Price Competition in an Inflationary Environment

Peter Duersch Thomas Eife*

University of Heidelberg University of Heidelberg

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Abstract

A constant price level facilitates cooperation among firms whereas steady inflation and deflation rates lower firms' ability to cooperate. In an experimental market with price competition we show that both inflation and deflation significantly reduce cooperation compared to treatments with a constant price level. The difficulties to cooperate also affect prices and welfare: depending on the market structure, inflation and deflation lead to significantly lower real prices and higher welfare.

Keywords: Bertrand Duopoly, Inflation, Experiment, Money Illusion

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*University of Heidelberg, Department of Economics, Bergheimer Str. 58, D-69115 Heidelberg, Germany. peter.duersch@awi.uni-heidelberg.de, thomas.eife@awi.uni-heidelberg.de

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1 Introduction

In an experimental market with price competition, firms are subject to inflation and deflation in order to study how this affects their ability to cooperate. The main findings are that inflation and deflation significantly reduce cooperation. The difficulties to cooperate also affect prices and welfare: depending on the market structure, inflation and deflation lead to significantly lower prices and higher welfare.

The experimental method is used in order to overcome one of the limitations of recent studies on prices setting that use "micro data" (i.e., the firm-level data underlying the consumer price indices).[1] The micro data permit a detailed analysis of how, for example, price-setting changes with the business cycle, and how the level of inflation affects the frequency and the size of price changes. A serious drawback of the data used in this literature is, however, that no information is available about the structure of the markets. Since there is no information and no model-free way of interpreting the data (Nakamura & Steinsson, 2008), it is typically assumed that firms operate in a monopolistic market where the firm's price is independent of its competitors' prices and only influenced by aggregate variables such as GDP, overall inflation, input costs.

The literature pioneered by Blinder (1991), who uses surveys to explore price-setting behavior of firms, illustrates the disadvantage of this assumption. Blinder finds strong support that firms hesitate to raise or lower prices until other firms move first. Fabiani *et al.* (2006), summarizing more recent surveys conducted in nine European countries, report that the single most important factor influencing the decision to lower a price are a firm's competitors' prices. In the case of price increases, competitors' prices come third after labor and other input costs. These surveys strongly support the notion that firms find themselves somewhere in between the two ex-

[1]See for example Bils & Klenow (2004), Angeloni *et al.* (2006), Dhyne *et al.* (2006), Nakamura & Steinsson (2008), and Gagnon (2009) The main findings of this literature support the notion of earlier papers by Cecchetti (1985) and Lach & Tsiddon (1992) that firms are reluctant to change prices often. Typically, retail prices change about once a year and services prices once about every two years. Price increases are more common than price decreases but this depends on the overall inflation rate and on the sector. In section 2 we will discuss how these findings influenced the design of our experiment.

tremes of a perfect competitive market and a pure monopoly and that they do not operate in a world in which the firm's competitors' prices are negligible. The surveys thus support Kreps' (1990) forceful critique of the model of monopolistic competition which is standard in the monetary economics literature because of its elegant predictions but which typically assumes the independence of a firm's price from its competitors' prices. However, this independence assumption is not innocuous. Inflation affects prices directly but also indirectly through changes in the amount of cooperation by the firms. This latter effect can only be detected in models that allow for cooperation between firms. In an experiment, one can control for the structure of a market and thus reveal insights that remain hidden in the firm-level data of the statistical offices. Even in the frictionless world of our experiment where there is no uncertainty about future inflation, no menu costs, no externally imposed staggering of prices, and no informational frictions about the behavior of a firm's competitors, inflation and deflation have a significant effect on firms' ability to cooperate and thus on how inflation of the overall price level is passed on to consumers.

The specific environment we consider is Dixit's (1979) classic model of Bertrand competition with differentiated products in a duopoly. Here, each firm needs to take into account the price set by the other firm when evaluating the most profitable own price. Cooperation (i.e., pricing above the Nash equilibrium) leads to higher profits, but is susceptible to deviations. Firms can try to prevent deviations by the threat of punishment, that is, by responding to deviations with lower prices in future rounds.[2]

The treatments looked at have positive (INF), negative (DEF), and zero inflation (NOINF). They are identical in real terms but differ in nominal terms. To study how the results vary with market structure, we vary the degree of homogeneity of the product (WEAK and STRONG). This results in a 3×2 design. There are no inflation surprises — all future price levels are known in advance. The inflation rate is constant over the entire 20 periods of the experiment. Nonetheless, we expect

[2]Cooperation is not a Nash-Equilibrium in a finitely repeated market since there is no incentive to punish in the last round. By backward-induction there is therefore no incentive to cooperate in any round. Nonetheless, a long literature, following Ostrom *et al.* (1992), shows that subjects are willing to punish in finite games.

inflation to affect a firm's price-setting. In an environment without inflation, the cooperative status quo is to not change prices. In an environment with inflation, the cooperative status quo is to change prices regularly. In order to stay at a cooperative real price, firms need to periodically raise their nominal price. Staying at the old nominal price is in effect a real price deviation; the task of sustaining cooperation becomes harder. The same is true for achieving coordination in the first place. Without inflation, coordination can follow a simple rule of thumb: if both firms play a cooperative price, they continue playing this price from now on. Even if non-coordinated firms played completely randomly, they would eventually — by chance — play the same price, creating a natural focal point to start coordinating on. Under inflation, no clear focal point exists since coordination (at the same real level) requires firms to adjust prices regularly. Given that the opponent did not raise her price by the same amount as I did, was she deviating? Or was she trying to coordinate on a nominal price instead of a real price? Did she fail to calculate the correct new nominal cooperative price? So, should I immediately start punishing, knowing that this could lead to a price war we will both suffer in, or should I allow for some mistakes by my opponent? If firms hesitate to punish a real deviation under inflation as strongly as they would punish a real (and nominal) deviation in the case with no inflation, then sophisticated firms might use inflation to hide some real deviations and make a higher profit that way.

As mentioned above, our main result is that inflation and deflation complicate cooperation. Independently of the market structure, cooperation is lower in INF and DEF compared to NOINF. Some firms cooperate in real, others in nominal terms. Nominal cooperation (i.e., playing the same (nominally) constant price for several periods) may be interpreted as a sign of money illusion. Money illusion can also explain why the real price has a slightly positive trend in DEF whereas it has a strong negative trend in INF. However, punishment does not appear to differ between treatments. One might expect that money illusion would make punishment harsher (in real terms) under inflation than under deflation when subjects focus on nominal instead of real prices but no such behavior is observed.

The difficulties inflation and deflation create for cooperation also affect real prices and welfare. Depending on the market structure, inflation and deflation significantly lower real prices. This result is in line with Banerjee and Russel's (2001) finding of a negative relationship between inflation and the price markup (see also Galí *et al.* (2007) and Enders (2013) for similar findings in a different framework). Using the utility of the representative agent that we use to generate the demand function as a measure of welfare, the reduced prices increase welfare by increasing the quantities traded in the economy.

We contribute to the experimental macroeconomic literature by modeling inflation as a steady increase of the overall price level rather than a one-off shock that raises or lowers the value of the numeraire from one period to the next by a multiple of a typical rate of year-on-year inflation.[3] Fehr and Tyran (discussed below) popularized this design when studying money illusion. Davis & Korenok (2013), for example, use such a large nominal shock to study price and information frictions. These one-off shocks are, however, rarely observed in practice. An example may be a currency changeover but inflation, at least in the OECD countries during the last decades, is a steady, often small increase of the price level of around 1 to 5 percent per year.

Since we use a Bertrand setting, our research intersects with the literature on oligopoly markets (see Potters & Suettens (2013) for a survey of recent oligopoly experiments). This is one of the experimentally most well studied fields of economics. A meta study by Engel (2007) lists over a hundred different experimental papers using Bertrand and Cournot settings. We want to study effects on cooperation and therefore restrict attention to the case of a duopoly where we expect cooperation to matter most (Huck *et al.*, 2004). Engels reports a large impact of product heterogeneity in some cases we, therefore, include treatments with different product heterogeneity.

