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Inflation Perception and Relative Price Variability: An Experimental Study

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Abstract: Standard macroeconomics assumes that the cost of inflation is particularly high if inflation distorts relative prices. If price setters adjust their nominal prices in a non-synchronized way, i.e., if inflation causes relative prices variability, consumers are forced re-optimize their consumption choices permanently. In contrast, with synchronized price adjustment, re-optimization is not necessary. This study investigates how relative price variability affects the perception of past inflation in addition to distorting consumption choices. In the experiment, consumers are repeatedly presented with a list of goods and prices from, which they can shop. In one treatment, all prices increase by at the same rate while in the other treatment rates are different across goods. Although, the findings show that relative price variability leads to efficiency losses in reoptimizing individual decisions, the efficiency losses are not statistically significant. Also, we show that the distribution of inflation perception is not statistically significantly different in relative price variability comparing to a synchronic increase in prices.

Key words: Perceived inflation, measured inflation, inflation perception, relative price variability, experimental study

INTRODUCTION

Inflation is defined as a sustained increase in the general level of prices for goods and services. It is measured as an annual percentage increase. As inflation rises, every dollar buys a smaller percentage of a good or service. The value of a dollar, observed in terms of purchasing power does not stay constant when there is inflation. The value of a dollar is the real, tangible goods that it can buy. When inflation goes up, there is a decline in the purchasing power of money. For example, if the inflation rate is 2% annually, then theoretically a $ 1 pack of gum will cost $ 1.02 in a year. After inflation, your dollar cannot buy the same goods, it could beforehand (www.wikipedia.com/inflation). Individuals perceive their own rate of inflation, which is characterized by personal experience. Since individual differs in consumption habits and endowment sets it is apparent that perceived inflation varies across consumers and very often perceived inflation is different from the actual inflation, which takes into account a great bulk of prices of commodities, which may or may not observe the same rate of increase.

The gap between perceived and measured inflation is an important phenomenon in various respects (Giovane and Sabbatini, 2005). Alt (1979) carried out two surveys in Britain and shown that the majority of the persons questioned tended heavily to overestimate the actual rates at, which prices were rising and that their expectations of inflation over the next year were closely related to these overestimate. Bates and Gabor (1986) mentioned that consumer's conceptions of the rate at, which the prices of frequently purchased goods are moving or have been moving over recent periods display a wide scatter and the tendency to overestimate. Fluch and Stix (2005), also confirm that the gap between actual and perceived inflation may influence inflation expectations and thus also actual inflation. It can also lead to questioning the credibility of monetary policy based upon a price index that is not publicly accepted. The Austrian general public, for example, think that the ability of official price measures to adequately represent price movements is mediocre (Fluch and Stix, 2005). This gap possibly diminishes the capacity of producers and consumers to assess price correctly, reducing thereby the price system's allocative efficiency (Brachinger, 2006). If inflation perception is different than the actual inflation rate, specially when perception is higher, workers are forcing for wage spiral. Furthermore, when perception of inflation is extremely higher than the announced inflation rate, people might think that the government is functioning very bad, creating social and political unrest. It is thus, evident that understanding and measuring perceived inflation is a useful undertaking.

Empirically, inflation is more variable and less predictable, when it is higher (Romer, 2006). Accordingly, the association arises through the effect of inflation on

policy. When inflation is low, there is a consensus that it should be kept low and so inflation is steady and predictable. When inflation is moderate or high, however, there is disagreement about the importance of reducing it; indeed, the costs of slightly more inflation may appear small. As a result, inflation is variable and difficult to predict. According to Fischer (1986), increased relative price variability, however is associated with unanticipated changes in the price level in either direction rather than with unanticipated inflation/SE.

Inflation can change the relative prices of goods and services. If, with inflation, all prices go up by same percentage points, then it is much easier for individuals and firms to adjust their prices (including wages and interest rates) and quantities. The economy observes a synchronic increase in all prices equivalent to the inflation rate. As a result, there is no change in real term, output and employment rather than the nominal changes. However, the problem arises when there is variation in price changes: some prices increases faster than the others. This results in a change in relative prices of goods and services.

Inflation induced relative-price variability, with non-synchronic price increase, disrupts markets where firms and customers form long-term relationships and prices are not adjusted frequently resulting from the fairness of the price they are trading at by comparing it with other prices. Highly variable inflation can also discourage long term investment because firms and individuals view as a symptom of a government that is functioning poorly and that may therefore, resort to confiscatory taxation or other policies that are highly detrimental to capital-holders (Romer, 2006).

Relative price variability has the impact on redistribution of wealth. Since prices are affected in different proportion people are gaining or losing in real term depending upon the basket of goods they are consuming and the changing prices of those baskets. This also leads to another problem for the individuals and firms: reoptimization of consumption bundles. With synchronic price increase, individual do not need to reoptimize her consumption bundle as there are no change in relative prices. But with relative price variability, a good can be relatively cheaper or expensive than the others comparing to its initial relative prices. Individuals and firms therefore have to revise their earlier quantities they bought when there is relative price change. This brings additional cost to inflation: collecting information regarding all prices from different markets, going through accounting processes, buying different goods possibly in different markets and so on (Shiller, 1996). Furthermore, a reoptimization task is not so easy and individuals can suffer if she fails to correctly reoptimize her choices. There might be an economy wide efficiency loss thereby with relative price variability.

Relative price variability might also lead to individual's perception of inflation different from the actual inflation rate. With synchronic increase in prices, it is easy to follow the price change. Individual can take any single price as a representative price and can observe the increase. But with relative price variability the representativeness disappears as different prices change at a different rate. Individual might not follow all the prices rather than the prices, which is relevant for her consumption bundle resulting in different level of inflation perceptions across individuals.

