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Limited Rationality and Strategic Interaction

The Impact of the Strategic Environment on Nominal Inertia

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ABSTRACT: The evidence from many experiments suggests that people are heterogeneous with regard to their abilities to make rational, forward looking, decisions. This raises the question when the rational types are decisive for aggregate outcomes and when the boundedly rational types shape aggregate results. We examine this question in the context of a long-standing and important economic problem – the adjustment of nominal prices after an anticipated money shock. Our experiments show that when agents' actions are strategic substitutes adjustment to the new equilibrium is extremely quick whereas under strategic complementarity adjustment lasts very long and is associated with relatively large real effects. This adjustment difference occurs because price expectations are very flexible under substitutability and very sticky under complementarity. Our results suggest that strategic complementarity does not only provide incentives for the rational types to partly mimic the behavior of the boundedly rational types but it also renders people less rational and forward looking. In addition, under complementarity people attribute less rationality to the other players.

Keywords: Bounded rationality, strategic substitutes, strategic complements, nominal rigidity, sticky prices.

JEL: C92, E31, E52.

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I. Introduction

There is now a large body of evidence suggesting that, at the level of individual decision-making, a substantial fraction of the people violate the rationality assumptions routinely made in most economic models (Kahneman, Slovic and Tversky 1982; Camerer 1995; Kahneman and Tversky 2000; Camerer, forthcoming). However, this evidence does not imply that individual deviations from rationality necessarily falsify the aggregate predictions of rational choice models. In competitive experimental markets, for instance, in which agents trade standardized, non-risky, goods, prices and quantities typically converge quickly and reliably to the competitive equilibrium derived from individual rationality assumptions (Smith 1962 and 1982). Gode and Sunder (1993) have shown that even programmed players with "zero intelligence" quickly converge to the competitive equilibrium. Thus, there are conditions in which deviations from individual rationality have little effect on aggregate outcomes.

It would, however, be also a mistake to assume that the impact of bounded rationality is always removed by interactions in competitive markets. Theoretical work by Akerlof and Yellen (1985), Haltiwanger and Waldman (1985, 1989) and Russell and Thaler (1985) shows that there are plausible conditions under which even a small fraction of boundedly rational agents may have important effects on aggregate results. Moreover, empirical work by Camerer (1987) and Gneezy, Kapteyn and Potters (forthcoming) suggests that individual deviations from full rationality can have a significant impact on competitive market outcomes. In view of these results the key question, therefore, is to identify the conditions under which limited rationality matters and when it does not matter.

In this paper we tackle this question experimentally in the context of an important economic problem – the sluggish adjustment of nominal prices after a fully anticipated and exogenous monetary shock. For decades, macroeconomists have been interested in the microfoundations of nominal price stickiness because it is widely believed that nominal inertia is a main reason for the short-run non-neutrality of money. Much of the literature has emphasized informational (Lucas 1972, Mankiw and Reis 2002), contractual (Fischer 1977, Taylor 1979) and other (Mankiw 1985, Ball and Romer 1991) frictions as causes of nominal inertia. There is, however, still considerable disagreement about the extent and the sources of nominal price inertia (see, e. g., Blinder, Canetti, Lebow and Ruud 1998; Romer 2001). Since we explicitly examine the determinants of nominal price stickiness, our experiments do not only illuminate when limits to rationality matter but they also contribute to a deeper understanding of the sources of nominal inertia. We show, in particular, that – in the absence of any exogenous frictions or costs of price adjustment – the strategic environment is a decisive factor shaping the nature and the extent of nominal price stickiness.

Our experimental design is inspired by the theoretical work of Haltiwanger and Waldman (henceforth HW, 1989). They show that a given fraction of agents with non-rational, adaptive, expectations have more or less influence on the speed of adjustment towards equilibrium depending on the extent to which agents' actions are strategic complements. The model of HW suggests that when strategic substitutability prevails boundedly rational players have a smaller impact on the adjustment of prices after an anticipated money shock than when complementarity prevails.[1] As a consequence, one would expect nominal inertia to be smaller under substitutability. However, to our knowledge there is no empirical work examining how strategic substitutes and complements differentially affect the nature and the speed of price adjustment after a shock.[2] Therefore, we implemented a price setting experiment with a complements and a substitutes condition. In both conditions any exogenous frictions for nominal price adjustment were absent. This means that if all subjects have rational expectations about the other players' actions and play a best reply to their expectation, the money shock leads to complete instantaneous adjustment in both the complements and the substitutes treatment. We know, however, from previous work (Fehr and Tyran 2001) that a fraction of the subjects exhibits money illusion in price setting games like ours because they take nominal payoffs as a proxy for real payoffs. Fehr and Tyran (2001) show, in particular, that the indirect effects of money illusion arising from the impact of money illusion on expectations are important. It is, therefore, of particular interest to examine how the strategic environment affects the subjects' expectations about other subjects' behavior.

Our results show that the strategic environment plays indeed a decisive role. Under strategic substitutability adjustment towards equilibrium is extremely quick whereas under

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1 Price competition in oligopolistic goods markets is often characterized by strategic complementarity because if other firms cut prices individual firms often have an incentive to also cut their price. Cournot duopoly is a good example of strategic substitutability. The more firm *j* produces the less will firm *i* produce. In a macroeconomic context strategic complementarity plays a role if search frictions (Diamond 1982), informational frictions (Bryant 1983) or increasing returns (Weitzman 1982) are important. For a general account of the role of strategic complementarity in macroeconomic models see Cooper (1999).

2 There is an interesting literature (Nagel 1995; Ho, Camerer and Weigelt 1998) on the depth of reasoning in games. However, the focus of this literature is not on how strategic substitutes and complements differentially affect behavior but how many steps of iterated reasoning underlies subjects' behavior in games that can be solved by iterated elimination of strictly dominated strategies. The literature also does not deal with how money

complementarity there is long-lasting nominal inertia that is associated with large real effects. In fact, in the substitutes treatment we cannot reject the hypothesis that nominal prices are instantaneously in equilibrium after the shock while in the complements treatment the hypothesis of equilibrium play can be rejected for 8 periods. These results provide support for the predictions of the HW-model. The proposition that the distinction between complements and substitutes has important effects on the adjustment dynamics of a heterogeneous population is well borne out by the data.

However, our results also go in important ways beyond the factors identified by HW. According to the HW-approach a *given* distribution of players with adaptive and rational expectations causes different aggregate adjustment behavior depending on whether actions are strategic complements or substitutes. The key idea here is that, for given expectations, differences in the strategic environment cause different behaviors. Under complementarity the rational types have an incentive to partly mimic the adaptive types whereas under substitutability the rational types compensate the behavior of the adaptive types. If that were indeed the only source of behavioral differences across treatments it should be possible to explain the adjustment differences by assuming that the fraction of adaptive players is constant across treatments. Yet, this is not the case.

If we simulate the post-shock adjustment dynamics with varying assumptions about the fraction of adaptive players, the best fit with the actual average price under strategic substitutes is achieved if we assume that only 25 percent of the players have adaptive expectations. In the complements treatment, however, we need a much larger percentage of adaptive players to reproduce the actual adjustment path. This suggests that strategic substitutability renders the players more rational and more forward looking. This view is also supported by the fact that in the substitutes treatment much more subjects choose the exact equilibrium price already *in the first post-shock period*. Moreover, immediately after the shock, the players in the substitutes treatment expect most other players to choose prices that are exactly at, or close to, the post-shock equilibrium. In contrast, in the complements treatment the majority of the subjects expects prices that are close to the pre-shock level. We conclude that the strategic environment not only translates given non-rational expectations into different extents of nominal inertia, but the strategic environment also importantly affects expectations formation. In particular, we find that

shocks affect nominal inertia.

under complementarity expectations are very sticky while under substitutability they are very flexible.

The rest of the paper is organized as follows. In the next section we discuss our experimental design. In Section III we present our results and section IV summarizes and concludes the paper.

II. Experimental Design

This section provides a general description of the experimental design and explains experimental procedures and parameters.

A. General Description of the Experimental Design

To study how the strategic environment affects aggregate outcomes we designed a complements treatment (CT) and a substitutes treatment (ST). Both treatments were embedded in an n-player price setting game with a unique equilibrium. The game was divided in a pre- and a post-shock phase and at the beginning of the post-shock phase we implemented an exogenous and fully anticipated nominal shock. By comparing price adjustment after the shock across the CT and the ST we can study the impact of the strategic environment on adjustment dynamics.

At the beginning of this project we designed a price setting game with monopolistic competition. It turned out, however, that – for our purposes – this design has two major drawbacks. First, and most importantly, within the context of monopolistic competition it is not possible to move from strategic complementarity to strategic substitutability while keeping everything else constant. If one changes the slope of the reaction functions one changes in general also equilibrium prices, the real payoffs at equilibrium, the number of dominated strategies and the real payoffs in the neighborhood of best replies. Thus, in the context of monopolistic competition it is not possible to conduct a clean comparison between the impact of strategic complements and strategic substitutes. Second, the equilibrium under monopolistic competition is not efficient and this hinders the adjustment towards equilibrium. The existence of an inefficient equilibrium means that subjects can earn more money if they try to collude to prevent adjustment towards equilibrium. These efforts to collude introduce themselves some nominal inertia, which is then confounded with the amount of nominal inertia that stems from strategic complementarity or substitutability.[3]

We solved these problems with the following experimental design. First, we implemented a money neutral and efficient Nash equilibrium in both treatments. This rules out that collusion slows down adjustment towards equilibrium. Since the equilibrium is neutral with regard to the nominal shock variable (money supply) any real effects of the nominal shock must be associated with out-of-equilibrium behavior. Second, equilibrium prices and real equilibrium payoffs do not change across the CT and the ST. Third, real payoffs along the reaction functions are also the same across CT and ST. Fourth, within the range of feasible price choices, the number of strictly dominated strategies is identical across CT and ST. Finally, if a player deviated from best reply behavior the real income loss for a given deviation from the best reply is also identical across treatments. Thus, the players faced exactly the same incentives to play best replies in both treatments. Taken together this means that the only difference between the treatments concerned the slope of the reaction function. If, at a given price vector in the CT, the slope was $z > 0$, then the slope in the ST was given by $-z < 0$ at that price vector.

In each experimental session we formed several groups of n players who played the pricing game for $T = 30$ periods. The group composition remained unchanged throughout the session. During the first $T/2$ periods of a session the money supply was given by M_0. Then we implemented a fully anticipated monetary shock by reducing the money supply to M_1 (see Table 1 for a complete list of parameters). This shock and the fact that the post-shock phase lasted again 15 periods was common knowledge. We were mainly interested in comparing subjects' pricing behavior across treatments in the post-shock phase. The pre-shock phase served the purpose of making subjects acquainted with the computer terminal and the decision environment. In addition, the pre-shock phase allowed subjects to reach an equilibrium in that phase. This is important as we wanted to study how the strategic environment affects adjustment

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[3] This question can also be viewed as a problem of unobservable strategic complementarity. It is well known that in the presence of cooperation opportunities many subjects exhibit preferences for conditional cooperation (see, e. g. Fehr and Fischbacher 2002). They are willing to cooperate if others cooperate as well. Since we cannot directly observe subjects' preferences this introduces *unobservable* strategic complementarity, i.e. we lose control over the precise amount of complementarity. We conducted pilot experiments with monopolistic competition, which confirmed these problems. After the nominal shock, subjects tried hard to reap the gains from collusion, which strongly retarded adjustment towards equilibrium. Note that this means that strategic complementarity is not necessarily a feature of the objectively given technology of interaction. Subjective preferences may also be an important source of strategic complementarity that adds to nominal inertia. Yet, since we wanted to have full control over the extent of strategic complementarity we ruled out that preferences for conditional cooperation can play a role in our experiments.

to a purely nominal shock after subjects had already reached the money neutral equilibrium. This ensures that the adjustment requirements are the same across treatments.

The real payoff of subject i was given by

(1) $$v_i = v_i(P_i, \overline{P}_{-i}, M),$$

where P_i denotes i's nominal price, $\overline{P}_{-i}$ represents the average price of the other n-1 group members while M denotes a common nominal shift variable (money supply).

The real payoff function $v_i(.)$ is homogenous of degree zero in $P_i, \overline{P}_{-i}$, and M. Since we implemented a unique equilibrium homogeneity of degree zero ensured that the equilibrium was neutral in money.[4] Note also that, for a given money supply, the optimal choice of P_i depends only on the average price of the other players and not on the other players' individual prices. This means that subjects need not form expectations about other players' individual prices but only about the average price $\overline{P}_{-i}$. In addition, this payoff function has the advantage that, for a given money supply, we can represent the subjects' payoffs in a matrix that informs subjects about their payoff at any feasible ($P_i, \overline{P}_{-i}$)-combination.

B. Experimental Procedures and Parameters

All major experimental parameters and design features are summarized in Appendix A and Table 1. The experimental instructions for the subjects are presented in Appendix B. The experiment was conducted in a computerized laboratory with groups of size n = 4.[5] In each group there were two types of subjects: Subjects of type x and subjects of type y. The two types have slightly different payoff functions. The difference implies that the best reply of the x-types involved slightly lower prices than the best reply of the y-types. Since heterogeneity is a fact of life, the case of four different payoff functions would be the most realistic but also the most complicated one. Therefore we chose an intermediate solution with only two types of players. In total 76 subjects participated in our experiment. Each subject participated either in the CT or in the ST. In the pre-shock phase of each treatment the money supply was given by M_0 = 42 while

4 To see that homogeneity of degree zero implies neutrality note that a change in M from M_0 to $\lambda M_0 = M_1$ leaves real payoffs unaffected if prices change to λP_i and $\lambda \overline{P}_{-i}$. Moreover, if P_i, i = 1, 2, ..., n, is a best reply to $\overline{P}_{-i}$ at M_0, λP_i also is a best reply to $\lambda \overline{P}_{-i}$ at λM_0. Thus, if P_i^* for all i is a pre-shock equilibrium, then λP_i^* for all i is the post-shock equilibrium.