Abbink & Brandts (2009) study a duopoly where demand increases or decreases. Similar to our design, the changes are implemented gradually from round to round.

[3]See Duffy (2012) for an excellent survey of the experimental macroeconomic literature.

The authors find that shrinking markets lead to higher prices and conclude that this is driven by increased cooperation in shrinking markets.

In a related line of research, Fehr and Tyran study the phenomenon of money illusion. Fehr & Tyran (2001, 2008) implement an experimental market with a large nominal shock (nominal equilibrium prices are halved in the 2008 paper and more than halved or doubled in the 2001 paper). They find that, depending on the direction of the shock and the strategic environment, a nominal shock can lead to a lengthy period of adjustment before equilibrium is reached again. In contrast to Fehr and Tyran, we use a standard differentiated Bertrand market setup where the demand functions can be derived from the utility function of a representative consumer. Fehr and Tyran deliberately do not implement a standard market structure because they want to avoid the effect of subjects trying to coordinate on non-equilibrium prices. In contrast, the study of the impact of inflation onto this coordination is our explicit goal; therefore, we stick to a model where firms can profit from collectively playing prices above the Nash-Equilibrium. In addition, deriving demand from first principles allows us to perform standard welfare analysis.

In a separate paper by Fehr & Tyran (2007), coordination is studied in an experimental market where the individual payoff of a firm is given in nominal terms. These "nominal points" are then divided by the average price of other firms to calculate the real payoff. In this market, three Nash-Equilibria exist. Play converges to an inefficient Nash-Equilibrium instead of the efficient equilibrium. This situation can roughly be interpreted as one where all other firms are large and combined make up the whole economy.[4] Then, price changes by other firms can be interpreted as inflation. In contrast to that, our firms are large within their respective market (i.e., are able to set prices) but are small relative to the economy: inflation is exogenously given and not influenced by decisions of the firms. Since our market only features one equilibrium, our notion of coordination failure is different from Fehr and Tyran. Whereas in Fehr & Tyran (2007), coordination failure results from converging to

[4]This interpretation does not work perfectly, since the payoff adjustment is made for each firm. That is, for each firm, all other firms would have to form the entire economy.

the wrong equilibrium, we define coordination failure as both firms playing different prices.

The paper is organized as follows. Section 2 describes the setting, and Section 3 the experimental design and the procedure. Section 4 discusses our predictions and Section 5 presents and discusses the results. Concluding remarks in section 6 close the paper.

2 Setting

The setting is a differentiated Bertrand duopoly as proposed by Dixit (1979) with a linear demand structure. Firms are symmetric, have zero marginal costs, zero fixed costs, and no capacity limits. The quantities of the products are q_1, q_2 and nominal prices are n_1, n_2. There is a competitive numeraire sector whose output is q_0 and whose price is P. Inflation is introduced by varying the value of the numeraire good. P is normalized to 1 in the first period of the inflation treatment. The demands are assumed to arise from the utility function of a representative consumer

$$U = u\left(q_1, q_2\right) + q_0. \tag{1}$$

Since this utility leads to zero income effects on the duopoly industry, we can consider it in isolation. The inverse demand functions are partial derivatives of the function u; thus

$$p_i = \frac{n_i}{P} = \frac{\partial u\left(q_1, q_2\right)}{\partial q_i}, \qquad i = 1, 2, \tag{2}$$

where p_i is firm i's real price. We make all standard assumptions that yield downward-sloping reaction functions with a stable intersection. In particular, we assume that utility is quadratic,

$$u\left(q_1, q_2\right) = a\left(q_1 + q_2\right) - \frac{1}{2}\left(q_1^2 + 2\theta q_1 q_2 + q_2^2\right)$$

where $\alpha > 0$, $\theta \in (0, 1)$ and we restrict prices and quantities to be nonnegative. This utility function generates linear demand and linear inverse demand functions of the form:

$$\begin{aligned} q_i &= \frac{1}{1+\theta}\left(a - \frac{1}{1-\theta}p_i + \frac{\theta}{1-\theta}p_j\right), \quad i,j = 1,2 \quad i \neq j \\ p_i &= a - q_i - \theta q_j, \quad i,j = 1,2 \quad i \neq j. \end{aligned}$$

Firms choose their prices given these demand functions. The parameter θ measures the cross-price effects and is a measure of the degree of product differentiation. When $\theta \to 0$, the goods are completely differentiated and the firms are in effect monopolists in two separate markets. As θ increases, the consumer is willing to substitute one good for the other. This is a standard linear demand system that has been used in experiments before, for example, by Dolbear *et al.* (1968) or, more recently, Huck *et al.* (2000). Since marginal costs are assumed to be zero, the profit functions are

$$\pi_i = q_i\left(a - q_i - \theta q_j\right), \quad i,j = 1,2 \quad i \neq j. \tag{3}$$

and the real Nash price and the real perfect collusive price are given by

$$\begin{aligned} p_i^{Nash} &= \frac{1-\theta}{2-\theta}a \\ p_i^{coll} &= \frac{1}{2}a. \end{aligned}$$

Regarding welfare, a natural measure of the household's welfare is its utility.[5] We assume in particular, that the representative household owns the two firms and that the firms' profits are her sole source of income. The budget constraint in this case can be written as

$$\pi_1 + \pi_2 = q_0 + p_1 q_1 + p_2 q_2$$

where π_i denotes firm i's profits. Profits can be simplified to $\pi_i = p_i q_i$. Combining

[5] A different measure would be the sum of the firms' rents and the consumer's rents in the two markets. This measure of welfare is equal to utility only if the two markets are completely separate, i.e., when $\theta q_1 q_2 = 0$.

this with utility (equation 1), our measure of welfare is given by

$$V = u(q_1, q_2).$$

Since quantities are monotone in prices and utility is monotone in quantities, lower prices increase the representative household's welfare by increasing the quantities traded in the economy.

3 Experimental Design

The setting is implemented in a computerized lab experiment. We use printed payoff tables depicting the payoff resulting from any price combination of the two duopolists. Gürerk & Selten (2012) show that subjects tend to be more cooperative in the presence of payoff tables. Since we are interested in the effect of inflation on cooperative behavior, this is advantageous. Implementing a duopoly instead of a larger market stems from the same reasoning. An additional advantage of not presenting payoff formulas is to avoid barriers to participation by subjects with low math skills.[6] To address possible difficulties with reading the payoff tables, we add several control questions between the instructions and the start of the experiment.[7] Additionally, we add a checker-board shading to the payoff table, which makes it easier to spot the payoffs of symmetric strategy choices, without highlighting these over other strategy combinations.

The market is repeated for 20 periods (More repetitions would require enlarging the payoff tables). Subjects are partner matched, that is, the same pair of subjects plays together for all 20 periods. The instructions use a firm-framing, but are neutral

[6] An alternative way of avoiding the payoff function in the instructions would have been a profit calculator. However, our strategy space, while finite, is large: subjects could chose any integer price $p_i \in [1, 40]$. Using a profit calculator would add implicit restrictions on the information intake by subjects due to limited time available to calculate price combinations. We also wanted to avoid the implied normative effect of a payoff calculator with an automated function calculating the best response to a given strategy of the other player (Requate & Waichman, 2011).

[7] The experiment started when all subjects in a session had correctly answered the control questions.

with respect to the matched partner. To introduce inflation, subjects are paid in "profit units" in each period. The exchange rate between profit units and Euro varies in the INF and DEF treatments. All of this, including the (constant) rate of inflation/deflation in each period is known to subjects beforehand: subjects are handed the payoff tables for all periods before making their first decision.

