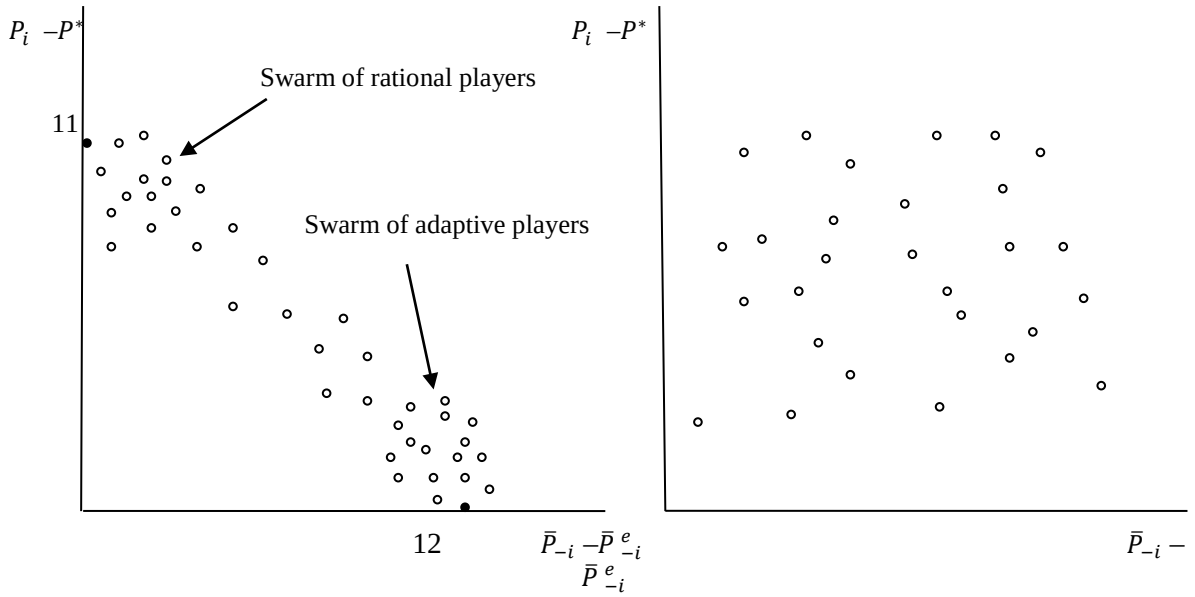
Either if $(\bar{P}_{-i} - \bar{P}^{\,e}_{-i})$ is high, then $(P_i - P^*)$ is low, which is the case of consistent rational player.

Or if $(\bar{P}_{-i} - \bar{P}^{e}_{-i})$ low, then $(P_i - P^*)$ is high, which is in line with consistent adaptive behaviour.

As a result, such consistent behaviour is associated with the coefficient $\beta<0$.

Following Figure 3 describes theoretical case of consistent and inconsistent behaviour of subjects at aggregate level. Illustrative case shows that consistent behaviour is present at aggregate level, where either the subject might be adaptive or rational, but still the consistency is reflected in their behaviour. On the x axis ideal case of consistent rational player is present (see black small point), whose expectations are further from equilibrium, according to simulations $\bar{P}_{-i} - \bar{P}^{e}_{-i} = 12$ on average, but the adjustment of individual price to equilibrium is perfect, where $P_i - P^* = 0$. In contrast on y axis ideal case of consistent adaptive player is present, whose expectations are very close to the pre-shock price, where $\bar{P}_{-i} - \bar{P}^{e}_{-i} = 0$, but individual price is far from optimum, according to simulations where $P_i - P^* = 11$ on average. Starting at the position of ideal rational player, the lower the expectation correction is, the higher the difference between individual and optimum price becomes. There is tendency to be less rational and more adaptive, for players, who emerge in this space.

Figure 3: Consistent and Inconsistent Behaviour in the Economy



If we begin at the position of adaptive player, then the higher the expectation correction is, the lower the difference between individual and optimum price. This implies less inertial behaviour and tendency towards rational behaviour for players who emerge further from ideal case of adaptive player. Nevertheless, whether present closer to ideal case of adaptive or rational player, distribution of players depicted in Figure still respects consistency, where $\beta<0$. Right graph of Figure 3 depicts the situation, where rather inconsistency is present, since no relationship is present between the expectation correction and distance from equilibrium. Moreover, we may not distinguish between the swarm of adaptive and rational players so clearly.