5 We used the experimental software Z-Tree developed by Fischbacher (1999).

in the post shock phase it was given by $M_1 = M_0/2 = 21$. In the pre-shock equilibrium the average price over all *n* group members was given by $\overline{P}_0^* = 25$, while the post-shock equilibrium price was $\overline{P}_1^* = 12.5$.

* Insert *Table 1* about here *

The subjects had to choose a nominal price $P_i \in \{1,2,3,\ldots,30\}$ in each decision period. In addition, they had to provide an expectation about $\overline{P}_{-i}$ which we denote by $\overline{P}_{-i}^e$. At the end of each period each subject was informed about the actual realization of $\overline{P}_{-i}$ and the actual real payoff v_i on a so-called outcome-screen (see Appendix B). In addition, the outcome screen provided information about the subject's past choices of P_i, past realizations of $\overline{P}_{-i}$ and past real payoffs v_i.

Subjects received the payoff information in the form of a matrix. In Appendix C and D we provide the post-shock payoff matrices for the *x*- and *y*-types for both treatment conditions. Appendix C shows the *real* payoffs for any feasible $(P_i, \overline{P}_{-i})$-combination whereas Appendix D shows the *nominal* payoffs. We know from previous work (Fehr and Tyran 2001) that a fraction of the subjects exhibits money illusion if they face nominal payoff tables in a pricing game like ours because they use nominal payoffs as a proxy for real payoffs. Therefore, we gave the subjects only the nominal payoff tables. This is crucial for our purposes because we were interested in how the strategic environment affects behavior when some subjects are not fully rational. In the nominal payoff tables the matrix showed the nominal payoff $V_i = \overline{P}_{-i} v_i$ for each feasible $(P_i, \overline{P}_{-i})$-combination. To compute the real payoff for a particular $(P_i, \overline{P}_{-i})$ combination a subject had to divide $V_i = \overline{P}_{-i} v_i$ by $\overline{P}_{-i}$. This was described at some length in the instructions (see Appendix B). The real payoff tables in Appendix C of our paper only serve the purpose of making it immediately transparent for the reader that, except for the slope of the best reply functions, the real payoff structure was kept constant across treatments. To render the difference across treatments transparent we have also shaded the best reply functions in Appendix C. Subjects did, of course, not receive nominal payoff tables with shaded best replies. To inform subjects about the payoffs of the other type, each subject also received the payoff matrix of the other type. This information was common knowledge.

At the end of period 15 the nominal shock was implemented in the following way: Subjects were publicly informed that *x*- and *y*-types receive new payoff tables. These tables were based on $M_1 = M_0/2$. Again, each subject received his or her own payoff table and the table of the other type. Subjects were told that, except for payoff tables everything else including group composition remained unchanged. They were given enough time to study the new payoff tables and to choose P_i for period 16.[6] This procedure ensures that in period 16 subjects face an *exogenous*, *fully anticipated* and *negative* nominal shock: It is exogenous because subjects' behavior does not affect the timing or the content of the new payoff tables. It is fully anticipated because the new tables were distributed before subjects had to decide and because the distribution of new tables was common knowledge. At the beginning of period 16 it was common knowledge that the experiment will last for further 15 periods.

Note that there are *no exogenous frictions* present in this design: There are no nominal frictions, since nominal prices can be changed from period to period at no cost. There are no informational frictions, since subjects are given all information about the shock.

III. Results

In total we had 10 groups in the CT and 9 groups in the ST. The experiments took place at the University of Zürich and subjects were undergraduate students from different disciplines. They were paid a show up fee of roughly $7 (CHF 10) and their earnings from the experiment were on average $24 (CHF 34). An experimental session lasted, on average, 80 minutes.

A. Adjustment of Prices

To what extent do different strategic environments affect the adjustment of prices towards the post-shock equilibrium? A first impression is provided by Figure 1, which plots the evolution of pre- and post-shock average prices across treatments. The figure indicates that in the pre-shock phase nominal prices are quickly close to the average equilibrium price, which is given by $\overline{P}_0^* =$

6 Subjects were given ten minutes in total from distributing the new tables until they had to decide. During the first 7 minutes, subjects could not enter any decision into the computer. Within the remaining 3 minutes, the average subject decided after 38 seconds in the CT and 39 seconds in the ST. Only very few subjects used up the available time entirely (two subjects in the CT and none in the ST took their decision less than 10 seconds before the available time had elapsed). Thus, if we observe disequilibrium play this cannot be due to time constraints.

25.[7] Except for period 1 and 2 the hypothesis that pre-shock prices in the ST and the CT are in equilibrium can never be rejected. The situation changes, however, dramatically after the nominal shock. In the first post-shock period average prices in the CT are far above the equilibrium whereas in the ST prices even overshoot somewhat relative to the equilibrium. Moreover, according to Figure 1, it takes a large number of periods until nominal prices in the CT have fully adjusted. Only in period 27, twelve periods after the shock, CT-prices seem to be fully back to equilibrium. This contrasts sharply with the price dynamics in the ST, where full adjustment already seems to be achieved in the second period after the shock.

* Insert *Figure* 1 about here *

To examine the deviations from equilibrium more rigorously we have conducted the following regression for the post-shock phase:

$$\overline{P}_{jt} - \overline{P}_1^* = \sum_{t=1}^{14} \alpha_t d_t + \sum_{t=1}^{15} \beta_t (1 - d_t) \qquad (2)$$

where $\overline{P}_{jt}$ denotes the average price of group j in period t, $\overline{P}_1^*$ represents the average equilibrium price after the shock, and $d_t = 1$ if the price observation in period t comes from the CT.[8] The coefficients α_t measure the deviation from equilibrium in the CT whereas the coefficients β_t measure the deviation in the ST. We have summarized the results of regression (2) in Table 2. The absolute size of the coefficients in Table 2 inform us about how much average group prices deviate from equilibrium. This indicates that in period 16 the average price in the CT is 6.6 above equilibrium while in the ST it is 1.17 below equilibrium. In fact, as the significance tests indicated in Table 2 show, we can never reject the hypothesis that group average prices in the ST are in equilibrium. For the CT, however, the hypothesis of equilibrium play can be rejected for the first eight post-shock periods at the 1 percent level. Thus, Figure 1 and Table 2 leave little doubt that the strategic environment has decisive effects on adjustment dynamics.

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7 The reason for the quick adjustment in the pre-shock phase is that both in the CT and the ST there is a large number of strictly dominated strategies. Note that this is an inevitable consequence of the higher money supply in the pre-shock phase. A change in the nominal price in the post-shock phase (i.e., at $M_0/2$) by one unit has the same real effects as a change in the nominal price by two units in the pre-shock phase (i.e., at M_0). Thus, if a nominal price is strictly dominated in the post-shock phase, there will, in general, be two nominal prices that are strictly dominated in the pre-shock phase.

8 To prevent linear dependence among the regressors we included no dummy variable for period 15 of the CT.

* Insert *Table* 2 about here *

So far we have only looked at average prices. However, equilibrium also requires that individual actions coincide with equilibrium prices. For this purpose we have constructed Table 3 and Figures 2a and 2b. The figures graph the distribution of prices in the first post-shock period across treatments for the *x*-types (Figure 2a) and the *y*-types (Figure 2b). Recall that the equilibrium price for *x*-types (*y*-types) in the post-shock phase is $P_i^* = 11$ ($P_i^* = 14$). In the ST a remarkably high percentage of the *x*-types (72 percent) jump directly to the new equilibrium and 17 percent are just one unit above the equilibrium. In contrast, in the CT the majority of the *x*-subjects (50 percent) choose a price far above the equilibrium (i.e., $P_i = 21$) and only 25 percent jump directly to the new equilibrium. For the *y*-types the picture is qualitatively similar: 61 percent of the subjects in the ST jump directly to the new equilibrium and 28 percent are only one unit above or below the equilibrium, whereas in the CT only 20 percent of the *y*-types play the equilibrium and the rest chooses prices far above the equilibrium.

Table 3 shows that these differences in individual play across treatments last for a long time. This can be illustrated by comparing period 18 in the ST with periods 28-30 in the CT. In $t = 18$ already 92 percent of the subjects in the ST choose exactly the equilibrium price. A similar incidence of exact equilibrium play only occurs in the final three periods of the CT. Taken together these results indicate that equilibrium adjustment is breathtakingly quick in the ST whereas it is extremely slow in the CT. This provides support for the view that bounded rationality has very different effects depending on the strategic environment in which subjects interact.

* Insert *Figures* 2a and 2b about here *

* Insert *Table* 3 about here *

B. Best Reply Behavior and Price Expectations

One reason for the different adjustment patterns could be that there are differences in best reply behavior across treatments. Since we asked subjects for their expectations regarding the average price of the other players we are able to compute the best reply for each subject in each period and compare it with the actual price choice.[9] We have done this for the different price intervals depicted in Figures 3a and 3b. These figures compare the average best reply, in each interval for which we observe price expectations, with the actually chosen average price in response to these expectations. The numbers above the bars indicate the relative frequency of price expectations in the different price intervals.

* Insert *Figures* 3a and 3b about here *

Figure 3a shows that in the CT the average best reply for each given expectations interval almost exactly coincides with the average price that was chosen in the respective interval. Thus, the slow adjustment in the CT cannot be attributed to deviations from best reply behavior. Likewise, in the ST the average best replies are very close to the actual average prices in the different intervals.[10] From this we can conclude that the differences in adjustment dynamics across treatments cannot be due to differences in best reply behavior.

If subjects play most of the time a best reply to the expected average price of others then the differences in actual price choices across treatments are likely to be generated by differences in expectations. To examine the role of price expectations we plotted the average expectations in both treatments in Figure 4. The figure indicates that the average expectations are in equilibrium in the ST and the CT before the shock. After the shock average expectations remain very sticky in the CT but jump almost completely to the new equilibrium expectations in the ST. From period 17 onwards, average expectations are in equilibrium in the ST whereas in the CT out-of-equilibrium expectations prevail till period 27. To examine this issue more rigorously we have conducted regressions analogously to equation (2). The only difference is that instead of the

9 If a subject does not exactly know the true value of $\overline{P}_{-i}$ the computation of the best reply requires that the whole subjective distribution over $\overline{P}_{-i}$ is taken into account. However, for simplicity, in the following we use the term "best reply" in the sense of a best reply to the expectation of $\overline{P}_{-i}$.

10 The only exception is the interval between 4 and 6. Note, however, that only one percent of the price expectations are in this interval so that the deviation between actual price and best reply is probably due to the small number of observations. Note also that in both treatments more than 80 percent of the post-shock choices represent exact best replies and the rest of the choices is typically close to the exact best reply.

actual deviation of group prices from the equilibrium we take the deviation of the groups' price expectations from the equilibrium expectation as the dependent variable. The results of this regression are displayed in Table 4. The table shows that in period 16 the average expectation in the CT is 8.0 units above the equilibrium while in the ST it is only 0.9 units above equilibrium. Moreover, in the CT we can reject the hypothesis that subjects have equilibrium expectations (at the five percent level) for eight periods and at the ten percent level ($p = 0.056$) for the ninth post-shock period, too. In the ST the hypothesis that expectations are in equilibrium can never be rejected at the ten percent level.

* Insert *Figure* 4 about here *

* Insert *Table* 4 about here *

These results suggest that the key mechanism that generates the different adjustment behaviors is the differential stickiness of price expectations. Whereas strategic substitutability causes very flexible expectations that instantaneously are close to the equilibrium, strategic complementarity is associated with very sticky expectations. The players then play best replies to their expectations so that the flexible expectations translate into flexible prices in the ST while sticky expectations translate into sticky prices in the CT.

C. Real Effects during Adjustment towards Equilibrium

One important question in macroeconomics is whether anticipated monetary shocks are associated with real effects. To the extent to which adjustment towards equilibrium is slow, anticipated money shocks will cause real effects. Therefore one can expect that the negative monetary shock causes larger reductions in the players' joint payoffs under complementarity than under substitutability. To check this we have computed for every group j and every period t how much the real average payoff of the group, v_j, falls short of the real average payoff in equilibrium v^*. Based on this computation we measure the efficiency loss of group j in period t by $\varepsilon_{jt} = (v_{jt} - v^*) / v^*$, i.e., as a percentage of the equilibrium payoff. In Figure 5 we present the evolution of the average value of ε_{jt} across treatments during the post-shock phase.

* Insert Figure 5 about here *

If one interprets this figure one has to remember that we deliberately implemented payoff functions that imply relatively large payoff reductions in case that a subject does not play a best reply to the *actual* average price of the other players. This means that subjects have strong incentives to predict the average price of the others correctly because otherwise they cannot play a best reply. It is an inevitable consequence of this payoff structure that large payoff reductions are associated with out-of-equilibrium play. When interpreting Figure 5 we do, therefore, not put too much emphasis on the absolute value of ε_{jt}. What is more important is the difference in the average value of ε_{jt} across treatments.

The figure reveals that throughout the whole post-shock phase the payoff losses due to non-equilibrium play are much larger in the CT than in the ST. Whereas in the ST sizeable payoff losses only occur in the first two post-shock periods, in the CT large losses occur until period 27. This indicates that the different adjustment dynamics associated with strategic complements and substitutes give rise to considerably larger real effects in the complements condition.