To avoid corner solutions, we choose the payoff tables such that, in all periods of all treatments, the Nash equilibrium price and the collusive price are strictly larger than one and strictly lower than 40. After each period, subjects receive the following feedback: their own chosen price, the price chosen by the other firm, their own nominal payoff and the nominal payoff of the other firm. We have six treatments. Homogeneity is either WEAK ($\theta = .75$) or STRONG ($\theta = .95$), and the market has either inflation (INF) of 5% per period, deflation (DEF) or no inflation (NOINF). Deflation is the reverse of inflation: Period 20 in INF is period 1 in DEF, period 19 in INF is period 2 in DEF and so on. Our treatments are listed in table 1.

`Table 1 about here.`

While all periods are identical in real terms, the nominal prices that constitute the Nash equilibrium strategy vary in INF and DEF. The same holds true for the collusive price. Table 2 summarizes the Nash and collusive predictions.[8]

`Table 2 about here.`

3.1 Procedures

The experiment consisted of fifteen sessions and was conducted at the laboratory of the University of Heidelberg from July 2012 to September 2012. All recruitment was done via ORSEE (Greiner, 2004). In total, 190 subjects took part in our experiment, 109 male and 81 female.

Subjects waited in front of the laboratory until the experiment started. While entering, subjects randomly drew a table tennis ball which assigned them their seat

[8]Due to rounding, the Nash equilibrium is sometimes not unique. Similarly, the perfect collusive strategy is not unique in period 3 of INF (period 18 of DEF).

number. Matching in the experiment was tied to seat numbers. Subjects then received the instructions, the profit tables, and after time for individual questions the sheet with test questions. The experiment did not proceed until all subjects had correctly answered the test questions.[9] The experiment itself, as well as a final questionnaire, were programmed in z-Tree (Fischbacher, 2007). At the end of the experiment, all subjects were called according to their seat number and paid their earnings in private and in cash. Subjects earned on average 9.18 EUR for roughly 75 minutes in the lab.

4 Predictions

The selfish, money-maximizing prediction is playing the Nash equilibrium price of the stage game in all 20 periods.[10] However, it comes at no surprise that subjects try to beat the Nash profit by cooperating with each other. Cooperation leads to higher profits for both parties, but is susceptible to deviations. Therefore, we expect that, in all treatments, some subjects will try to establish cooperation on the collusive price, but that they will not always succeed. We predict a lower rate of cooperation in INF and DEF compared to NOINF. In NOINF, optimal cooperation is achieved by a pair of firms coordinating to play the collusive price of 23 for all 20 periods. It is also possible to coordinate on values between the collusive price and the Nash-equilibrium price.[11] In INF and DEF, collusion requires subjects to frequently change their nominal price to match the real collusive price of 23. These required nominal price adjustments make collusion more complex. As a primary effect, cooperation could be lower because some subjects fail to realize that adjustments are needed. As a secondary effect, punishment might be less prevalent: since it is not clear whether

[9]In some sessions, we had replacement subjects, who also read the instruction and answered the test questions and were to be substituted in for any subject not answering the test questions correctly. However, this never happened. All subjects answered correctly.

[10]In sections 4 and 5 "price" refers to a real price if not stated otherwise.

[11]In principle, subjects could also coordinate to play asymmetric price combinations. However, these lead to unequal outcomes. Given the symmetric setup of the game, a 50-50 split is a clear focal point. Therefore we disregard the possibility of coordinated asymmetric play.

a failure to adjust is a deliberate deviation or a mistake due to complexity, subjects might punish less, thus opening the door to deliberate deviations.

A slightly less profitable, but perhaps easier, way to coordinate is for both firms to coordinate on a (nominally) constant price for several periods. To distinguish the two, we call continued cooperation on a real price "real cooperation" and continued cooperation on a nominal price "nominal cooperation". Figure 1 shows some extreme examples of real cooperation (right hand panels) and nominal cooperation (left hand panels) from the inflation treatment. Nominal cooperation over many rounds reduces the gains from cooperation considerably. Group 405 in the upper left panel starts playing the collusive price and nominally coordinates on this price for most of the experiment. Two attempts to coordinate on a higher nominal price fail, and by period 20, they play the Nash equilibrium and achieve zero gains from cooperation.

`Figure 1 about here.`

Inflation and deflation may also affect subjects regardless of coordination. Following Fehr & Tyran (2001), we call this effect money illusion. If subjects use nominal prices as a proxy for real prices, their (real) choices should have an upward bias in the DEF treatments and a downward bias in the INF treatments.

Engel (2007) finds, for fixed partner matching, lower prices in a market with homogeneous products compared to a market with heterogeneous products. Since we have higher homogeneity in STRONG, compared to WEAK, we expect overall higher prices in the WEAK treatments, at least in the case of no inflation. Engel's results do not include inflation and deflation, but we can search for a similar difference in our INF and DEF treatments.[12]

[12]There certainly will be many reasons for subjects to set a specific price that are common to all our treatments: e.g., some subjects might be more altruistic, some might even play randomly, and there is a large endgame effect. When possible, we control for these in the regressions, but they are not the main focus of our study.

5 Results

To structure the results, we will divide our analysis into three parts. First, we will look at cooperation between the subjects in our treatments. Here we answer the question whether introducing inflation or deflation leads to lower cooperation. Second, we investigate whether the price *level* differs between treatments and thus, how welfare is affected. Finally, we track whether price *changes* differ between treatments. There, we are especially interested in how subjects react to price decreases by their partners, i.e., whether and how subjects punish firms that deviate towards lower prices.

We call pairs of subjects who play an equal price *coordinated* on this price. However, coordination on some price levels does not qualify as *cooperation*. E.g., playing the Nash-equilibrium of the stage game is a sign of coordination, but does not require any cooperation with the other firm, since playing the Nash price follows already from pure self-interest. To differentiate cooperation from coordination, we define cooperation as both firms playing the same price above the Nash price:

$$coop_t = \begin{cases} 1 & \text{if } p_{1t} = p_{2t} > p_t^{Nash} \\ 0 & \text{otherwise,} \end{cases}$$

where p_{it} is firm i's price in period t and $i = 1, 2$. *Collusion* is cooperation on the most profitable price, the collusive price. Additionally, we use the dummy variable $coll\_first3$ to describe attempted collusion. $coll\_first3$ is equal to one if a subject plays the collusive price at least once during the first three periods, and zero otherwise.

5.1 The Effect of Inflation on Cooperation

`Figure 2 about here.`

Figure 2 shows the levels of cooperation in our treatments over time. While the overall share of firms cooperating is 25.6%, we find considerable differences between our treatments. In almost all periods, cooperation in our NOINF treatments is higher than in the INF and DEF treatments. There also appears to be a strong endgame effect, particularly in the STRONG treatments.

Table 3 shows dynamic probit regressions.[13] Specification (4a) is our baseline model. In specifications (1) - (3) we look at levels alone, and then add period and period interaction terms in specifications (4a) - (5). In specification (3) and (5) the first three and last three periods are left out to control for possible endgame and starting effects. In specification (4b), we change the omitted category from NOINFweak to NOINFstrong to allow for easier comparisons among the STRONG treatments. In specifications (2) - (5) we add the dependent variable one period lagged in order to control for any unobserved effects.[14]

`Table 3 about here.`

In specifications (1) - (3), we find that cooperation is significantly lower in the INF and DEF treatments when the homogeneity of products is WEAK. The direction of the effect is the same with STRONG homogeneity, but here it is only strongly significant for the INF treatment.[15] Cooperation in t predicts cooperation in $t+1$ ($coop_{t-1}$), as does being male, although this effect goes away when concentrating on the middle periods. Cooperation in t is higher when a firm's price in $t-1$ is high (p_{1t-1}). Including the variable *period* to take time trends into account (specifications 4a, 4b, and 5) we find that some of the significant differences between the cases with no inflation and those with inflation or deflation are due to different trends in cooperation. INFweak has decreasing cooperation, compared to the case without

[13]We started the data analysis with non-parametric tests but decided to run regressions instead. Non-parametric tests require aggregation of dependent observations. This leads to very few observations (11 in the case of DEFstrong if we pool across periods) making inference difficult. More importantly, many of the variables of interest are trending. Pooling the data across periods ignores this fact.