Presumptions Regarding Results

In line with our initial hypothesis, we expect in case of uncertain nominal treatment (which is our experimental group) more players to be closer to the ideal situation of adaptive player. Thus, under the nominal frame weak coordination effort related to uncertainty will lead to the fact that subjects will be closer to left upward part of y axis, with expectation correction approaching to zero and higher distance from equilibrium, followed by implication at aggregate level. On the other hand, in the real treatment we expect more players present closer to the ideal situation of rational player, with intensive expectation correction and negligible distance from equilibrium. This should lead to the fact that majority of players will be close to the right downward part of x axis, whereas not many adaptive players will be present close to the y axis. However, common expected result for both treatments is that consistency should be reflected in incidence of players in line with $\beta<0$.

Results for the nominal treatment (NH Mgr)

The model is significant at the 5% level, where the coefficient β is negative, which confirms that even in the nominal treatment, subjects proved to behave in consistent way (See Table 1 below). Based on results if the expected price level declines, the player will reduce his price.

Table 1: Nominal treatment, (Experimental Group)

	Coefficient	t-value	n	R2
constant	12.4859***	18.2	44	62.46%
$(\bar{P}_{-i} - \bar{P}^{e}_{-i})$	-0.833861***	-8.36		

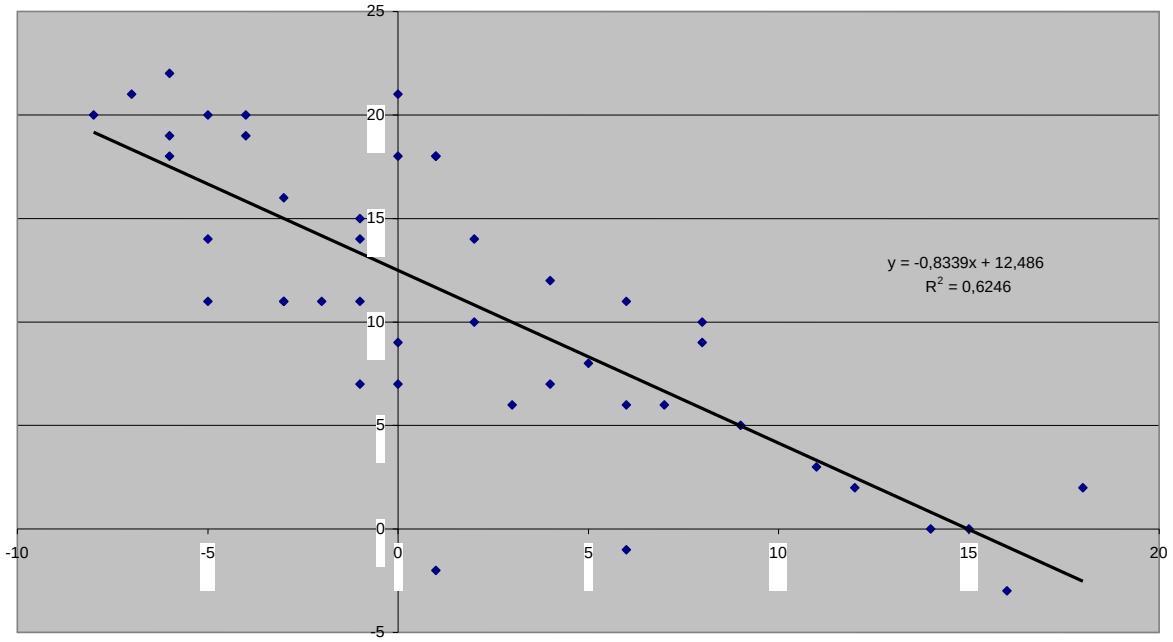
Notes: $(\widehat{P_i - P^*}) = 12.48 - -0.83 * (\bar{P}_{-i} - \bar{P}^{e}_{-i})$

*** Significance at the 1-percent level

Additionally, if players do not correct their expectations at all, the coefficient β equals 12.48. In other words deviation from equilibrium is 12.48 is very close to the simulated case of adaptive player, for which the deviation from equilibrium in case of zero expectation correction is 11, (See Figure 4 below).

Introduction of the nominal frame in this economy however proved to affect behaviour of players, where more of them corrected their expectations inappropriately compared to the real treatment and thus ended even at the upward left part of the graph, (i.e. their expectations about future post-shock development were even higher than the pre-shock average price). Nevertheless, the difference as opposed to the real treatment may be confirmed, where players do not correct their expectations in so intensive way like in the real treatment and are closer to behaviour of adaptive player. The same holds for distance from equilibrium as mentioned above. Despite that, still it is visible that trajectory reflects consistent direction, where points respect mostly negative slope of the curve, i.e. $\beta<0$.