D. How does the Strategic Environment affect Behavior?

In our view the outstanding feature of the post-shock adjustment of prices and expectations is how quickly equilibrium is reached in the ST relative to the CT. According to the approach taken by HW (1989) these large adjustment differences can be explained by the interaction between a *given* distribution of rational and adaptive players and the strategic environment. What is important here is that, in this approach, the rational players are also assumed to correctly anticipate the fraction and the behavior of the adaptive players.

To illustrate how a given mix of rational and adaptive players affects the adjustment towards equilibrium in different strategic environment we have constructed Figures 6a and 6b. Both figures show simulations of adjustment behavior under different assumptions about the fraction of fully adaptive and rational agents. In addition, both figures also depict the actual price adjustment in our treatments. In Figure 6a, for instance, the graph associated with (2*x*,2*y*) is based on the assumption that, in the ST, both *x*-types and both *y*-types in the group exhibit fully adaptive expectations. Adaptations are fully adaptive if a player believes that last period's average price of the other players is also this period's average price. The graph shows that in this case we should observe a cyclical adjustment behavior with large amplitudes and full adjustment would only be reached in period 27. The graph associated with (2*x*,1*y*) assumes that both *x*-players but only one of the *y*-players has fully adaptive expectations whereas the other *y*-player correctly anticipates the behavior of the three adaptive players. In this case adjustment is also cyclical but with much smaller amplitudes and full adjustment is already reached in period 18. If only one of the *x*-players has adaptive expectations, and the others in the group are rational, then equilibrium in the ST is reached already in period 17 (see 1*x*-graph in Figure 6a). Figure 6b is constructed analogously. A comparison of the two figures shows that if all players are fully adaptive, in both treatments complete adjustment is only achieved in period 27. However, whereas in the ST adjustment is cyclical, in the CT the players gradually converge to the equilibrium from above. The big differences in adjustment speed across treatments occur when there are some rational players in the population because they partly mimic the actions of the adaptive players in the CT whereas in the ST they counteract the actions of the adaptive players. For instance, if one of the *x*-types is a rational player (see the (2*x*,1*y*)-graphs), equilibrium in the ST is reached in period 18 whereas in the CT adjustment is completed only in period 26. Thus, if one or more (but not all) players are rational the strategic environment has a large impact on adjustment speed.[11]

* Insert *Figures* 6a and 6b about here*

Figures 6a and 6b provide, however, also a first indication that the impact of the strategic environment may go beyond the factors discussed by HW (1989). In the ST a very good fit with the actual average price path is achieved if one assumes that only one player is adaptive (see 1*x*-graph in Figure 6a). In the CT this assumption implies that complete adjustment is already achieved in period 19 whereas in fact this occurs only in period 27. In the CT the best fit with the actual average price path is achieved if we take the actually observed prices of period 16 as our initial values and assume thereafter that all players in the group have fully adaptive

[11] Our results regarding adjustment speed vary a bit depending on whether we assume that *x*- or *y*-players are rational. The quantitative differences are, however, very small. In Figure 6a, for instance, the graph for the case where only the *x*-player is fully adaptive is almost identical to the case where only the *y*-player is fully adaptive (this case is not shown in the graph).

expectations. This simulation is shown in the graph (2*x*,2*y*, t = 16 actual) of Figure 6b.[12] Thus, it seems difficult to explain the actual average price path on the basis of the assumption that there is the same mix of rational and adaptive players across treatments. This suggests that the strategic environment does more than just translate a given mix of expectation formation rules into different aggregate behaviors. Perhaps it also changes the players' expectation formation rules.

To explore this issue further we examined the distribution of individual price expectations in the *first* post-shock period in more detail (see Figures 7a and 7b). We concentrate on the first post-shock period for two reasons. First, in both treatments subjects played (very close to) the equilibrium for the last 10 pre-shock periods. This means that fully adaptive expectations, which rely only on the previous period's price, and more backward looking adaptive expectations, which take into account the prices of several past periods, lead virtually to the same expectation in the first post-shock period. Therefore, details in the nature of adaptive expectations do not matter for the expectations of the players in the first post-shock period. Second, in t = 16 the expectations of the adaptive players are not yet affected by the responses of the rational players to the shock. In t > 16 the adaptive players' expectations are affected by how the strategic environment shaped the responses of the rational players in t = 16. Thus, the observations in t = 16 are particularly useful for discussing whether the strategic environment *directly* changes expectation formation across treatments.

One important feature of Figures 7a and 7b is that equilibrium expectations are much more prevalent in the ST. Recall that the equilibrium expectation is given by $\bar{P}_{-i}^{e}$ = 13 for the *x*-players and by $\bar{P}_{-i}^{e}$ = 12 for the *y*-players. In the ST 44.5, percent of the players exhibit exact equilibrium expectations; in the CT only 20 percent of the subjects have equilibrium expectations. Moreover, in the ST, 78 percent of the *x*-players and 88 percent of the *y*-players have expectations that are within two price units of the equilibrium expectation whereas in the CT we have only 25 and 20 percent, respectively. This indicates that the players attribute more rationality to the other players in the ST.

12 All the other simulations in Figure 6b do not capture the features of the actual average price path. This is due to the fact that 23 percent of the players in the CT directly jump to the equilibrium in period 16. However, this jump was based on wrong expectations about the behavior of the other players so that thereafter the players' expectations are very sticky. This explains why after t = 16 the best simulation is based on the assumption that all players have fully adaptive expectations.

* Insert *Figures* 7a and 7b about here*

The view that the strategic environment does more than just translating given expectation formation rules into different behaviors is further supported if we look at the stickiness of the expectations across treatments. Recall from Table 1 that, independently of the treatment condition, an adaptive *x*-player (*y*-player) expects $\overline{P}_{-i}$ to be equal to 26 (24) in period 16. In the CT, 45 percent of the *x*-players and 60 percent of the *y*-players have price expectations that are within 2 units of adaptive expectations. In contrast, in the ST only 6 percent of the *x*-players and zero percent of the *y*-players have such sticky price expectations. Thus, in the first post-shock period the frequency of adaptive expectations is much larger in the CT.

Our data also suggest that subjects' price expectations in the ST are more rational than in the CT. In the first post-shock period only 7.5 percent of the subjects in the CT but 25 percent in the ST predict the average price of the other players correctly. 15 percent of the subjects in the CT deviate at most by one unit from the correct prediction whereas in the ST the corresponding percentage is 42 percent. Thus, in the ST subjects do in fact make more accurate predictions about the other players' behavior.

Taken together, the evidence thus suggests that the strategic environment exerts an impact on behavior that goes beyond the factors predicted by the model of Haltiwanger and Waldman. It seems that strategic complementarity induces the players to be more backward looking and less rational. In addition, under complementarity the players attribute less rationality to the other players. We would like to stress, however, that these results do not invalidate the important insights following from the HW-approach but they complement this approach by showing that the strategic environment has an even stronger impact than suggested by HW.

Our results raise the question why people are less forward looking and rational in the CT. Our conjecture is that this might occur because in the ST the pre- and the post-shock best replies for agents with adaptive expectations are radically different whereas in the CT they are relatively close together. To see this in more detail recall that in the final pre-shock period the equilibrium price for agents of type *x* is P_i = 24 and the equilibrium expectation is given by $\overline{P}^e_{-i}$ = 26. Almost all *x*-players indeed chose the equilibrium price and had equilibrium expectations towards the end of the pre-shock phase. Suppose that an *x*-player has adaptive expectations and chooses a best reply to this expectation, that is, he expects the pre-shock equilibrium value of

$\overline{P}_{-i}$ = 26 in the first post-shock period and chooses P_i = 21 in the CT and P_i = 1 in the ST. This means that if the other players also exhibit adaptive expectations, and hence choose similar prices as our *x*-player, the expectation error in the ST is much larger than in the CT. Therefore, the expectation error that arises from adaptive expectations becomes much more transparent in the ST than in the CT which may induce the players in the ST to be more forward looking. In a sense the ST "tells" me that if the other players do the same as I do, my expectation is completely wrong whereas in the CT my expectation is still roughly in line with what will happen. If this argument is correct we should observe that the players in the ST are less likely to exhibit adaptive expectations, which is indeed the case.

IV. Summary

There is now a lot of evidence indicating that a fraction of the people is not fully rational but in strategic interactions aggregate outcomes are more than just the summation of individual behaviors. Therefore, it is, in principle, possible that a large fraction of boundedly rational agents nevertheless will end up in a situation that is predicted by rational choice models. Yet, it is also possible that a small fraction of boundedly rational agents has a large effect on the behavior of the rational agents so that aggregate behavior is driven away from the rational prediction. In view of this it is important to know when bounded rationality matters and when it does not affect aggregate outcomes. We examined this question in the context of an important economic problem – the adjustment of nominal prices after a fully anticipated negative money shock.

In our experiments the adjustment of nominal prices is instantaneous, and real effects of the money shock are absent, if all players have rational expectations and play a best reply to their expectation. This holds regardless of whether subjects' actions are strategic complements or strategic substitutes. In fact, however, the strategic environment has a decisive impact on the nature and the speed of the adjustment process. When strategic complementarity prevails adjustment to the new equilibrium is very slow and associated with large effects on subjects' real income. Under strategic substitutability adjustment is extremely quick and subjects even overshoot slightly relative to the new equilibrium. The evidence indicates that differences in the stickiness of price expectations are the key for understanding these results. If actions are complements expectations are very sticky while if actions are substitutes expectations are very flexible. Since the players choose almost always a best reply to their expectations the differences in the inertia of price expectations translates into differences in actual price adjustment.

The data suggest that the complementarity condition does not only provide incentives for the rational types to (partly) mimic the behavior of the adaptive players but it renders the subjects less forward looking and rational. In addition, the data also indicate that subjects attribute less rationality to the other players. We conjecture that some of these effects are triggered by the fact that in the complementarity condition the irrationality of adaptive expectations is less transparent. It remains a task for future work to examine whether this conjecture is valid.

In view of the relevance of strategic complementarity for nominal inertia it is important to know to what extent it prevails in the field. There is work by Oh and Waldman (1990) and by Cooper and Haltiwanger (1993, 1996) suggesting the empirical relevance of strategic complementarity. The evidence of Blinder, Canetti, Lebow and Rudd (1998) on coordination failure as a source of nominal inertia also supports the view that strategic complementarity is important in the field. If real economies are indeed characterized by strategic complementarity then two conclusions follow from our results. First, if one neglects the existence of boundedly rational agents there is a high risk of making wrong predictions even if one is only interested in aggregate predictions. Second, theoretical analysis should not be limited to the analysis of equilibrium behavior but disequilibrium processes should be more seriously taken into account.

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Appendix A - Functional Specification of Payoffs

The real payoff function for all *i* is:

$$v = 1 + \frac{38}{1 + (P_i / M - \text{Reaction function})^2}$$

Table A1: Reaction functions

Average price of other firms is in the range	Reaction function for **Strategic Complements**	Reaction function for **Strategic Substitutes**
$\frac{\bar{P}_{-i}}{M} \le \frac{\bar{P}^*_{-i}}{M} - \frac{P^*_i}{M}$	$\frac{\Delta}{M}$	$\frac{2P^*}{M} - \frac{\Delta}{M}$
$\frac{\bar{P}^*_{-i}}{M} - \frac{P^*_i}{M} \le \frac{\bar{P}_{-i}}{M} \le \frac{\bar{P}^*_{-i}}{M} - \frac{\Delta}{M}$	$\frac{A}{M} + \frac{\bar{P}_{-i}}{M}$	$\frac{A}{M} - \frac{\bar{P}_{-i}}{M}$
$\frac{\bar{P}^*_{-i}}{M} - \frac{\Delta}{M} \le \frac{\bar{P}_{-i}}{M} \le \frac{\bar{P}^*_{-i}}{M} + \frac{\Delta}{M}$	$\frac{P^*_i}{M}$	$\frac{P^*_i}{M}$
$\frac{\bar{P}^*_{-i}}{M} + \frac{\Delta}{M} \le \frac{\bar{P}_{-i}}{M} \le \frac{\bar{P}^*_{-i}}{M} + \frac{P^*_i}{M}$	$\frac{A}{M} + \frac{\bar{P}_{-i}}{M} - \frac{2\Delta}{M}$	$\frac{A}{M} - \frac{\bar{P}_{-i}}{M} + \frac{2\Delta}{M}$
$\frac{\bar{P}^*_{-i}}{M} + \frac{P^*_i}{M} \le \frac{\bar{P}_{-i}}{M}$	$\frac{2P^*_i}{M} - \frac{\Delta}{M}$	$\frac{\Delta}{M}$
where	A = -1 if type *x* A = 3 if type *y* Δ = 1 for both types	A = 23 if type *x* A = 25 if type *y* Δ = 1 for both types

P^*_i is the equilibrium price for player *i*, $\bar{P}^*_{-i}$ is the average price of the other players in equilibrium. *M* is the nominal shift variable. For the numerical values of the parameters please refer to *Table 1*.

Appendix B Instructions

The original instructions were in German. This appendix contains a translation of the instructions used in the complements treatment (CT) for agents of type *y*.

General instructions for participants

You are participating in a scientific experiment, which is funded by the Swiss National Science Foundation. The purpose of this experiment is to analyze decision making in experimental markets. If you read instructions carefully and take appropriate decisions, you may earn a considerable amount of money. At the end of the experiment all the money you earned will be immediately paid out in cash.

Each participant is paid CHF 15.- for showing up. During the experiment your income will not be calculated in Swiss Francs but in points. The total amount of points you collected during the experiment will be converted into Swiss Francs, by applying the following exchange rate: **10 Points = 15 centimes.**

Here is a brief description of the experiment. A more detailed description is given below. All participants are in the role of firms, selling some product. In this experiment, there are two types of firms: firms of type *x* and firms of type *y*. Each firm has to choose a selling price in every period. The income you earn depends on the price you choose and on the prices all other firms choose.