[14]Dynamic probit models (probit models that include the lagged dependent variable as regressor) are prone to a bias which is called the "initial conditions problem" in the literature. In order to control for this problem we follow Wooldridge (2005). Ignoring this problem and running standard (clustered) probit regressions instead increases the significance of the treatment effects in table 3.

[15]The price level in DEFstrong differs from NOINFstrong at 10% in specifications (1) and (3), and does not significantly differ in specification (2).

inflation, while the time trend is more positive for INFstrong and DEFstrong. Some of the differences between NOINF, INF and DEF are due to different time trends, confirming the impressions from figure 2.

Looking at the comparison between STRONG and WEAK homogeneity, we find a difference in the time trend for the case of no inflation, but no significant differences for the cases of inflation and deflation.[16] Overall, there is strong evidence for lower cooperation under inflation and deflation.

Result 1a (Cooperation): Inflation and deflation reduce cooperation between firms in the experiment.

`Figure 3 about here.`

Until now, we considered real and nominal cooperation equally. The histogram in figure 3 shows the distribution of *nominal* price changes ($\Delta n_t = n_t - n_{t-1}$) of firms that cooperate in period t ($p_{1t} = p_{2t}$). Unsurprisingly, by far the most common observation in the NOINF treatments is a zero price change. In the INF and DEF treatments a zero price change implies that the firms cooperate in nominal terms. In order to cooperate in real terms firms need to raise (lower) their prices by one unit in the INF (DEF) treatments. We see that in the INF treatments, real cooperation is more common than nominal cooperation especially under INFstrong, whereas in the DEF treatments no strong preference for one or the other type of cooperation appears. While over time both forms of cooperation can be achieved between the two firms in a market, the fact that both nominal and real cooperation are chosen by subjects implies that coordination is initially harder: firms in a market not only have to find out whether their opposing firm will cooperate, but also have to build expectations about whether it will cooperate in nominal or real terms. This additional complication can explain the lower rates of overall cooperation we find in INF and

[16] Performing WALD tests in (4a), we find no significant differences between: DEFweak & DEFstrong; INFweak & INFstrong; periodDEFweak & periodDEFstrong; periodINFweak & periodINFstrong.

DEF. This complication is closely related to what Fehr & Tyran (2008) call money illusion. It is not necessary that subjects suffer from money illusion ("individual level money illusion") but it suffices that subjects are not sure about whether their opponent suffers from money illusion.

Result 1b (Nominal versus real cooperation): Under inflation and deflation subjects cooperate both on nominal and on real prices.

5.2 The Effect of Inflation on the Price Level

`Figure 4 about here.`

Figure 4 shows the average real price of all six treatments over the 20 periods of the experiment. We see, again, a clear endgame effect and a strong effect of the first few periods of play. Under WEAK homogeneity, we see a similar downward trend for NOINF and INF, with lower prices in INF. DEF, on the other hand, displays a positive trend in the central periods of the experiment. This positive trend in DEF is repeated in the STRONG treatments but there, no obvious difference between DEF and NOINF appears. INF, on the other hand, displays a strong downward trend.

`Figure 5 about here.`

The average price levels shown in figure 4 disguise the underlying heterogeneity of prices. Figure 5 plots the distributions of prices in our six treatments. The distributions typically have two modes: one close to the Nash equilibrium and one around the collusive (monopoly) price. In the WEAK treatments, inflation and deflation reduce the mass around the higher mode — confirming the impressions from figure 4. A similar picture appears in the STRONG treatments though there the bimodality is less pronounced. It is interesting how the distributions shift over time. Comparing the first 10 with the last 10 periods, we see slight leftward shifts of the distributions in INF and NOINF but a slight rightward shift in DEF. This pattern is even stronger in the STRONG treatments. In the regressions below, the residuals inherit to some extent the bimodality of the regressand.[17]

`Table 4 about here.`

In table 4, we present the regression on the price level. Specification (4a) is our baseline model. We start with describing the non-treatment variables, which have clear results in all specifications. Male subjects set higher prices, as do subjects who played the collusive price during the first three periods ($coll\_first3$). Subjects who are in a group that cooperated in t set considerably higher prices in $t+1$ ($coop_t$).

Regarding the difference between NOINF, INF and DEF, we find a negative price effect when moving from NOINFweak to DEFweak. In later rounds, this is counteracted by the positive time trend in DEFweak. INFweak and NOINFweak are never significantly different at the 5% level in price levels or trends. With STRONG homogeneity, the picture is reversed. DEFstrong is never different from NOINFstrong, but INFstrong is in most specifications.[18]

What about the difference between STRONG and WEAK holding the inflation regime constant? Without inflation, we find a significant difference only when taking the time trend into account and controlling for cooperation ($coop_t$) and for subjects that played the collusive price in the first 3 periods ($coll\_first3$). Under deflation, we never find any significant difference between WEAK and STRONG, however, we do find a difference for the inflation treatments, mostly due to a more negative time trend in STRONG.[19]

Result 2a (Inflation/deflation): Prices in the experiment are significantly higher under deflation and weak homogeneity of products, and under inflation and

[17] The distributions are almost identical when we drop the first and last three rounds to take care of starting and end-game effects.

[18] Specification (4b) is shown with NOINFstrong omitted. Results from Wald tests on NOINFstrong=INFstrong for the other specifications are: (1) n.s.; (2) 10% ; (3) 5% for price levels and 0.1% for trends; (5) 1% for price levels and 0.1% for trends.

[19] WALD test results for INFweak=INFstrong are: (1) 1% for price levels; (2) 5% for price levels; (3) 10% for price levels and 0.1% for price trends; (4) 5% for price levels and 0.1% for price trends; (5) 10% for price levels and 1% for price trends; (6) 10% for price levels and 1% for price trends.

strong homogeneity of products than in the case without inflation.[20]

Result 2b (Weak/strong homogeneity): Prices in the experiment are significantly higher under weaker homogeneity of products in the case of inflation, and, less robustly, under no inflation, but not under deflation.

Since we derive our market demands from a representative agent model, we can calculate welfare as the utility of this representative agent. As discussed in section 2, utility is determined solely by consumption of the two goods (even though the agent owns both firms) so that lower prices raise welfare by increasing the quantities consumed. A figure and a regression on utility levels can be found in the appendix (table 6). While the relationship between prices and utilities is not linear, the results are almost the mirror image of the regression in price levels: welfare is significantly higher in the INFstrong and DEFweak treatments compared to the NOINF cases.

`Table 5 about here.`

5.3 The Effect of Inflation on Price Changes

What influences the decision to change a price? In regression 5, we look at price changes. Our main variable of interest here is Δp_{2t-1}, the price change of the other player in the previous period. An increase, after observing an increase by the other player, can be interpreted as a reward (since a higher price raises the payoff of the

[20]It is a bit of a puzzle why the effect is significant for INFstrong and DEFweak, but not for INFweak and DEFstrong (although the estimates point in the same direction in all four cases). One possible explanation comes from the relative incentives to play nominal cooperation or real cooperation in the next period after a current cooperative price was played. In the weak homogeneity regime, the profit function is rather flat. That is, the loss from being the higher price is relatively minor. Under strong homogeneity, the loss, even from being just one unit above the other firm, is severe. That is, the "safe" option is more attractive under strong homogeneity. But the safe option (the lower price) corresponds to choosing the same nominal price as before under inflation, and corresponds to choosing the same real price as before under deflation. If players are attracted more towards the safe option under strong homogeneity, one would expect INFstrong to differ more from NOINFstrong than INFweak from NOINFweak. On the other hand, DEFstrong would be more similar to NOINFstrong than DEFweak to NOINFweak, explaining our result. However, we do not find these shifts in figure 3, casting some doubt on this explanation.

other player). Similarly, a decrease, after seeing a decrease in price by the other player, can be seen as a punishment.