Figure 4: Difference from Optimum on Expectations Correction, the Nominal Treatment



Possible explanation for frequent occurrence of adaptive players in nominal environment lies not only in uncertainty, which induces players to switch to adaptive behaviour, but also in strategic complementarity built in experimental design, where rational players have no reason to doubt that

other players will behave in adaptive way and thus adjust their behaviour accordingly in order to maximize rewards. Therefore the share of adaptive players is substantial. This has additional implications, since due to the majority of adaptive players prevailed under nominal treatment convergence to aggregate equilibrium is significantly decelerated.

Results for the Real treatment (RH Mgr)

Based on results in Table 2, the model is significant at the 5% level, where the coefficient β is negative, which implies individuals were consistent, because if expectation correction is present, price adjustment takes place. Moreover, Figure 5 below shows that players are found more frequently in sector closer to the case of rational player if compared with the economy of nominal treatment and difference from optimum is not so striking either.

Table 2: Real Treatment, (Control Group)

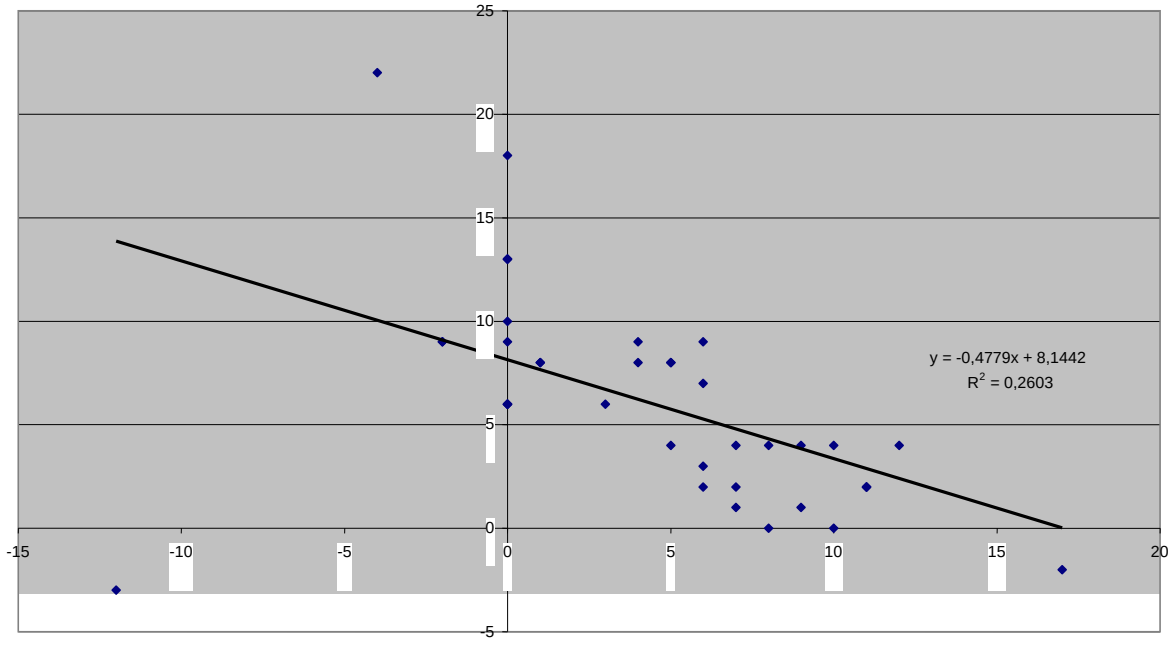
	Coefficient	t-value	n	R2
constant	8.14424***	9.13	40	26%
$(\bar{P}_{-i} - \bar{P}^{e}_{-i})$	-0.477926***	-3.66		

Notes: $(\widehat{P_i - P^*}) = 8.14 - -0.4779 * (\bar{P}_{-i} - \bar{P}^{e}_{-i})$

*** Significance at the 1-percent level

This is in accordance with our previous presumptions. In addition, it suggests that players in the real treatment corrected their expectations more frequently. If expectation correction is approaching to zero, which is ideal case of adaptive player, then deviation from optimum is 8.14, (See Figure 5). However, only few players follow very closely ideal adaptive behaviour. In this case the channel of strategic complementarity under the real frame is substantially weaker, since subjects do not have any reason to believe that other subjects will behave in adaptive way, since no barrier related to converting of nominal values into the real ones is present. Thus, prevalence of rather weaker adaptive or even rational behaviour in this treatment implies that convergence to equilibrium is significantly faster, as was already demonstrated with help of ideal simulations.

Figure 5: Difference from Optimum on Expectations Correction, the Real Treatment



Conclusion

This article aimed to evaluate whether subjects tend to adaptive rather than rational behavior under uncertain environment of nominal treatment, where subjects have to overcome barrier of nominal pay-offs. Our initial hypothesis was confirmed via experiment based on n-player pricing game with monopolistic competition and strategic complementarity in vein of Fehr and Tyran (2001), where subjects cope with either nominal or real pay-offs. In order to provide appropriate grounds for experimental results gained, simulations were performed. Thus, results of our investigation are two-folded.