During the experiment you are **not allowed to communicate with any other participant. If you have any questions, the experimenters will be glad to answer them.** If you do not follow these instructions you will be excluded from the experiment and deprived of all payments.

The following pages describe the procedures of the experiment in detail.

Detailed information for firms of type *y*

This experiment lasts 15 periods plus one trial period. You are not paid for the trial period. You should nevertheless take the trial period seriously since you may gain experience in this period. This experience helps you to take decisions in the other periods which are paid. You are in the role of a firm, just as all other participants in this experiment. All participants are in **groups of 4**, i.e. every participant is in a group with three other firms. There are two firms of type *x* and two firms of type *y* in every group.

You are a firm of type *y*

Consequently, there are two other firms of type *x* and one more firm of type *y* in your group. No participant knows which persons are in his or her group. Yet, everybody knows that the group composition remains constant throughout the experiment. The decisions taken by other groups are irrelevant for your group.

In every period all firms simultaneously decide which selling price they set for the current period. Every firm has to choose an integer price from the interval $1 \leq$ selling price ≤ 30.

How much you earn depends on the price you choose and on the average price of all other firms in your group. Independent of the type, the average price for every firm is calculated by the following formula:

Average price = (Sum of selling prices of the <u>other</u> 3 firms) / 3

Consequently, the average price will be in the interval 1 ≤ selling price ≤ 30.
The average price is rounded to the closest integer.

How to read the income table for a firm of type *y*

The **green** income table shows your *nominal* income in points if you choose a specific price and a specific average price results in this period (see separate table). Your income at the end of the experiment is not based on nominal income in points, but on *real* income in points. The following relation between the two holds:

Real income = Nominal income / Average price of other firms

This formula holds for all firms. The real point income that will be paid out is rounded in every period to the closest integer.

Example: Suppose, you choose a price of 2 and the actual average price is 4. In this case your nominal point income is 13 points. Your (rounded) real income is 3 points (= 13 / 4).

When you decide which price to choose, you do not yet know which average price will actually result in this period. The green income table can consequently help you to calculate your real point income given your **expectation** on the average price of other firms.

Example: Given an expectation about the average price you can read off the green table the payoff you get when choosing different selling prices. For example, if you expect an average price of 27 and choose a price of 17, your expected nominal income is 55 points, your expected real income is 2 points (= 55/27). If you choose a price of 26 at this expected price, your expected nominal income is 343 points and your expected real income is 13 points (= 343/27).

Please note that you are in a group with one firm of type *y* and two firms of type *x*. To determine the income of the other firm of type *y*, you have to use the green table. To determine the income of the other two firms of type *x*, you have to use the blue income table. This table also shows nominal income in points. The same formula above is used to calculate real payoffs for firms of type *x*.

What the screens show

On both screens described below the current period is indicated in the upper left corner, and the upper right corner displays remaining time in seconds to decide or to view the screen.

The upper half of the **input screen** (see figure on next page) has three cells, where you can enter your decisions into the computer.

Price decision: Enter an integer number between 1 and 30 into the first cell. You can activate this cell (as well as the other cells) by clicking into the cell with your mouse. If you want to revise your decision, you can erase the number by hitting the backspace key.

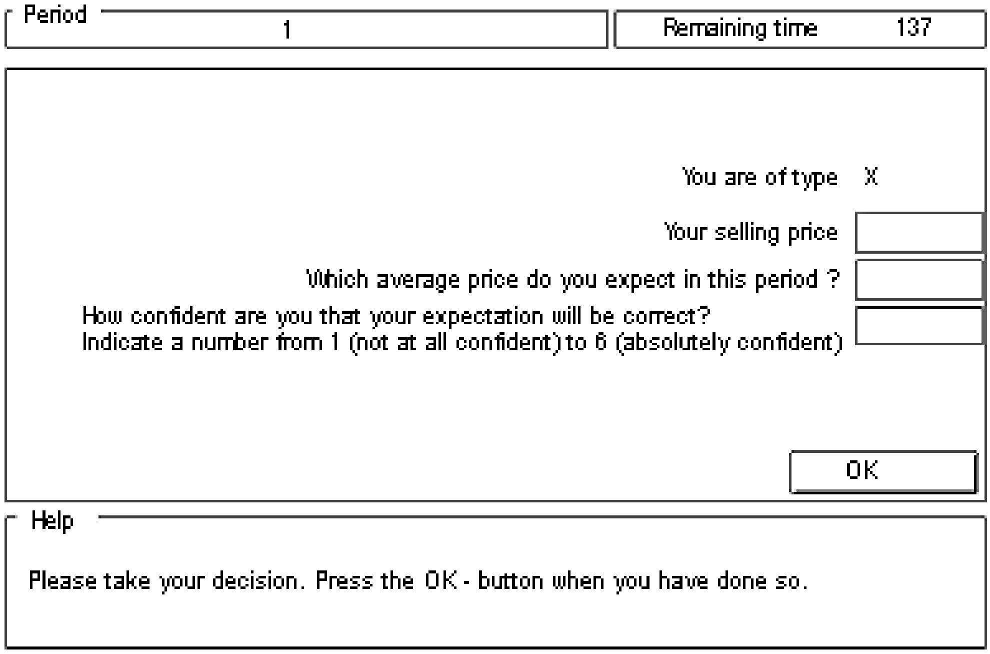
Expected average price: Enter an integer number between 1 and 30 into the second cell. This input does not affect your income and will not be known to other firms. Your payoff will be determined by the actual average price of this period. Please try to indicate an expectation that is as exact as possible since this is going to help you to take your own price decision.

Confidence: Enter an integer number from 1 to 6 to indicate how confident you are that the average price you expect (= number in the second cell) will actually result.

The numbers stand for:
1 = I am not at all confident that my expectation will be correct
2 = I am not very confident that my expectation will be correct
3 = I am not quite confident that my expectation will be correct
4 = I am quite confident that my expectation will be correct
5 = I am very confident that my expectation will be correct
6 = I am absolutely confident that my expectation will be correct

When you finished entering the numbers into the respective cells, press the **OK-button**. Once you have pressed the button, you can no longer revise your decision for this period.

Figure B1: Input screen

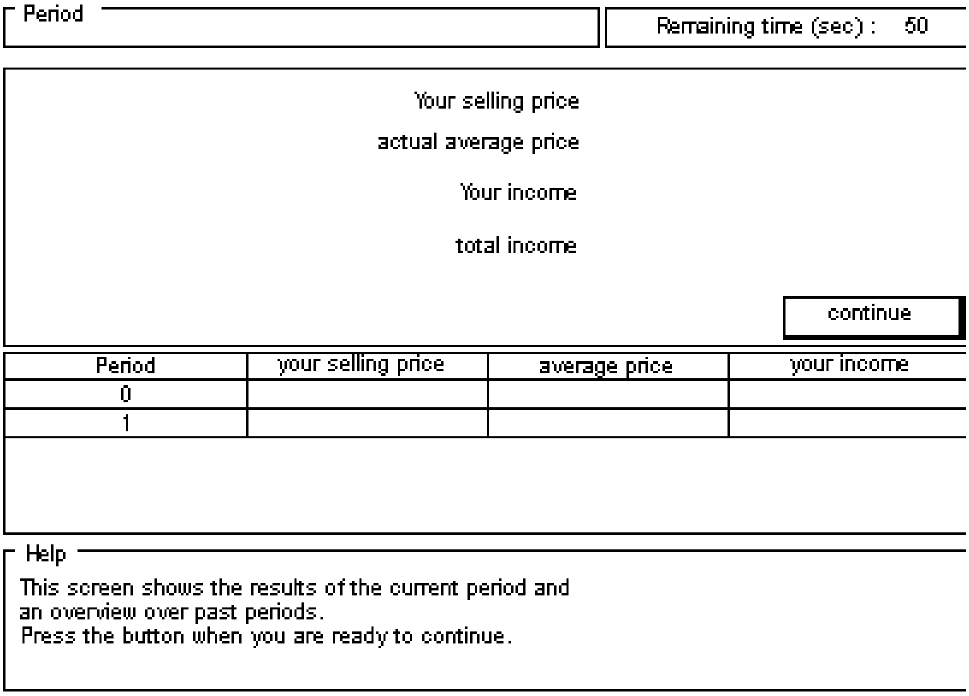


As soon as all firms have chosen their prices, the outcomes of this period will be shown in the outcome-screen.

The upper part of this screen shows the outcomes of the current period. This screen shows your decision in the current period, the average price, your real income in this period, and your total real payoff.

The lower part of this screen displays the outcomes of past periods.

Figure B2: Outcome screen



Overview: What you have to do in each period.

In each period, each firm has to choose a price. Every integer price from 1 to 30 can be chosen ($1 \leq$ selling price ≤ 30).

- Enter your price decision into the first cell of the input screen.
- Enter the average price you expect to prevail in this period into the second cell ($1 \leq$ selling price ≤ 30)
- Enter your confidence in your price expectation into the third cell (numbers **1 to 6**).

When you have completed the three cells, press the OK-Button. The remaining time to take your decisions is shown in the upper right corner of the screen.

When all participants have taken their decisions, or when the time has elapsed, all participants are shown the outcome screen. This screen shows your decisions, actual average prices and your real payoff in points for the current and the past periods.

To take your decisions the following aids are at your disposition:

***Green* income table**: Helps you to estimate your expected nominal point income (You are a firm of type *y*). Your payoff is determined by your real income in points.

You can calculate your real income from the nominal income (= numbers shown in the income table) by applying the following formula:

Real income = Nominal income / Average price of other firms

***Blue* income table**: Helps to estimate the nominal point income of the firms of type *x* in your group. The payoff of these firms are also determined by their real point income. To calculate the real income of firms of type *x*, you also apply the formula above.

Outcome screen: Displays your selling price, the actual average price and your real income for the present and the past periods.

Do you have any questions?

Control questions

You have to answer all of the following questions. If you do not answer a question, you will be excluded from the experiment and all payments. Wrong answers do not have any consequences. If you have any questions, please ask us.

1. Please indicate an expectation for the average price of other firms from 1 to 30.
   Expected average price ....

2. Please indicate a selling price from 1 to 30.
   Selling price ....

3. What is your expected nominal income in points at the prices you indicated in 1) and 2)?
   Your nominal income ....

4. What is your expected real income at the prices you indicated in 1) and 2)?
   Your real income ....

5. Suppose you choose a price of 1. The other firm of type *y* chooses a price of 30. The first firm of type *x* chooses a price of 7 and the second firm of type *x* chooses a price of 23.

a) What is your average price at the (fictitious) prices? ....
   What is your nominal income? ....
   What is your real income? ....

b) What is the average price of the other firm of type *y*? ....
   What is the nominal income of this firm? ....
   What is the real income of this firm? ....

c) What is the average price of the first firm of type *x*? ....
   What is the nominal income of this firm? ....
   What is the real income of this firm? ....

d) What is the average price of the second firm of type *x*? ....
   What is the nominal income of this firm? ....
   What is the real income of this firm? ....

yoff Table C1: Complements, post-shock, Type *x*

Average price of other firms

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
39	39	20	9	5	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	20	39	20	9	5	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	9	20	39	20	9	5	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
5	5	9	20	39	20	9	5	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1
3	3	5	9	20	39	20	9	5	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
2	3	3	5	9	20	39	20	9	5	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1	1
2	2	2	3	5	9	20	39	20	9	5	3	3	3	2	2	2	2	1	1	1	1	1	1	1	1
2	2	2	3	3	5	9	20	39	20	9	5	5	5	3	2	2	2	2	1	1	1	1	1	1	1
2	2	2	2	2	3	5	9	20	39	20	9	9	9	5	3	2	2	2	2	1	1	1	1	1	1
1	2	2	2	2	3	3	5	9	20	39	20	20	20	9	5	3	2	2	2	2	1	1	1	1	1
1	2	1	2	2	2	2	3	5	9	20	39	39	39	20	9	5	3	2	2	2	2	1	1	1	1
1	2	1	2	2	2	2	3	3	5	9	20	20	20	39	20	9	5	3	2	2	2	2	1	1	1
1	2	1	2	1	2	2	2	2	3	5	9	9	9	20	39	20	9	5	3	2	2	2	2	2	2
1	1	1	1	1	2	2	2	2	3	3	5	5	5	9	20	39	20	9	5	3	2	2	2	2	2
1	1	1	1	1	1	1	2	2	2	2	3	3	3	5	9	20	39	20	9	5	3	2	2	2	2
1	1	1	1	1	1	1	2	2	2	2	3	2	2	3	5	9	20	39	20	9	5	3	2	2	2
1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	5	9	20	39	20	9	5	3	3	3
1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	5	9	20	39	20	9	5	5	5
1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	5	9	20	39	20	9	9	9
1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	2	2	2	3	5	9	20	39	20	20	20
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9	20	39	39	39
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9	20	20	20
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9	9	9
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	5	5
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	3	3
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