There is a significant punishing/rewarding effect in all our specifications which does not depend on the treatment: the treatment interaction terms are never significant at the 10% level with the exception of the interaction with DEFweak.[21] The estimate for Δp_{2t} can be interpreted as punishment or reward of *expected* price changes. Of course, here the measurement could be very noisy, since we do not know how well subjects' expectations of the opponent's choice align with real choices. What we find is an effect of much smaller magnitude, but in the different direction: subjects reward price raises in the previous period, but do not reward expected price raises in this period.[22] For Δp_{2t}, too, there are no treatments effects (not shown).

The results for the treatment dummies confirm the impression provided by regression 4: price trends are measured by treatment dummies here, whereas there they were measured by treatment-period interaction dummies. Regarding the other control variables, we find a downward trend when play is at higher levels (p_{1t-1}). This is not surprising, since the Nash price forms a natural selfish lower bound on declining prices. Playing the collusive price ($coll\_first3$) during the first three periods is significant, but only when not controlling for the price level directly. Also unsurprisingly, cooperation has a strong positive effect on the price trend. The result for the lagged own price changes (Δp_{1t-1} & Δp_{1t-2}) is interesting. Price paths are not monotone, but "oscillate" (compare to figure 1, top right panel): all else equal, a price increase is likely to be followed by a price decrease in the next period.

Result 3a (Reward and punishment): Subjects reward price increases by their opponents and punish price decreases. This rewarding and punishing behavior does not differ across treatments.

[21] NOINFweak is the omitted category, but there is no difference in punishment among the STRONG treatments as well. Nor is there a significant difference between $\Delta p_{2t-1} \times INFweak$ and $\Delta p_{2t-1} \times INFstrong$, or $\Delta p_{2t-1} \times DEFweak$ and $\Delta p_{2t-1} \times DEFstrong$.

[22] A different explanation of the result would be that subjects want to reward, but have systematically wrong beliefs.

Result 3b (Price paths): Price paths in the experiment are not monotone but have a tendency to oscillate.

6 Conclusion

In an experimental Bertrand duopoly with differentiated products firms are exposed to inflation and deflation. Our main result is that inflation complicates cooperation. Independently of the market structure, cooperation is lower in the inflation and deflation treatments than in the treatments with a constant price level. Interestingly, some firms cooperate in nominal instead of real terms. This may be interpreted as a sign of money illusion. Money illusion can also explain why real prices have a slightly positive trend under deflation whereas they have a strong negative trend under inflation. Punishment does not appear to differ between treatments. Using utility as a measure of welfare, we find that cooperation by firms lowers welfare. Depending on the market structure, inflation and deflation may significantly raise welfare. Welfare in the treatments with a constant price level is never above welfare in the treatments with inflation or deflation. Intuitively, this is because the reduced prices in these treatments increase the quantities traded in the economy and thus increase welfare.

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7 Tables and Figures

Table 1: Treatments and Number of Subjects per Treatment

	$\theta = 0.75$	$\theta = 0.95$
No Inflation	NOINF WEAK (42 subjects)	NOINF STRONG (24 subjects)
Inflation	INF WEAK (36 subjects)	INF STRONG (26 subjects)
Deflation	DEF WEAK (40 subjects)	DEF STRONG (22 subjects)

Table 2: Equilibria and Collusion in Nominal Terms

		Nash-Equilibrium	Collusion
NOINF	WEAK	10	23
	STRONG	3	23
INF	WEAK	$5 \rightarrow 15$	$15 \rightarrow 38$
	STRONG	$2 \rightarrow 4$	$15 \rightarrow 38$
DEF	WEAK	$15 \rightarrow 5$	$38 \rightarrow 15$
	STRONG	$4 \rightarrow 2$	$38 \rightarrow 15$

Nash Equilibrium and perfect collusion values for each treatment. The arrows ($\rightarrow$) indicate movements of the values from period 1 to period 20.

Table 3: Cooperation Regression

	(1) period 1-20	(2) period 1-20	(3) period 4-17	(4a) period 1-20	(4b) period 1-20	(5) period 4-17
VARIABLES	$coop_t$	$coop_t$	$coop_t$	$coop_t$	$coop_t$	$coop_t$
NOINFweak					-0.233***	
					(0.0420)	
INFweak	-0.123***	-0.113***	-0.156***	-0.0353	-0.241***	-0.154*
	(0.0374)	(0.0343)	(0.0520)	(0.0639)	(0.0374)	(0.0918)
DEFweak	-0.133***	-0.113***	-0.210***	-0.112**	-0.286***	-0.0461
	(0.0360)	(0.0339)	(0.0460)	(0.0538)	(0.0355)	(0.118)
NOINFstrong	-0.0729	-0.0602	-0.0188	0.390***		0.520***
	(0.0464)	(0.0425)	(0.0775)	(0.104)		(0.161)
INFstrong	-0.172***	-0.153***	-0.254***	-0.0791	-0.241***	-0.121
	(0.0298)	(0.0304)	(0.0356)	(0.0619)	(0.0301)	(0.107)
DEFstrong	-0.141***	-0.123***	-0.131**	-0.0589	-0.226***	0.0351
	(0.0348)	(0.0349)	(0.0581)	(0.0691)	(0.0300)	(0.157)
period×NOINFweak					0.0345***	
					(0.00542)	
period×INFweak				-0.00856*	0.0259***	-0.00297
				(0.00443)	(0.00559)	(0.00964)
period×DEFweak				-0.000639	0.0338***	-0.0195**
				(0.00436)	(0.00561)	(0.00977)
period×NOINFstrong				-0.0345***		-0.0433***
				(0.00542)		(0.0114)
periodINFstrong				-0.0100*	0.0244***	-0.0184
				(0.00513)	(0.00612)	(0.0113)
period×DEFstrong				-0.00788	0.0266***	-0.0207*
				(0.00527)	(0.00626)	(0.0114)
period				-0.153***	-0.187***	0.0656
				(0.0463)	(0.0469)	(0.0510)
p_{1t-1}		0.00601***	0.00265	0.00540***	0.00540***	0.00441
		(0.00170)	(0.00279)	(0.00176)	(0.00176)	(0.00286)
$coll\_first3$		0.0461	0.0835	0.0528	0.0528	0.0905
		(0.0376)	(0.0620)	(0.0401)	(0.0401)	(0.0674)
$male$	0.0904***	0.0687**	0.0456	0.0728**	0.0728**	0.0886*
	(0.0330)	(0.0286)	(0.0474)	(0.0301)	(0.0301)	(0.0488)
$coop_{t-1}$		0.187***	0.0922***	0.155***	0.155***	0.0847**
		(0.0258)	(0.0351)	(0.0258)	(0.0258)	(0.0355)
Observations	3,800	3,610	2,280	3,610	3,610	2,280
Log Lik	-1606	-1515	-926.9	-1489	-1489	-928.4

Dependent variable $coop_t$: indicator variable equal to one if both firms set same price ($p_{1t} = p_{2t}$). Probit regressions on six treatment dummies, their period-interactions, firm 1's price level and an indicator variable that equals one if a firm played the collusive price in the first three periods ($coll\_first3$). Specification (1): probit regressions clustered over subjects. Specifications (2) - (5): dynamic probit regressions. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Regressions 1, 3, 4a, 4b: full sample. Regressions 2 and 5: periods 4 - 17.