Firstly, simulations proved that individual behavior of both types of adaptive players in our experimental economy is associated with substantial backward-looking behavior, where only slow movement towards post-shock equilibrium is present. Additionally this adaptive behavior is associated with zero expectation correction and significant deviation from post-shock equilibrium at size of 11 on average. In contrast individual behavior of both types of rational players exhibits quick adjustment to equilibrium, where zero deviation in ideal case is present on average and substantial expectation correction is present after the shock at size of 12 on average. This is also reflected at aggregate level, where simulations suggest that even equal share of rational versus adaptive players in the economy is sufficient to converge smoothly to equilibrium. In contrast, simulated case of purely adaptive economy indicates slow convergence dependent on pre-shock average price of the economy.

Secondly, experimental results proved our initial hypothesis. In case of nominal treatment, subjects tend to behave rather in adaptive way, since the size of expectation correction is close to simulated case of adaptive player together with substantial deviation from equilibrium. On the other hand, subjects in the real treatment behave in less adaptive and even rational way, where the size of expectation correction is far away from the case of adaptive player and deviation from equilibrium substantially smaller, in line with previous simulations. Prevalence of adaptive players under the nominal treatment has also implications in terms of slower convergence to equilibrium at aggregate level, as opposed to the real treatment where more rational players are present. This is also in line with our previous simulations, where the nominal treatment is closer to the situation of adaptive economy, whereas the real treatment is closer to the situation of the economy mixed of rational versus adaptive players. Additionally it was proved that subjects in both treatments behaved consistently.

Results indicate that when subjects have to cope with uncertain nominal environment, they tend to switch to rule-guided (backward-looking) behavior of adaptive type, which is the best option in terms of costs minimization and as well in terms of strategic complementarity, where it is optimal to follow behavior of other players, although they behave in suboptimal way, since rewards may be maximized. In other words, it appears that rationality under uncertain environment of nominal values is more expensive, which has been revealed in comparison of the nominal versus real treatment and character of players prevailed. This is certainly reflected in the size of rewards gained by rational versus adaptive players, whose evaluation might be suggestion for future research.

References:

Bornstein, G., Kugler, T., Ziegelmeyer, A. Individual and Group Decisions in the Centipede Game: Are groups more "Rational" Players? Journal of Experimental Social Psychology, Vol. 40, Issue 5, pp. 599–605, 2004.

Fehr, E., Tyran, J. Does Money Illusion Matter? Institute for Empirical Research in Economics, University of Zurych, Working Paper *No.45*, ISSN 1424-0459, 2000.

Fehr E. and Tyran J.R., Does Money Illusion Matter? The American Economic Review, Vol. 91 No.5, pp.1239-1262, 2001.

Fehr, E., Tyran, J. Limited Rationality and Strategic Interaction: The Impact of the Strategic Environment on Nominal Inertia. Econometrica, Vol. 76, No. 2, pp. 353–394, 2008.

Haltiwanger, J. and Waldman, M. Limited Rationality and Strategic Complements: Implications for Macroeconomics, The Quarterly Journal of Economics, Vol.104, No.3, pp.463-483, 1989.

Hey, J.D. Expectations Formation: Rational or Adaptive or....? Journal of Economic Behavior and Organization, Vol.25, Issue 3, pp.329-349, 1994.

Van Huyck, J.B., Cook, J.P., Battalio, R.C. Adaptive behavior and coordination failure. Journal of Economic Behavior & Organization, Vol. 32, Issue 4, pp. 483–503, 1997.

Marimon, R., Sunder, S. Rational Expectations versus Adaptive Behavior in a Hyperinflationary World: Experimental Evidence, Discussion Paper No.247, Center for Economic Research, University of Minnesota, 1988.
Nagel, R., Grosskopf, B. Rational Reasoning or Adaptive Behaviour? Evidence from Two-Person Beauty Contest Games, Harvard NOM Research Paper 01-09, 2007.
Smith, V., What is Experimental Economics? Available from: http://time.dufe.edu.cn/wencong/smith/422.txt, 2002, 2003.
Terracol, A., Vaksmann, J. Dumbing Down Rational Players: Learning and Teaching in an Experimental Game. Journal of Economic Behavior & Organization 70, pp. 54–71, 2009.
Williams, A.W. The Formation of Price Forecasts in Experimental Markets, Journal of Money, Credit and Banking.Vol. 19, No. 1, pp. 1-18, 1987.