yoff Table C2: Complements, post-shock, Type *y*

Average price of other firms

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
5	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	5	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	9	5	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
39	20	9	5	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	39	20	9	5	3	2	2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	20	39	20	9	5	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1
5	9	20	39	20	9	5	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
3	5	9	20	39	20	9	5	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1
2	3	5	9	20	39	20	9	5	3	2	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1
2	3	3	5	9	20	39	20	9	5	3	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1
2	2	2	3	5	9	20	39	20	9	5	5	5	3	2	2	2	2	1	1	1	1	1	1	1	1
2	2	2	3	3	5	9	20	39	20	9	9	9	5	3	2	2	2	2	1	1	1	1	1	1	1
1	2	2	2	2	3	5	9	20	39	20	20	20	9	5	3	2	2	2	2	1	1	1	1	1	1
1	2	2	2	2	3	3	5	9	20	39	39	39	20	9	5	3	2	2	2	2	1	1	1	1	1
1	2	1	2	2	2	2	3	5	9	20	20	20	39	20	9	5	3	2	2	2	2	1	1	1	1
1	2	1	2	2	2	2	3	3	5	9	9	9	20	39	20	9	5	3	2	2	2	2	1	1	1
1	2	1	2	1	2	2	2	2	3	5	5	5	9	20	39	20	9	5	3	2	2	2	2	1	1
1	1	1	1	1	2	2	2	2	3	3	3	3	5	9	20	39	20	9	5	3	2	2	2	2	1
1	1	1	1	1	1	1	2	2	2	2	3	2	3	5	9	20	39	20	9	5	3	2	2	2	2
1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	5	9	20	39	20	9	5	3	2	2	2
1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	5	9	20	39	20	9	5	3	2	2
1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	5	9	20	39	20	9	5	3	2
1	1	1	1	1	1	1	1	1	1	1	2	1	2	2	2	2	3	5	9	20	39	20	9	5	3
1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9	20	39	20	9	5
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9	20	39	20	9
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9	20	39	20
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9	20	39
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9	20
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5

yoff Table C3: Substitutes, post-shock, Type *x*

Average price of other firms

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9	20	39	39	39
1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	2	2	2	3	5	9	20	39	20	20	20
1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	5	9	20	39	20	9	9	9
1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	5	9	20	39	20	9	5	5	5
1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	5	9	20	39	20	9	5	3	3	3
1	1	1	1	1	1	1	2	2	2	2	3	2	2	3	5	9	20	39	20	9	5	3	2	2	2
1	1	1	1	1	1	1	2	2	2	2	3	3	3	5	9	20	39	20	9	5	3	2	2	2	2
1	1	1	1	1	2	2	2	2	3	3	5	5	5	9	20	39	20	9	5	3	2	2	2	2	2
1	2	1	2	1	2	2	2	2	3	5	9	9	9	20	39	20	9	5	3	2	2	2	2	2	2
1	2	1	2	2	2	2	3	3	5	9	20	20	20	39	20	9	5	3	2	2	2	2	1	1	1
1	2	1	2	2	2	2	3	5	9	20	39	39	39	20	9	5	3	2	2	2	2	1	1	1	1
1	2	2	2	2	3	3	5	9	20	39	20	20	20	9	5	3	2	2	2	2	1	1	1	1	1
2	2	2	2	2	3	5	9	20	39	20	9	9	9	5	3	2	2	2	2	1	1	1	1	1	1
2	2	2	3	3	5	9	20	39	20	9	5	5	5	3	2	2	2	2	1	1	1	1	1	1	1
2	2	2	3	5	9	20	39	20	9	5	3	3	3	2	2	2	2	1	1	1	1	1	1	1	1
2	3	3	5	9	20	39	20	9	5	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1	1
3	3	5	9	20	39	20	9	5	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
5	5	9	20	39	20	9	5	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1
9	9	20	39	20	9	5	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
20	20	39	20	9	5	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
39	39	20	9	5	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	20	9	5	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	9	5	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	5	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

yoff Table C4: Substitutes, post-shock, Type *y*

Average price of other firms

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9	20	39
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9	20	39	20
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9	20	39	20	9
1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	5	9	20	39	20	9	5
1	1	1	1	1	1	1	1	1	1	1	2	1	2	2	2	2	3	5	9	20	39	20	9	5	3
1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	5	9	20	39	20	9	5	3	2
1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	5	9	20	39	20	9	5	3	2	2
1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	5	9	20	39	20	9	5	3	2	2	2
1	1	1	1	1	1	1	2	2	2	2	3	2	3	5	9	20	39	20	9	5	3	2	2	2	2
1	1	1	1	1	2	2	2	2	3	3	3	3	5	9	20	39	20	9	5	3	2	2	2	2	1
1	2	1	2	1	2	2	2	2	3	5	5	5	9	20	39	20	9	5	3	2	2	2	2	1	1
1	2	1	2	2	2	2	3	3	5	9	9	9	20	39	20	9	5	3	2	2	2	2	1	1	1
1	2	1	2	2	2	2	3	5	9	20	20	20	39	20	9	5	3	2	2	2	2	1	1	1	1
1	2	2	2	2	3	3	5	9	20	39	39	39	20	9	5	3	2	2	2	2	1	1	1	1	1
1	2	2	2	2	3	5	9	20	39	20	20	20	9	5	3	2	2	2	2	1	1	1	1	1	1
2	2	2	3	3	5	9	20	39	20	9	9	9	5	3	2	2	2	2	1	1	1	1	1	1	1
2	2	2	3	5	9	20	39	20	9	5	5	5	3	2	2	2	2	1	1	1	1	1	1	1	1
2	3	3	5	9	20	39	20	9	5	3	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1
2	3	5	9	20	39	20	9	5	3	2	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1
3	5	9	20	39	20	9	5	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1
5	9	20	39	20	9	5	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
9	20	39	20	9	5	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1
20	39	20	9	5	3	2	2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
39	20	9	5	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	9	5	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	5	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

l Payoff Table D1: Complements, post-shock, Type *x*

Average price of other firms

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
39	78	60	34	24	19	17	16	16	16	16	17	18	19	20	20	21	21	22	23	24	25	25	26	27	28
20	40	117	80	43	29	23	20	18	18	17	18	19	20	21	21	21	22	23	23	24	25	26	27	28	29
9	17	60	156	100	52	34	26	22	20	19	19	21	22	22	22	22	23	23	24	25	25	26	27	28	29
5	10	26	80	195	120	60	38	29	25	22	21	23	25	24	23	23	24	24	24	25	26	26	27	28	29
3	6	14	34	100	234	140	69	43	32	27	24	26	28	26	25	25	25	25	25	26	26	27	28	29	30
2	5	10	19	43	120	273	160	77	48	36	30	32	34	30	28	27	26	26	26	27	27	27	28	29	30
2	4	7	13	24	52	140	312	180	86	53	39	42	45	37	32	30	29	28	28	28	28	28	29	30	31
2	4	6	10	16	29	60	160	351	200	95	58	62	67	49	39	34	32	30	29	29	29	29	29	31	32
2	3	5	8	12	19	34	69	180	390	220	103	112	120	72	52	42	36	33	32	31	30	30	30	32	33
1	3	5	7	10	15	23	38	77	200	429	240	260	280	129	77	55	44	39	35	33	32	32	31	33	34
1	3	4	6	9	12	17	26	43	86	220	468	507	546	300	138	82	58	47	41	37	35	34	33	34	36
1	3	4	6	8	11	14	20	29	48	95	240	260	280	585	320	146	86	61	49	43	39	36	35	37	38
1	3	4	6	7	10	12	16	22	32	53	103	112	120	300	624	340	155	91	65	52	45	40	38	40	41
1	2	4	5	7	9	11	14	18	25	36	58	62	67	129	320	663	360	163	96	68	54	47	42	44	46
1	2	4	5	7	8	10	13	16	20	27	39	42	45	72	138	340	702	380	172	101	71	57	49	51	53
1	2	4	5	6	8	10	12	14	18	22	30	32	34	49	77	146	360	741	400	181	106	74	59	62	64
1	2	4	5	6	8	9	11	13	16	19	24	26	28	37	52	82	155	380	780	420	189	110	78	81	84
1	2	3	5	6	7	9	10	12	15	17	21	23	25	30	39	55	86	163	400	819	440	198	115	120	125
1	2	3	5	6	7	9	10	12	14	16	19	21	22	26	32	42	58	91	172	420	858	460	206	215	224
1	2	3	5	6	7	8	10	11	13	15	18	19	20	24	28	34	44	61	96	181	440	897	480	500	520
1	2	3	4	6	7	8	10	11	13	14	17	18	19	22	25	30	36	47	65	101	189	460	936	975	1014
1	2	3	4	6	7	8	9	11	12	14	16	17	18	21	23	27	32	39	49	68	106	198	480	500	520
1	2	3	4	6	7	8	9	11	12	13	15	16	18	20	22	25	29	33	41	52	71	110	206	215	224
1	2	3	4	5	7	8	9	10	12	13	15	16	17	19	21	23	26	30	35	43	54	74	115	120	125
1	2	3	4	5	7	8	9	10	11	13	14	16	17	18	20	22	25	28	32	37	45	57	78	81	84
1	2	3	4	5	7	8	9	10	11	13	14	15	16	18	20	21	24	26	29	33	39	47	59	62	64
1	2	3	4	5	6	8	9	10	11	12	14	15	16	18	19	21	23	25	28	31	35	40	49	51	53
1	2	3	4	5	6	8	9	10	11	12	14	15	16	17	19	20	22	24	26	29	32	36	42	44	46
1	2	3	4	5	6	8	9	10	11	12	13	15	16	17	18	20	21	23	25	28	30	34	38	40	41
1	2	3	4	5	6	7	9	10	11	12	13	14	15	17	18	20	21	23	24	27	29	32	35	37	38

Payoff Table D2: Complements, post-shock, Type *y*

Average price of other firms

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
5	6	7	8	9	10	10	11	12	13	13	15	16	17	18	18	19	20	21	22	23	24	25	26	27	27
9	10	10	10	10	11	11	12	12	13	14	15	16	17	18	19	20	20	21	22	23	24	25	26	27	28
20	17	14	13	12	12	12	13	13	14	14	16	17	18	18	19	20	21	21	22	23	24	25	26	27	28
39	40	26	19	16	15	14	14	14	15	15	17	18	18	19	20	20	21	22	23	23	24	25	26	27	28
20	78	60	34	24	19	17	16	16	16	16	18	19	19	20	20	21	21	22	23	24	25	25	26	27	28
9	40	117	80	43	29	23	20	18	18	17	19	21	20	21	21	21	22	23	23	24	25	26	27	27	28
5	17	60	156	100	52	34	26	22	20	19	21	23	22	22	22	22	23	23	24	25	25	26	27	28	28
3	10	26	80	195	120	60	38	29	25	22	24	26	25	24	23	23	24	24	24	25	26	26	27	28	29
2	6	14	34	100	234	140	69	43	32	27	30	32	28	26	25	25	25	25	25	26	26	27	28	28	29
2	5	10	19	43	120	273	160	77	48	36	39	42	34	30	28	27	26	26	26	27	27	27	28	29	29
2	4	7	13	24	52	140	312	180	86	53	58	62	45	37	32	30	29	28	28	28	28	28	29	29	30
2	4	6	10	16	29	60	160	351	200	95	103	112	67	49	39	34	32	30	29	29	29	29	29	30	30
1	3	5	8	12	19	34	69	180	390	220	240	260	120	72	52	42	36	33	32	31	30	30	30	31	31
1	3	5	7	10	15	23	38	77	200	429	468	507	280	129	77	55	44	39	35	33	32	32	31	32	32
1	3	4	6	9	12	17	26	43	86	220	240	260	546	300	138	82	58	47	41	37	35	34	33	33	33
1	3	4	6	8	11	14	20	29	48	95	103	112	280	585	320	146	86	61	49	43	39	36	35	34	34
1	3	4	6	7	10	12	16	22	32	53	58	62	120	300	624	340	155	91	65	52	45	40	38	37	36
1	2	4	5	7	9	11	14	18	25	36	39	42	67	129	320	663	360	163	96	68	54	47	42	40	38
1	2	4	5	7	8	10	13	16	20	27	30	32	45	72	138	340	702	380	172	101	71	57	49	44	41
1	2	4	5	6	8	10	12	14	18	22	24	26	34	49	77	146	360	741	400	181	106	74	59	51	46
1	2	4	5	6	8	9	11	13	16	19	21	23	28	37	52	82	155	380	780	420	189	110	78	62	53
1	2	3	5	6	7	9	10	12	15	17	19	21	25	30	39	55	86	163	400	819	440	198	115	81	64
1	2	3	5	6	7	9	10	12	14	16	18	19	22	26	32	42	58	91	172	420	858	460	206	120	84
1	2	3	5	6	7	8	10	11	13	15	17	18	20	24	28	34	44	61	96	181	440	897	480	215	125
1	2	3	4	6	7	8	10	11	13	14	16	17	19	22	25	30	36	47	65	101	189	460	936	500	224
1	2	3	4	6	7	8	9	11	12	14	15	16	18	21	23	27	32	39	49	68	106	198	480	975	520
1	2	3	4	6	7	8	9	11	12	13	15	16	18	20	22	25	29	33	41	52	71	110	206	500	1014
1	2	3	4	5	7	8	9	10	12	13	14	16	17	19	21	23	26	30	35	43	54	74	115	215	520
1	2	3	4	5	7	8	9	10	11	13	14	15	17	18	20	22	25	28	32	37	45	57	78	120	224
1	2	3	4	5	7	8	9	10	11	13	14	15	16	18	20	21	24	26	29	33	39	47	59	81	125