Table 4: Price-Level Regression

	(1) period 1-20	(2) period 4-17	(3) period 1-20	(4a) period 1-20	(4b) period 1-20	(5) period 1-20	(6) period 4-17
VARIABLES	p_{1t}	p_{1t}	p_{1t}	p_{1t}	p_{1t}	p_{1t}	p_{1t}
NOINFweak					3.481***		
					(1.179)		
INFweak	-0.768	-1.090	-0.285	-1.346*	2.135*	-1.346	-1.537
	(0.951)	(1.058)	(0.897)	(0.797)	(1.240)	(1.020)	(0.955)
DEFweak	-1.799**	-1.268	-4.277***	-3.136***	0.345	-3.136**	-3.355***
	(0.896)	(1.017)	(0.889)	(0.929)	(1.297)	(1.246)	(1.125)
NOINFstrong	-1.422	-0.823	-1.703	-3.481***		-3.481**	-4.145***
	(1.145)	(1.284)	(1.415)	(1.179)		(1.596)	(1.375)
INFstrong	-3.096***	-3.198***	1.532	0.990	4.471***	0.990	1.328
	(0.896)	(1.028)	(1.022)	(1.036)	(1.404)	(1.300)	(1.434)
DEFstrong	-1.711	-0.238	-2.819*	-2.310	1.171	-2.310	-2.730
	(1.125)	(1.302)	(1.511)	(1.466)	(1.728)	(1.990)	(1.958)
period×NOINFweak					-0.158**		
					(0.0772)		
period×INFweak			-0.0460	0.0500	-0.108	0.0500	0.0532
			(0.0615)	(0.0583)	(0.0839)	(0.0754)	(0.0700)
period×DEFweak			0.236***	0.259***	0.101	0.259***	0.344***
			(0.0661)	(0.0651)	(0.0895)	(0.0888)	(0.0878)
period×NOINFstrong			0.0268	0.158**		0.158	0.272***
			(0.0808)	(0.0772)		(0.0994)	(0.0935)
period×INFstrong			-0.441***	-0.328***	-0.486***	-0.328***	-0.361***
			(0.0861)	(0.0826)	(0.104)	(0.107)	(0.121)
period×DEFstrong			0.105	0.137	-0.0211	0.137	0.301*
			(0.110)	(0.111)	(0.126)	(0.150)	(0.173)
period			-0.215***	-0.297***	-0.139*	-0.297***	-0.236***
			(0.0371)	(0.0341)	(0.0711)	(0.0448)	(0.0426)
male	2.490***	2.809***	2.490***	1.775***	1.775***	1.775***	2.023***
	(0.573)	(0.648)	(0.573)	(0.523)	(0.523)	(0.472)	(0.580)
$coop_{t-1}$				4.152***	4.152***	4.152***	4.031***
				(0.492)	(0.492)	(0.652)	(0.518)
$coll\_first3$				1.978***	1.978***	1.978***	1.959***
				(0.633)	(0.633)	(0.632)	(0.718)
Constant	14.65***	14.43***	16.90***	16.11***	12.63***	16.11***	15.25***
	(0.755)	(0.835)	(0.673)	(0.621)	(1.150)	(0.750)	(0.699)
Observations	3,800	2,660	3,800	3,610	3,610	3,610	2,660
adj. R^2	0.060	0.076	0.130	0.222	0.222	0.222	0.204

Dependent variable p_{1t}: firm 1's price in period t. OLS regressions on treatment dummies, their period-interactions, a cooperation dummy ($coop_{t-1}$), and an indicator variable that equals one if a firm played the collusive price in the first three periods ($coll\_first3$). Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Regressions 1, 2, 3, 4a, 4b, and 6: clustered over Subjects. Regression 5: clustered over Groups. Regressions 1, 3, 4a, 4b, and 5: full sample. Regressions 2 and 6: periods 4 - 17.

Table 5: Price-Changes Regression

	(1) period 1-20	(2) period 4-17	(3) period 1-20	(4a) period 1-20	(4b) period 1-20	(5) period 1-20	(6) period 4-17
VARIABLES	Δp_{1t}	Δp_{1t}	Δp_{1t}	Δp_{1t}	Δp_{1t}	Δp_{1t}	Δp_{1t}
NOINFweak						0.263	
						(0.248)	
INFweak	-0.00889	0.137	-0.0239	0.128	-0.0817	0.182	-0.0817
	(0.0806)	(0.115)	(0.0856)	(0.117)	(0.249)	(0.267)	(0.334)
DEFweak	0.227***	0.348***	0.287***	0.354***	0.280	0.543**	0.280
	(0.0717)	(0.101)	(0.0792)	(0.101)	(0.225)	(0.262)	(0.304)
NOINFstrong	-0.0319	0.0847	-0.0470	0.0792	-0.263		-0.263
	(0.127)	(0.174)	(0.131)	(0.175)	(0.248)		(0.309)
INFstrong	-0.235**	-0.445***	-0.276**	-0.439***	-0.992***	-0.729**	-0.992***
	(0.0936)	(0.138)	(0.114)	(0.152)	(0.270)	(0.289)	(0.347)
DEFstrong	-0.0403	0.0460	-0.0168	0.0714	-0.0112	0.252	-0.0112
	(0.117)	(0.128)	(0.121)	(0.125)	(0.265)	(0.292)	(0.359)
$\Delta p_{2t-1}\times$NOINFweak						0.0117	
						(0.0660)	
$\Delta p_{2t-1}\times$INFweak			0.00236	-0.0199	-0.0165	-0.00485	-0.0165
			(0.0776)	(0.0674)	(0.0622)	(0.0662)	(0.0709)
$\Delta p_{2t-1}\times$DEFweak			0.0981	0.107	0.106	0.118*	0.106
			(0.0599)	(0.0679)	(0.0644)	(0.0677)	(0.0733)
$\Delta p_{2t-1}\times$NOINFstrong			0.0156	-0.0121	-0.0117		-0.0117
			(0.0776)	(0.0696)	(0.0660)		(0.0593)
$\Delta p_{2t-1}\times$INFstrong			0.0710	0.0365	0.0304	0.0420	0.0304
			(0.0703)	(0.0655)	(0.0617)	(0.0660)	(0.0643)
$\Delta p_{2t-1}\times$DEFstrong			0.113	0.119	0.116	0.127	0.116
			(0.0813)	(0.0854)	(0.0798)	(0.0827)	(0.0843)
Δp_{2t-1}		-0.0613***	-0.135***	-0.0620***	-0.0762***	-0.0762***	-0.0762***
		(0.0207)	(0.0242)	(0.0202)	(0.0190)	(0.0190)	(0.0254)
male	-0.0336	-0.0846	-0.0257	-0.0842	0.369**	0.369**	0.369**
	(0.0568)	(0.0827)	(0.0603)	(0.0821)	(0.160)	(0.160)	(0.152)
p_{1t}					-0.231***	-0.231***	-0.231***
					(0.0211)	(0.0211)	(0.0242)
Δp_{1t-1}		-0.405***		-0.405***	-0.257***	-0.257***	-0.257***
		(0.0323)		(0.0320)	(0.0297)	(0.0297)	(0.0336)
Δp_{1t-2}		-0.214***		-0.216***	-0.131***	-0.131***	-0.131***
		(0.0310)		(0.0310)	(0.0307)	(0.0307)	(0.0253)
$coll\_first3$		-0.570***		-0.571***	-0.0129	-0.0129	-0.0129
		(0.102)		(0.102)	(0.197)	(0.197)	(0.192)
$coop_{t-1}$		0.681***		0.679***	1.432***	1.432***	1.432***
		(0.145)		(0.143)	(0.191)	(0.191)	(0.239)
Δp_{2t-2}	0.208***	0.155***	0.107**	0.118**	0.107**	0.0952*	0.107**
	(0.0264)	(0.0274)	(0.0447)	(0.0475)	(0.0448)	(0.0523)	(0.0481)
Constant	-0.261***	-0.504***	-0.335***	-0.512***	2.513***	2.250***	2.513***
	(0.0671)	(0.0870)	(0.0757)	(0.0891)	(0.310)	(0.328)	(0.371)
Observations	3,420	3,230	3,420	3,230	3,230	3,230	3,230
$adj.R^2$	0.047	0.209	0.065	0.211	0.269	0.269	0.269

Dependent variable: first difference of firm 1's price in t (Δp_{1t}=$p_{1t} - p_{1t-1}$). OLS regressions on six treatment dummies, their interaction with Δp_{2t-1}) (the other firm's first difference lagged once), the dependent variable lagged, a cooperation dummy ($coop_{t-1}$), and an indicator variable that equals one if a firm played the collusive price in the first three periods ($coll\_first3$). Robust standard errors in parentheses, *** p <0.01, ** p<0.05, * p<0.1. Regressions 1, 2, 3, 4a, 4b, and 6: clustered over Subjects. Regression 5: clustered over Groups. Regressions 1, 3, 4a, 4b, and 5: full sample. Regressions 2 and 6: periods 4 - 17.