Payoff Table D3: Substitutes, post-shock, Type *x*

Average price of other firms

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
1	2	3	4	6	7	8	10	11	13	14	17	18	19	22	25	30	36	47	65	101	189	460	936	975	1014	1
1	2	3	5	6	7	8	10	11	13	15	18	19	20	24	28	34	44	61	96	181	440	897	480	500	520	5
1	2	3	5	6	7	9	10	12	14	16	19	21	22	26	32	42	58	91	172	420	858	460	206	215	224	2
1	2	3	5	6	7	9	10	12	15	17	21	23	25	30	39	55	86	163	400	819	440	198	115	120	125	1
1	2	4	5	6	8	9	11	13	16	19	24	26	28	37	52	82	155	380	780	420	189	110	78	81	84	
1	2	4	5	6	8	10	12	14	18	22	30	32	34	49	77	146	360	741	400	181	106	74	59	62	64	
1	2	4	5	7	8	10	13	16	20	27	39	42	45	72	138	340	702	380	172	101	71	57	49	51	53	
1	2	4	5	7	9	11	14	18	25	36	58	62	67	129	320	663	360	163	96	68	54	47	42	44	46	
1	3	4	6	7	10	12	16	22	32	53	103	112	120	300	624	340	155	91	65	52	45	40	38	40	41	
1	3	4	6	8	11	14	20	29	48	95	240	260	280	585	320	146	86	61	49	43	39	36	35	37	38	
1	3	4	6	9	12	17	26	43	86	220	468	507	546	300	138	82	58	47	41	37	35	34	33	34	36	
1	3	5	7	10	15	23	38	77	200	429	240	260	280	129	77	55	44	39	35	33	32	32	31	33	34	
2	3	5	8	12	19	34	69	180	390	220	103	112	120	72	52	42	36	33	32	31	30	30	30	32	33	
2	4	6	10	16	29	60	160	351	200	95	58	62	67	49	39	34	32	30	29	29	29	29	29	31	32	
2	4	7	13	24	52	140	312	180	86	53	39	42	45	37	32	30	29	28	28	28	28	28	29	30	31	
2	5	10	19	43	120	273	160	77	48	36	30	32	34	30	28	27	26	26	26	27	27	27	28	29	30	
3	6	14	34	100	234	140	69	43	32	27	24	26	28	26	25	25	25	25	25	26	26	27	28	29	30	
5	10	26	80	195	120	60	38	29	25	22	21	23	25	24	23	23	24	24	24	25	26	26	27	28	29	
9	17	60	156	100	52	34	26	22	20	19	19	21	22	22	22	22	23	23	24	25	25	26	27	28	29	
20	40	117	80	43	29	23	20	18	18	17	18	19	20	21	21	21	22	23	23	24	25	26	27	28	29	
39	78	60	34	24	19	17	16	16	16	16	17	18	19	20	20	21	21	22	23	24	25	25	26	27	28	
20	40	26	19	16	15	14	14	14	15	15	16	17	18	19	20	20	21	22	23	23	24	25	26	27	28	
9	17	14	13	12	12	12	13	13	14	14	15	16	18	18	19	20	21	21	22	23	24	25	26	27	28	
5	10	10	10	10	11	11	12	12	13	14	15	16	17	18	19	20	20	21	22	23	24	25	26	27	28	
3	6	7	8	9	10	10	11	12	13	13	14	16	17	18	18	19	20	21	22	23	24	25	26	27	28	
2	5	6	7	8	9	10	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	25	27	28	
2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	23	24	25	26	27	
2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	20	21	22	23	24	25	26	27	
2	3	4	6	7	8	9	10	11	11	12	13	15	16	17	18	18	19	20	21	22	23	24	25	26	27	
1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	

Payoff Table D4: Substitutes, post-shock, Type *y*

Average price of other firms

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	2	3	4	6	7	8	9	11	12	13	15	16	18	20	22	25	29	33	41	52	71	110	206	500	1014
1	2	3	4	6	7	8	9	11	12	14	15	16	18	21	23	27	32	39	49	68	106	198	480	975	520
1	2	3	4	6	7	8	10	11	13	14	16	17	19	22	25	30	36	47	65	101	189	460	936	500	224
1	2	3	5	6	7	8	10	11	13	15	17	18	20	24	28	34	44	61	96	181	440	897	480	215	125
1	2	3	5	6	7	9	10	12	14	16	18	19	22	26	32	42	58	91	172	420	858	460	206	120	84
1	2	3	5	6	7	9	10	12	15	17	19	21	25	30	39	55	86	163	400	819	440	198	115	81	64
1	2	4	5	6	8	9	11	13	16	19	21	23	28	37	52	82	155	380	780	420	189	110	78	62	53
1	2	4	5	6	8	10	12	14	18	22	24	26	34	49	77	146	360	741	400	181	106	74	59	51	46
1	2	4	5	7	8	10	13	16	20	27	30	32	45	72	138	340	702	380	172	101	71	57	49	44	41
1	2	4	5	7	9	11	14	18	25	36	39	42	67	129	320	663	360	163	96	68	54	47	42	40	38
1	3	4	6	7	10	12	16	22	32	53	58	62	120	300	624	340	155	91	65	52	45	40	38	37	36
1	3	4	6	8	11	14	20	29	48	95	103	112	280	585	320	146	86	61	49	43	39	36	35	34	34
1	3	4	6	9	12	17	26	43	86	220	240	260	546	300	138	82	58	47	41	37	35	34	33	33	33
1	3	5	7	10	15	23	38	77	200	429	468	507	280	129	77	55	44	39	35	33	32	32	31	32	32
1	3	5	8	12	19	34	69	180	390	220	240	260	120	72	52	42	36	33	32	31	30	30	30	31	31
2	4	6	10	16	29	60	160	351	200	95	103	112	67	49	39	34	32	30	29	29	29	29	29	30	30
2	4	7	13	24	52	140	312	180	86	53	58	62	45	37	32	30	29	28	28	28	28	28	29	29	30
2	5	10	19	43	120	273	160	77	48	36	39	42	34	30	28	27	26	26	26	27	27	27	28	29	29
2	6	14	34	100	234	140	69	43	32	27	30	32	28	26	25	25	25	25	25	26	26	27	28	28	29
3	10	26	80	195	120	60	38	29	25	22	24	26	25	24	23	23	24	24	24	25	26	26	27	28	29
5	17	60	156	100	52	34	26	22	20	19	21	23	22	22	22	22	23	23	24	25	25	26	27	28	28
9	40	117	80	43	29	23	20	18	18	17	19	21	20	21	21	21	22	23	23	24	25	26	27	27	28
20	78	60	34	24	19	17	16	16	16	16	18	19	19	20	20	21	21	22	23	24	25	25	26	27	28
39	40	26	19	16	15	14	14	14	15	15	17	18	18	19	20	20	21	22	23	23	24	25	26	27	28
20	17	14	13	12	12	12	13	13	14	14	16	17	18	18	19	20	21	21	22	23	24	25	26	27	28
9	10	10	10	10	11	11	12	12	13	14	15	16	17	18	19	20	20	21	22	23	24	25	26	27	28
5	6	7	8	9	10	10	11	12	13	13	15	16	17	18	18	19	20	21	22	23	24	25	26	27	27
3	5	6	7	8	9	10	10	11	12	13	14	16	16	17	18	19	20	21	22	23	24	25	25	26	27
2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	23	24	25	26	27
2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	20	21	22	23	24	25	26	27

Table 1: Overview of Parameters

		Strategic Complements	Strategic Substitutes
All periods	Group size	$n = 4$	$n = 4$
	Information feedback in period t	$\overline{P}_{-i}, v_i$	$\overline{P}_{-i}, v_i$
	Representation of payoffs	nominal $(\overline{P}_{-i} v_i)$	nominal $(\overline{P}_{-i} v_i)$
	Real equilibrium payoff	39	39
	Choice variables	$P_i = \{1,2,\ldots,30)$	$P_i = \{1,2,\ldots,30)$
Pre-shock periods	Money supply M_0	42	42
	Average equilibrium price $\overline{P}*$ and average equilibrium expectation for the *whole* group	25	25
	Equilibrium price for type x	22	22
	Equilibrium expectation for type x	26	26
	Equilibrium price for type y	28	28
	Equilibrium expectation for type y	24	24
Post-shock periods	Money supply $M_1 = M_0/2$	21	21
	Average equilibrium price $\overline{P}*$ and average equilibrium expectation for the *whole* group	12.5	12.5
	Equilibrium price for type x	11	11
	Equilibrium expectation for type x	13	13
	Equilibrium price for type y	14	14
	Equilibrium expectation for type y	12	12
	Number of dominated strategies for type x	9	9
	Number of dominated strategies for type y	6	6
	Slope of reaction function	+ 1 or 0	- 1 or 0

Table 2: Deviation of Prices from Post-Shock Equilibrium

Post-shock period	Strategic Complements treatment (CT) Coefficient α_t	Strategic Substitutes treatment (ST) Coefficient β_t
1	6.600***	- 1.167
2	5.175***	0.194
3	4.275***	- 0.028
4	3.425***	0.000
5	2.950***	- 0.139
6	2.375***	- 0.111
7	1.625**	- 0.167
8	1.475**	0.056
9	1.000	0.000
10	0.800	0.083
11	0.275	0.000
12	- 0.050	0.000
13	0.000	0.000
14	- 0.025	0.000
15	-	0.528

Notes: $\overline{P}_{jt} - \overline{P}_1^* = \sum_{t=1}^{14} \alpha_t d_t + \sum_{t=1}^{15} \beta_t (1 - d_t)$

$d_t = 1$ if price observation in period t is from CT

*** significant at $p = 0.001$,
** significant at $p = 0.01$,
* significant at $p = 0.05$.

Table 3: Percentages of Nominal Price Choices above, in and below Equilibrium (Subjects as Units of Observation)

	Strategic complements			Strategic substitutes		
Period	**Above** equilibrium	**in** equilibrium	**Below** equilibrium	**above** equilibrium	**in** equilibrium	**below** equilibrium
13 - 15	3	93	5	1	96	3
16	75	23	3	14	67	19
17	75	23	3	19	67	14
18	68	28	5	3	92	6
19 - 21	48	51	1	1	97	2
22 - 24	34	65	1	3	96	1
25 - 27	18	77	6	3	96	1
28 - 30	2	94	4	1	99	0

Table 4: Deviation of Expectations from Post-Shock Equilibrium

Post-shock period	Strategic Complements treatment (CT) Coefficient α_t	Strategic Substitutes treatment (ST) Coefficient β_t
1	8.025***	0.917
2	6.325***	- 0.083
3	4.950***	0.056
4	3.800***	0.000
5	3.100***	0.000
6	2.825***	- 0.083
7	2.000**	- 0.139
8	1.525*	- 0.111
9	1.225	0.028
10	0.625	0.028
11	0.400	0.000
12	- 0.050	0.000
13	- 0.050	0.028
14	- 0.050	- 0.028
15	-	0.028

Notes: $\overline{E}_{jt} - \overline{E}_1^* = \sum_{t=1}^{14} \alpha_t d_t + \sum_{t=1}^{15} \beta_t (1 - d_t)$

where $\overline{E}_{jt}$ is group *j*'s average expectation of others' average price in period *t*, and $\overline{E}_1^*$ is the average equilibrium expectation. $d_t = 1$ if a price observation in period *t* is from the CT.