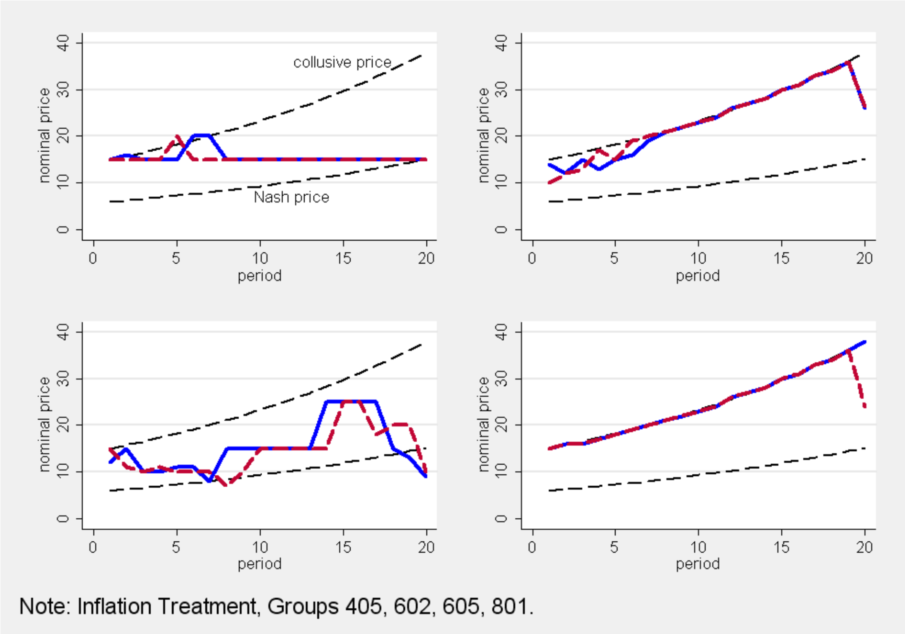

Figure 1: Examples of play in INF. Left hand panels: "Nominal cooperation", right hand panels: "Real cooperation".

Table 6: Utility Regression

	(1) period 1-20	(2) period 4-17	(3) period 1-20	(4a) period 1-20	(4b) period 1-20	(5) period 1-20	(6) period 4-17
VARIABLES	u_t	u_t	u_t	u_t	u_t	u_t	u_t
NOINFweak					13.40*		
					(7.156)		
INFweak	7.640	9.623	3.843	12.73**	26.14***	12.73	10.71
	(7.497)	(8.415)	(6.751)	(6.309)	(7.556)	(8.676)	(7.645)
DEFweak	14.18**	9.348	34.09***	25.81***	39.21***	25.81***	24.45***
	(6.994)	(7.999)	(6.524)	(6.863)	(8.010)	(9.546)	(8.086)
NOINFstrong	-31.15***	-35.38***	-24.19**	-13.40*		-13.40	-14.33**
	(8.173)	(9.105)	(9.561)	(7.156)		(9.906)	(6.830)
INFstrong	-17.75***	-16.52**	-27.98***	-23.37***	-9.972	-23.37***	-25.63***
	(6.083)	(6.797)	(6.900)	(6.239)	(7.566)	(8.489)	(6.764)
DEFstrong	-30.25***	-39.74***	-11.82	-16.00*	-2.601	-16.00	-18.11
	(7.666)	(8.752)	(9.233)	(8.510)	(9.492)	(11.82)	(12.21)
period×NOINFweak					1.478***		
					(0.402)		
period×INFweak			0.362	-0.443	1.035**	-0.443	-0.203
			(0.436)	(0.419)	(0.432)	(0.593)	(0.521)
period×DEFweak			-1.896***	-2.063***	-0.585	-2.063***	-2.525***
			(0.474)	(0.471)	(0.496)	(0.668)	(0.613)
period×NOINFstrong			-0.663	-1.478***		-1.478**	-1.677***
			(0.463)	(0.402)		(0.568)	(0.389)
period×INFstrong			0.975**	0.0828	1.561***	0.0828	0.323
			(0.464)	(0.427)	(0.457)	(0.605)	(0.509)
period×DEFstrong			-1.755***	-1.959***	-0.481	-1.959**	-2.538**
			(0.602)	(0.598)	(0.617)	(0.848)	(1.061)
period			1.793***	2.386***	0.908***	2.386***	1.763***
			(0.285)	(0.265)	(0.312)	(0.375)	(0.310)
male	-15.91***	-18.60***	-15.91***	-10.87***	-10.87***	-10.87***	-12.67***
	(4.104)	(4.662)	(4.107)	(3.657)	(3.657)	(3.297)	(4.089)
$coop_{t-1}$				-31.24***	-31.24***	-31.24***	-31.07***
				(3.555)	(3.555)	(4.857)	(3.759)
$coll\_first3$				-13.45***	-13.45***	-13.45***	-13.88***
				(4.568)	(4.568)	(4.473)	(5.184)
Constant	450.2***	452.8***	431.3***	437.4***	424.0***	437.4***	446.7***
	(5.807)	(6.570)	(5.186)	(4.750)	(6.302)	(6.234)	(5.214)
Observations	3,800	2,660	3,800	3,610	3,610	3,610	2,660
adj. R^2	0.196	0.237	0.247	0.364	0.364	0.364	0.372

Dependent variable u_t: household's utility in period t. OLS regressions on treatment dummies, their period-interactions, a cooperation dummy ($coop_{t-1}$), and an indicator variable that equals one if a firm played the collusive price in the first three periods ($coll\_first3$). Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Regressions 1 2 3 4a 4b 6: clustered over Subjects Regression 5: clustered over Groups. Regressions 1 3 4a 4b 5: full sample Regressions 2 and 6: periods 4-17.

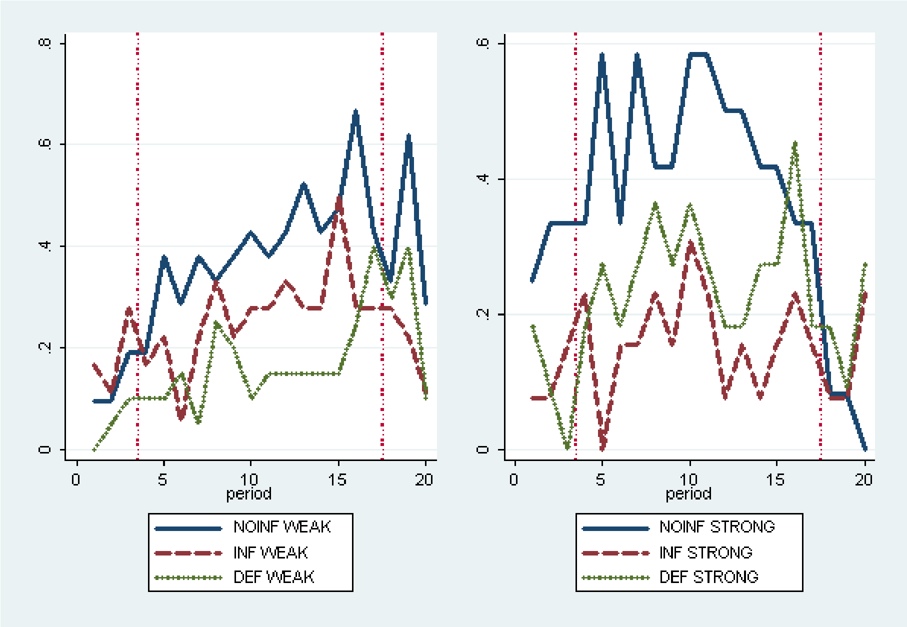

Figure 2: Cooperation over time (by treatment)