*** significant at $p = 0.001$,
** significant at $p = 0.01$,
* significant at $p = 0.05$.

gure 1: Nominal Average Prices over Time

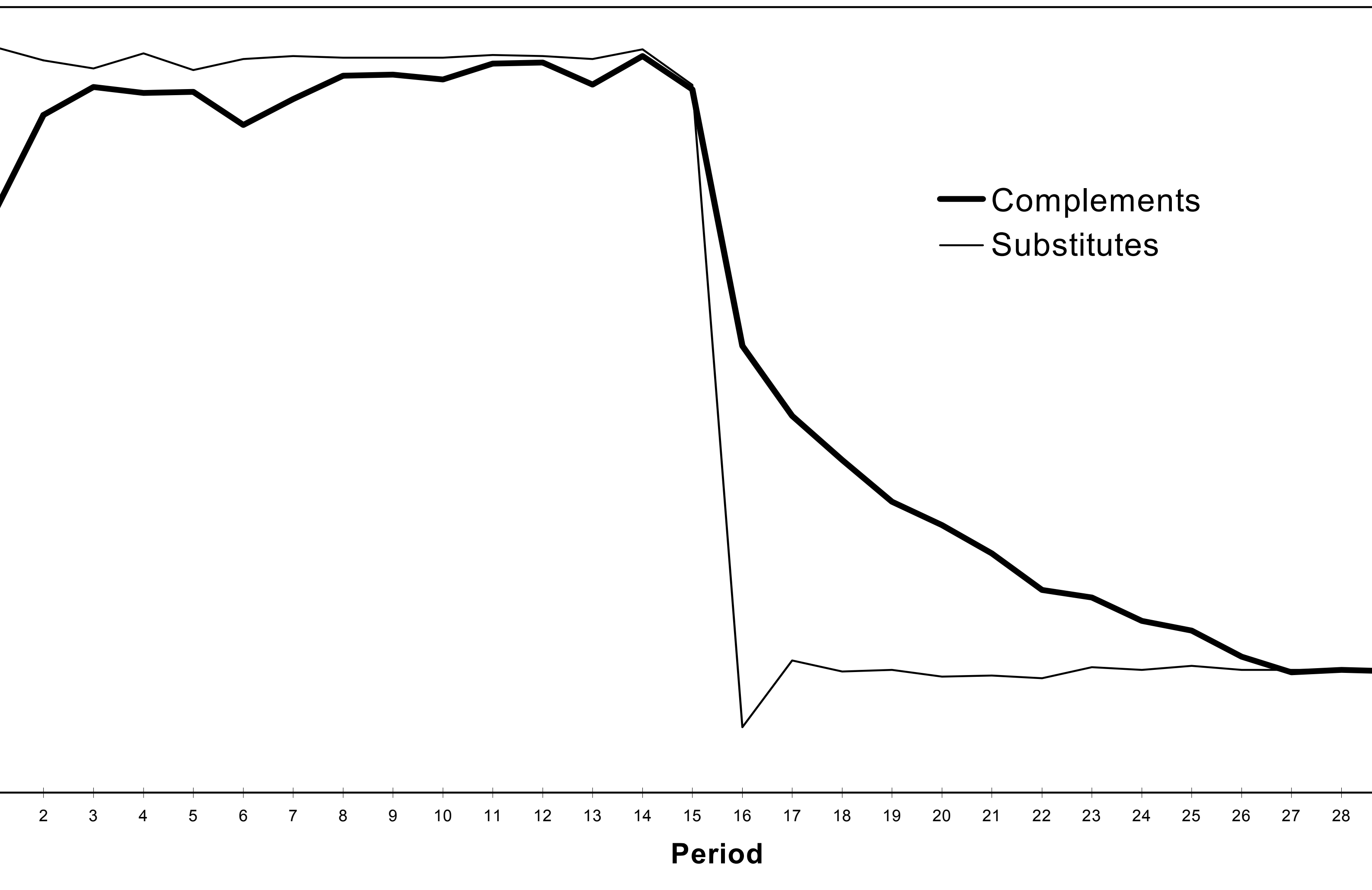


***Figure 2a*:** Distribution of Individual Price Choices in Period 16 (*x*-types)

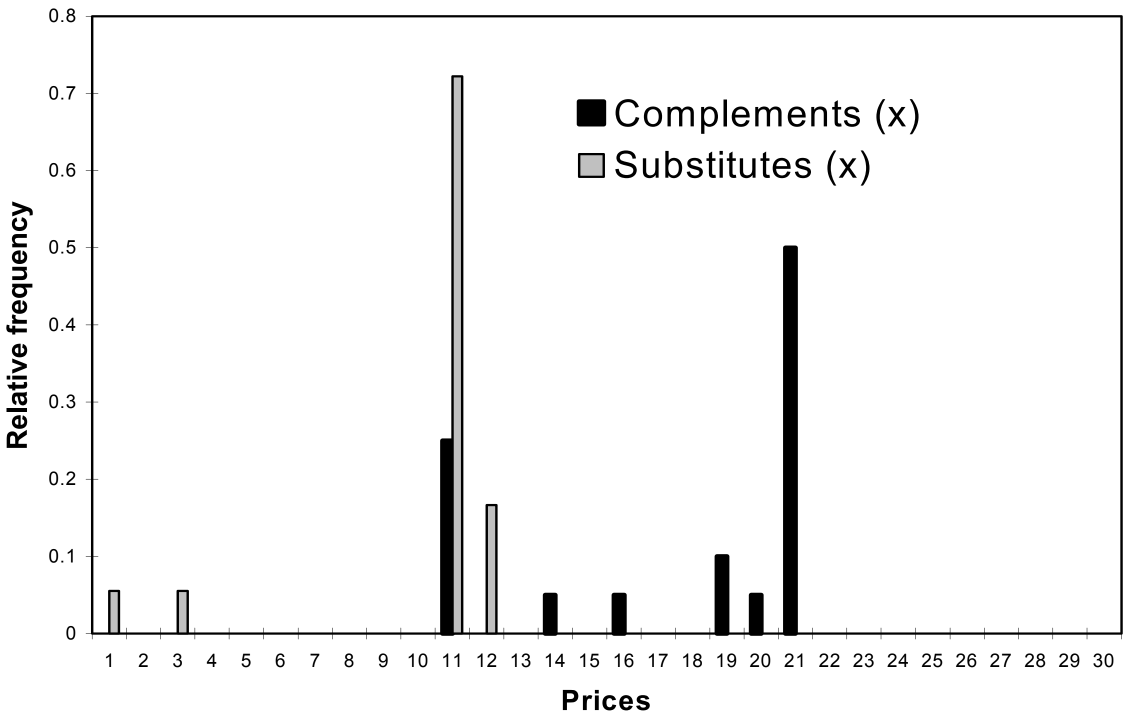


***Figure 2b*:** Distribution of Individual Price Choices in Period 16 (*y*-types)

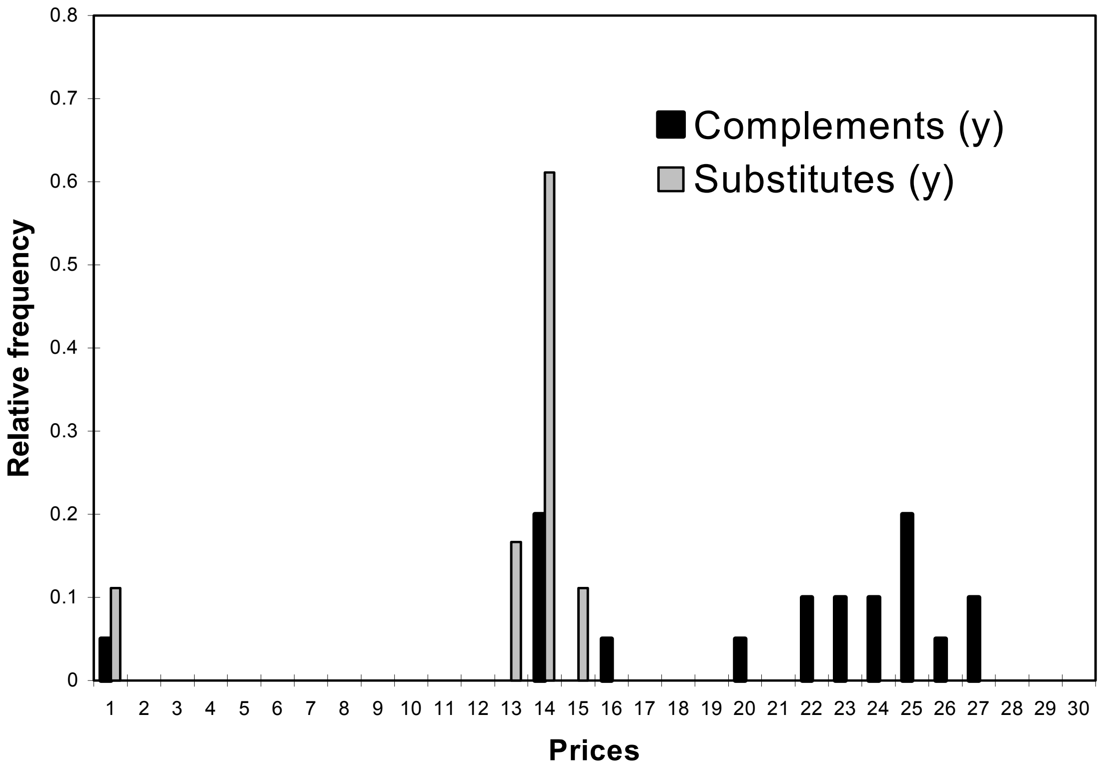


***Figure 3a*:** Actual Average Prices and Average Best Reply for given Expectations Complements Treatment (Periods 16-18)

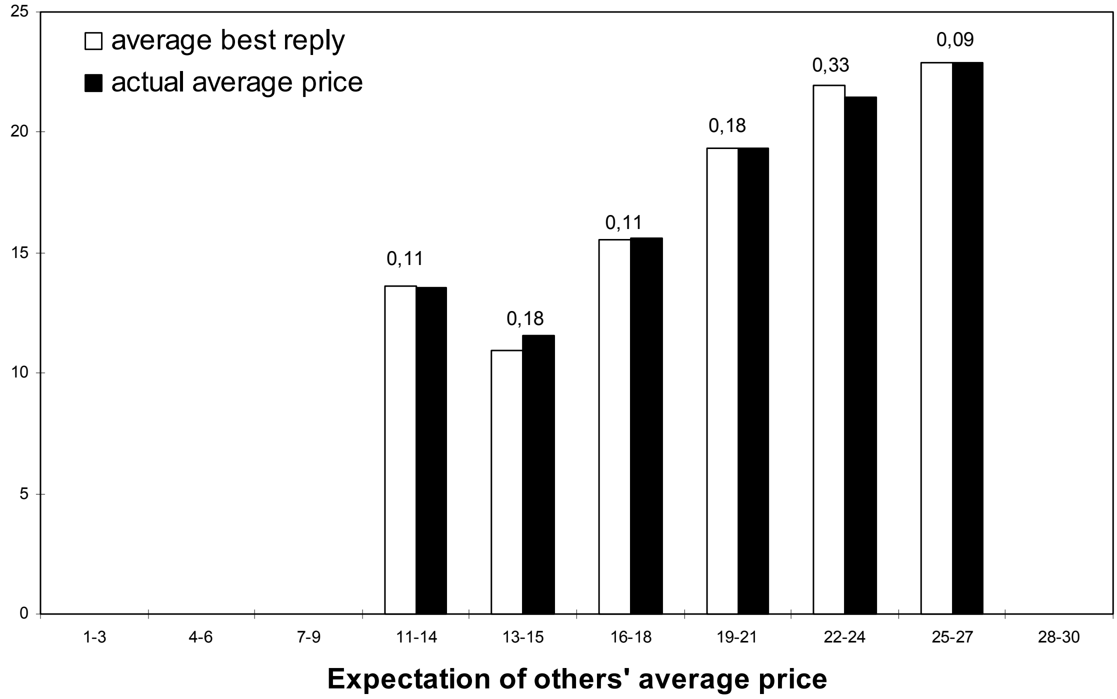
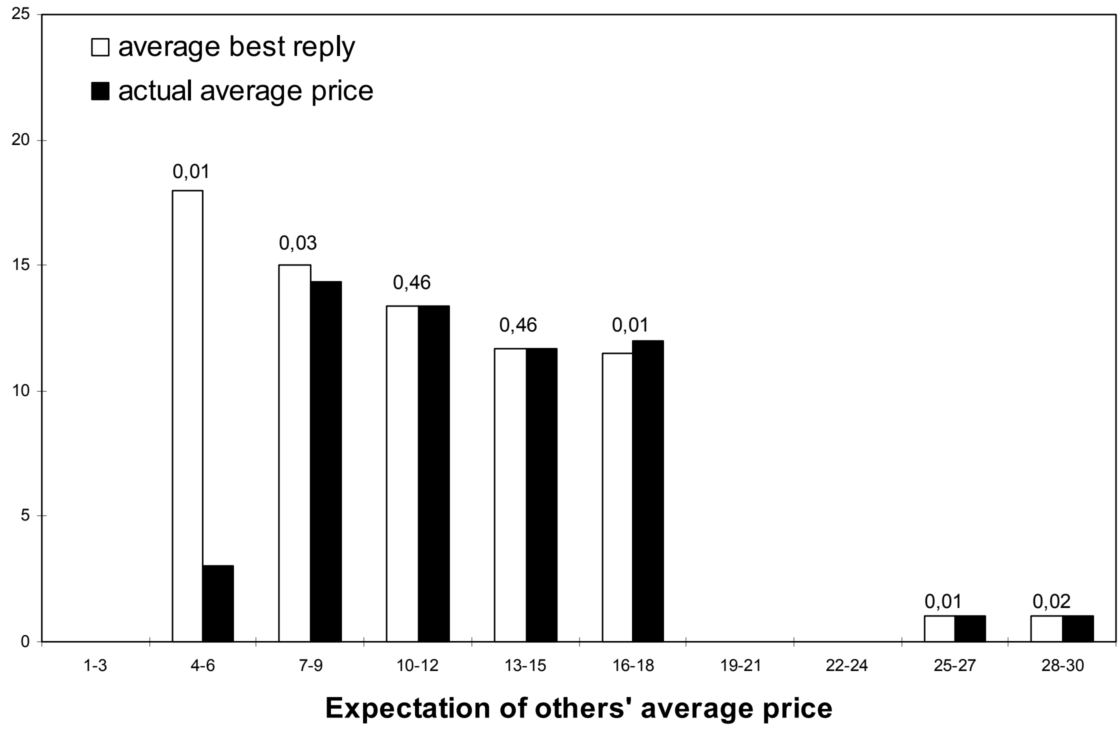


***Figure 3b*:** Actual Average Prices and Average Best Reply for given Expectations Substitutes Treatment (Periods 16-18)



gure 4: Average Price Expectations over Time

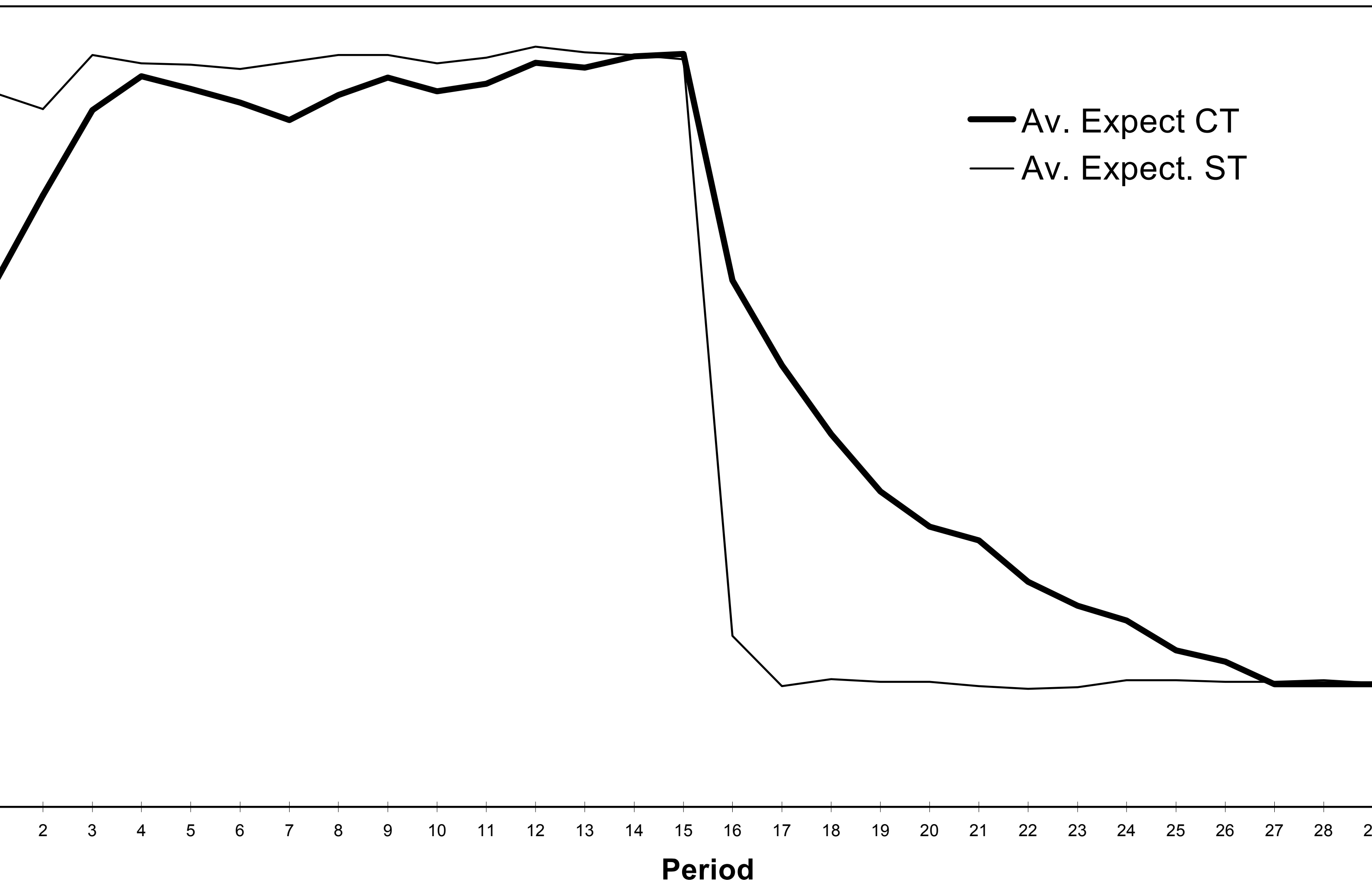


Figure 5**:** Efficiency Losses during the Post-shock Phase

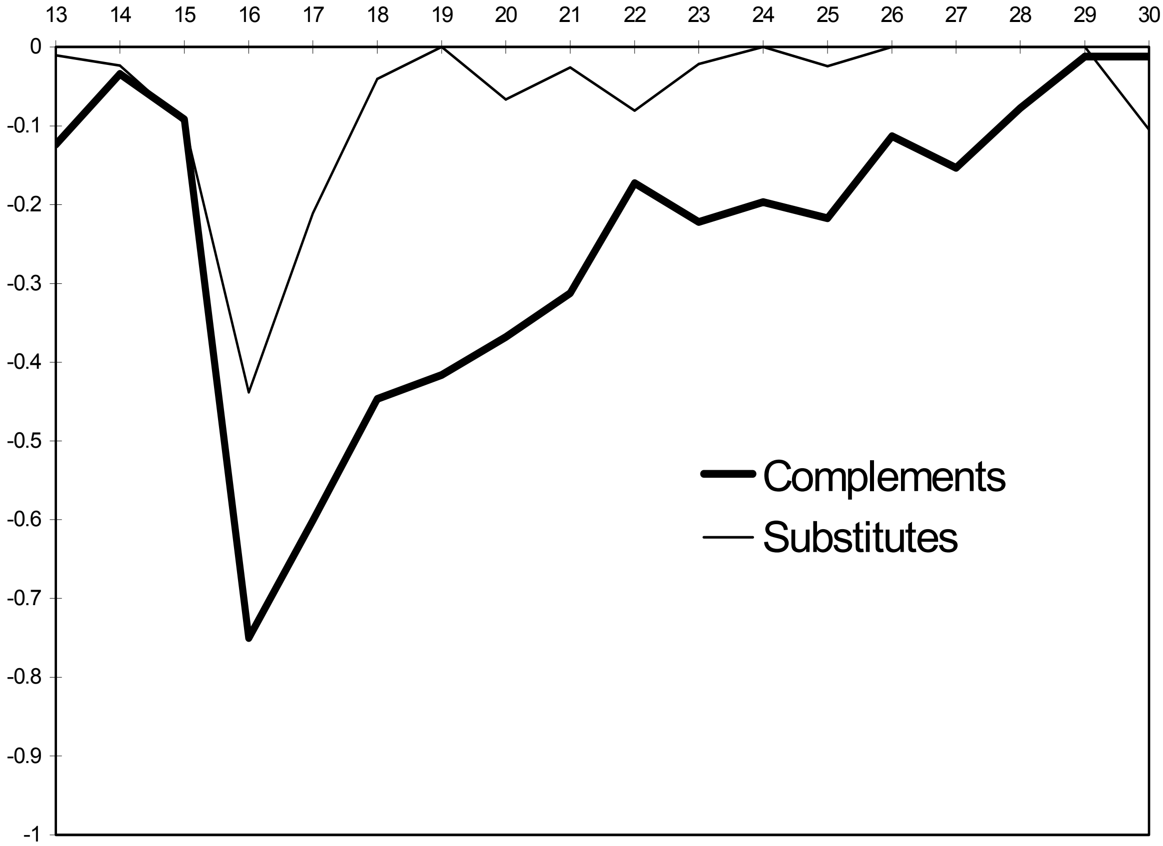


Figure 6a: Simulations of Price Adjustment with Varying Numbers of Adaptive Players in the Substitutes Treatment (ST)

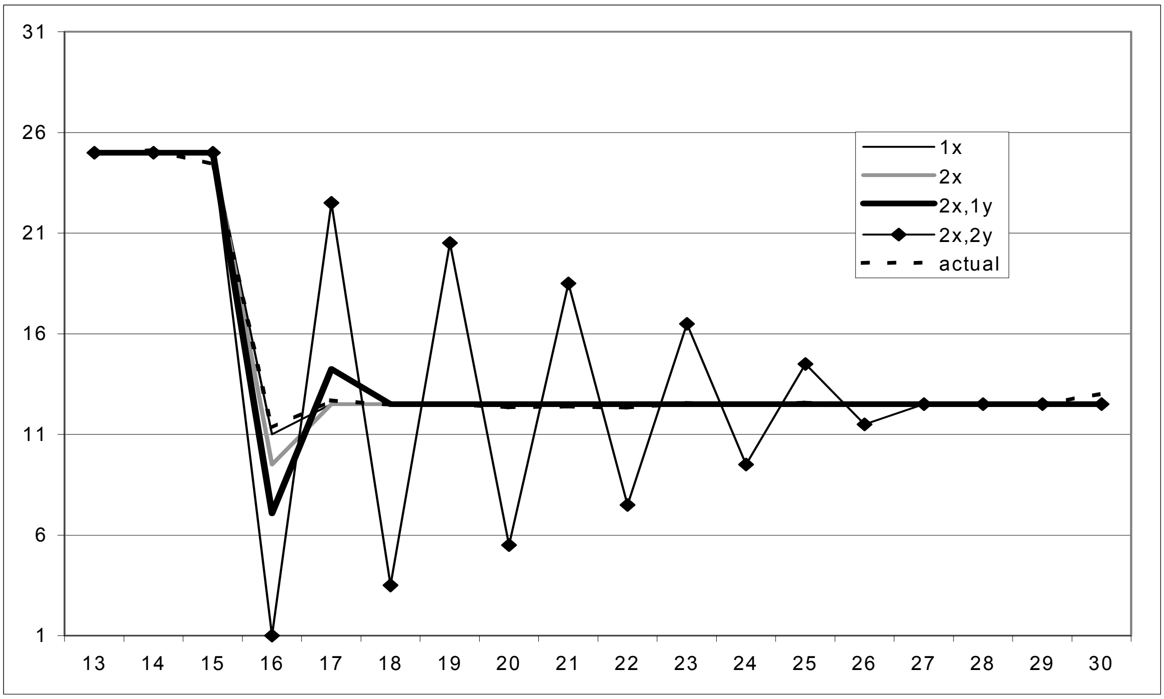


Figure 6b: Simulations of Price Adjustment with Varying Numbers of Adaptive Players in the Complements Treatment (CT)

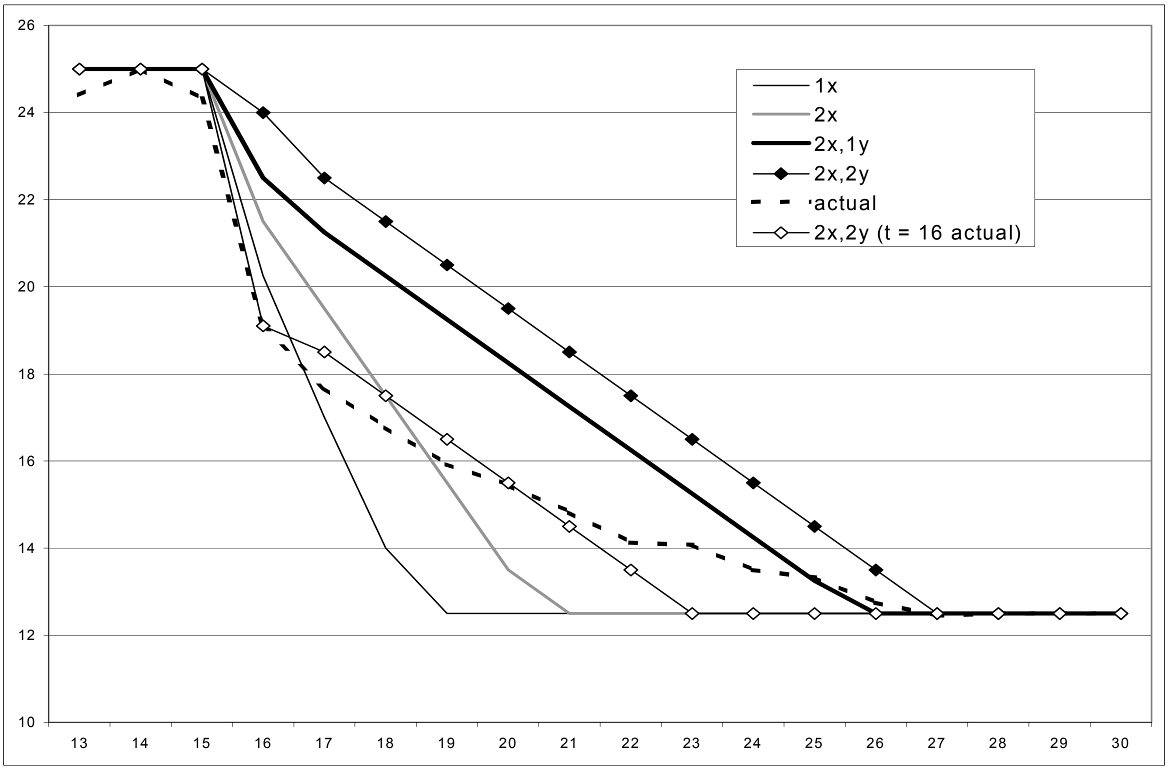


Figure 7a: Distribution of Individual Price Expectations in Period 16 (*x*-types)

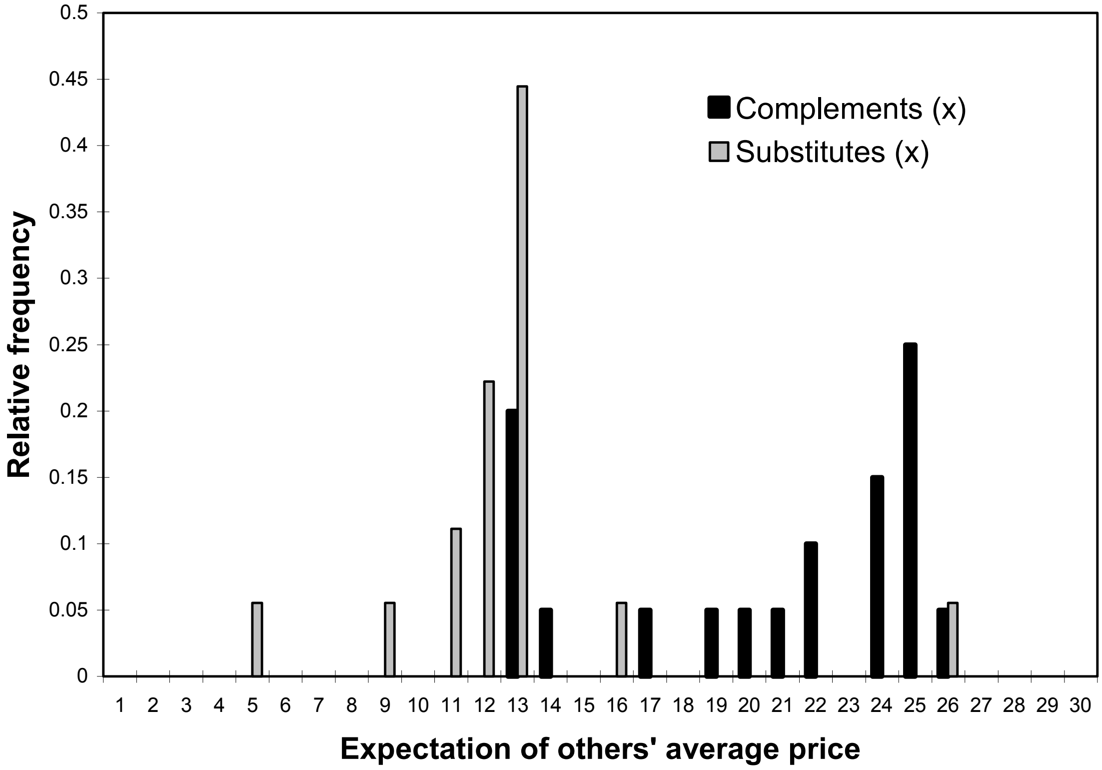


Figure 7b: Distribution of Individual Price Expectations in Period 16 (*y*-types)