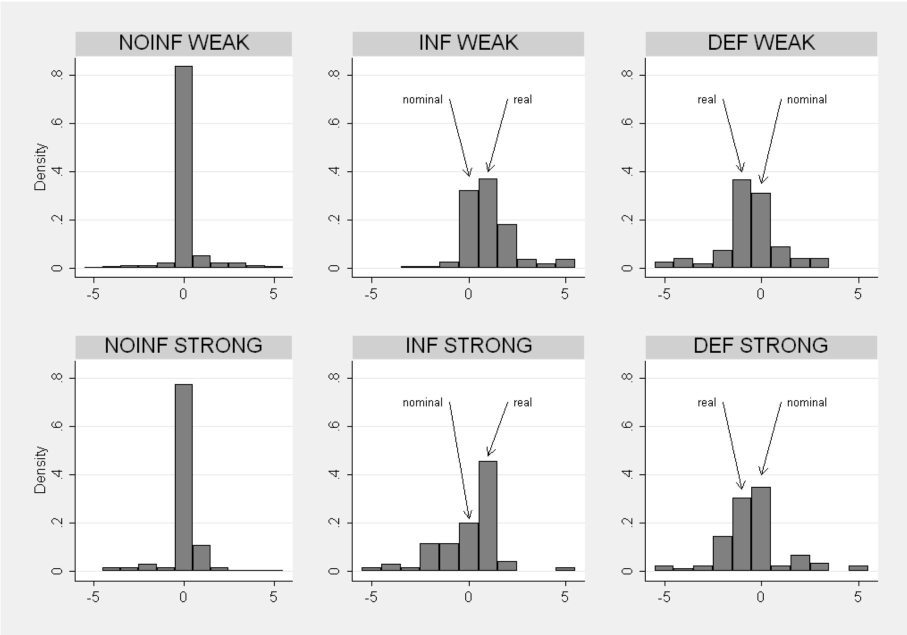

Figure 3: Real and nominal cooperation. Histogram of nominal price changes ($\Delta n_t = n_t - n_{t-1}$) for groups that achieve cooperation in period t. (For ease of exposition, we restrict the observations to $|\Delta n_t| < 6$. Very few observations are outside this range.)

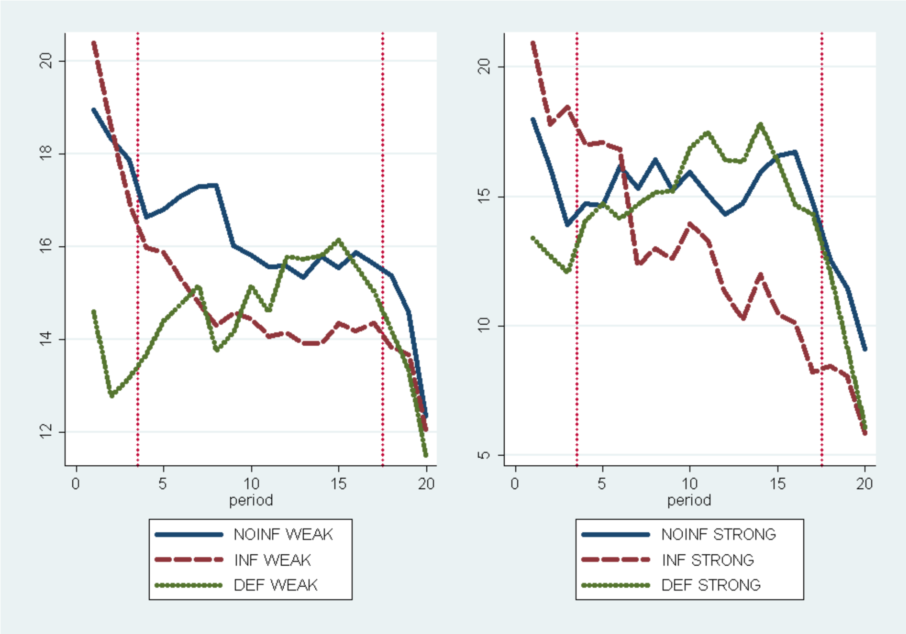

Figure 4: Average price over time (by treatment)

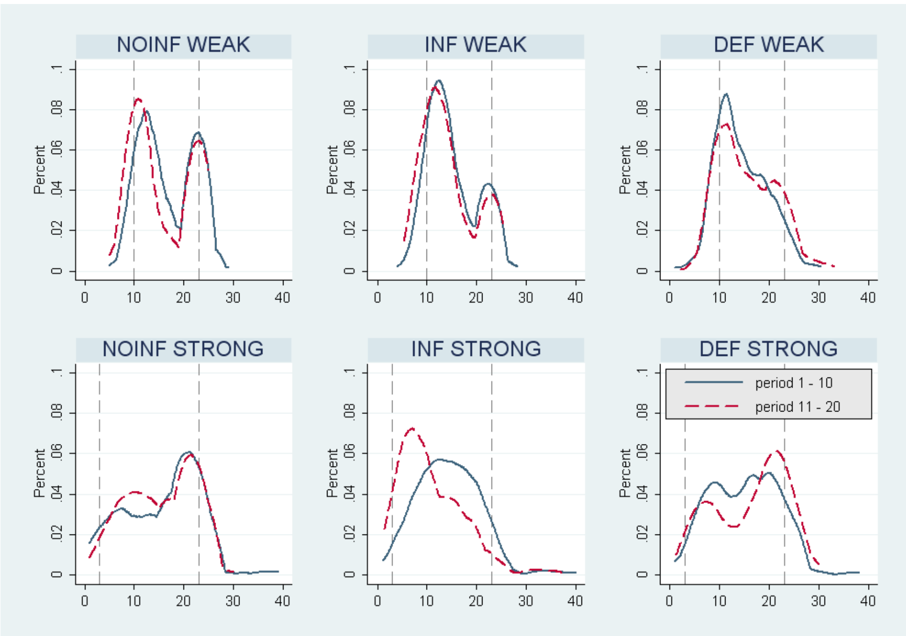

Figure 5: Price Distributions. Kernel density estimates of the price distributions, by treatment and separate for the first 10 and the second 10 rounds of the experiments (Epanechnikov kernel with n=50). Vertical lines: Nash and collusive price.

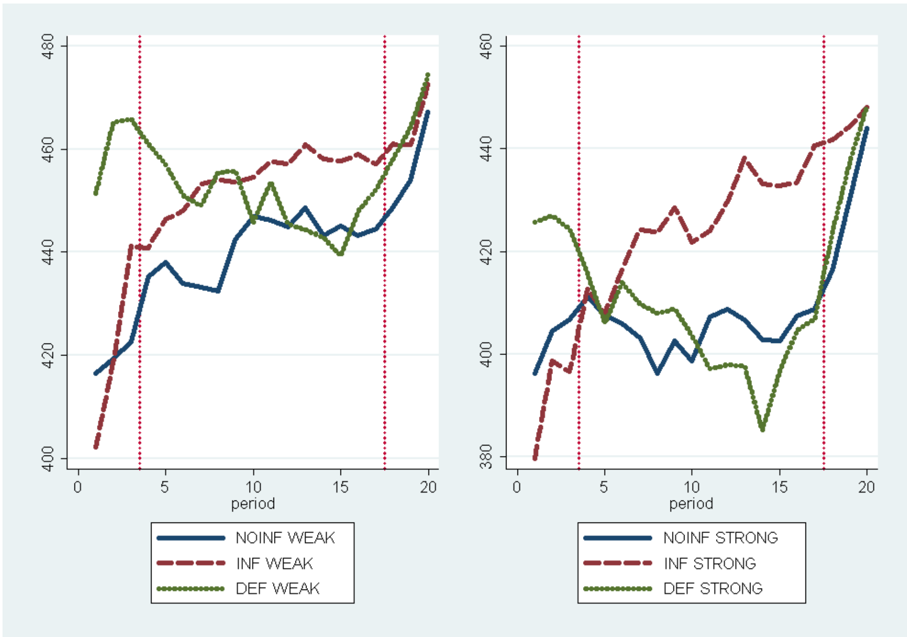

Figure 6: Average utility over time (by treatment)