Differences in inflation perception resulting from relative price variability can affect real economy, specially in the short run. Individual with higher perception of inflation can seek higher wages. The wage contracts then can break down disrupting employment and output. The problem of reoptimization associated with the possibility of redistribution of wealth induced by relative price variability can beget people's dissatisfaction, resulting socio-political unrest too.

In this study, we attempt to study individual's perception of inflation in two aspects: a synchronic increase in prices and a relative price change. The hypotheses are:

- Perception of inflation by individual is higher and varies significantly when there is relative price variability that is with a non-synchronic price increase, comparing to a situation when price increase is synchronic
- There is an efficiency loss for the consumers due to reoptimization problem when there is relative price variability due to non-synchronic price increase. Individual faces difficulties in reoptimizing their quantity choices with relative price changes result in the efficiency losses comparing to the synchronic price increase

We choose experimental study to test these hypothesises. The specific reasons to choose experimental study for the research purpose are:

- In the experiment, we can control the environment so that it is possible to see the only effect of different pattern of price changes
- In experiment random and wrong decision are costly as it reduces subject's profit. This induces correct decision
- It has not discussed in experimental economics so far and the research on relative price variability is still scanty

Table 1: Description of treatments

Treatments	Increase of prices	Relative prices	Inflation rate (%)
1	By 10% each good each period	Unchanged from period to period	160
2	At different rates for different goods in each period	Changes every period	160

We design two treatments in the experimental set up: treatment 1 consists of a synchronic increase in all prices from period to period and treatment 2 observes variation in price increase, altering the relative prices from one period to another. The two treatments can be summarized in Table 1.

We show from the last column of Table 1 that the inflation rate is same in both treatments and the only difference is that in treatment 2, we have relative price variability, while in treatment 1 price increases synchronically every period. There are six goods in both treatments and subjects have to indicate the quantity she wishes to buy at different periods. Each period starts listing prices of goods and subjects are asked to buy in order to earn profits, which are finally converted to Danish Kroner at a discounted rate for final payment in cash. The higher the profits they make from shopping goods the higher will be their earnings. At the end of each treatment, we also ask about the rate of inflation over the entire treatment. Subjects can earn profit by answering this rate too. We then compare the results whether inflation perception is different across two treatments and whether there is any efficiency losses due to reoptimization task from relative price variability in the second treatment comparing to the first one.

We have 10 observations in each treatment, so 20 observations in totals. The results do not confirm the hypothesis that inflation perception is significantly different with relative price variability comparing to the synchronic increase in prices. Also the findings show that the efficiency losses in reoptimizing individual decisions due to relative price variability in treatment 2 are not statistically significantly different comparing to treatment 1.

MATERIALS AND METHODS

To test the hypothesises, we develop the experiment in each treatment consisting two parts. Subject can make profits from both parts of the experiment specifically, the shopping game: by shopping goods in different periods and the inflation perception part: by answering questions relating change in prices and quantities, namely inflation, at the end of the experiment. Profit is calculated in points and converted to Danish Kroner for final payment with the exchange rate: 50 points equal for one Kroner.

The shopping game: The shopping game we have in the experiment is an individual optimization task. There are prices shown at the beginning of each period. Individual has to find out appropriate quantities for each good, which maximizes her profit. For each set of prices in a specific period there is a unique set of optimum quantities. Any deviation from the optimum quantity reduces individual profits for that good. The profit function for a good is given as:

$$\pi_i = \alpha \left[Q_i - \{\beta - \eta \left(P_i/\bar{P}_i\right)\}\right]^2 \quad (1)$$

Where:

π_i = Profit form good i and $\pi_i \geq 0$
α = 100
Q_i = Individual's choice of quantity for good i
β = 1000
η = 20
P_i = Price of good i
$\bar{P}_i$ = Average price of all other goods

This profit function implies that individual can earn a maximum of 100 points from choosing an optimum Quantity (Q_i) per good per period. It can be also noticed that individual can earn his maximum profit by making the term in the big bracket [ ], zero. That is by choosing Q_i equal to the term in the curly bracket { } individual can reach the optimal quantity of good i. Since $\beta = 1000$, this also implies that the maximum quantity is 1000 for each good any period. This helps to simplify individual optimization task in the experiment. The instruction for experiment clearly mentions it.

The term over the big bracket [ ], measures the deviation, if any of quantity choice by the individual from the optimal one. The square term and the negative sign before it further indicate that any deviation from the optimal quantity will reduce individual's profit from this good. This is thus clear that there is a unique optimum quantity for each good per period. Deviation from that will be costly for the individual. However, negative profit from buying a good is omitted so that there is no penalty of choosing a quantity. This is compatible with traditional economic theory that individual must get non-negative utility buying a good.

To make it easier, the game consists of a calculation help part in the active screen of the computer to help the subjects to justify their alternative decisions. The profit calculator calculates profits for a choice of quantity by the individual whenever, she enters a quantity and press the calculate button. Individual can repeat this process as

many times as she likes before confirming her quantity of a good in the actual decision part. Of course, a subject can see the profit calculations for her own choices only. Taking help from the profit calculator, individual then has to confirm her quantities in the actual decision part of the screen. The program takes her quantities as final choices here and proceeds to the next period displaying new prices. Individual has to find out optimal quantities again as before.

The game has 11 periods in total in each treatment. In each period, we have 6 different goods. Prices are different for different goods. The prices in the initial period range from 10-45. There are three categories of prices: two goods relatively cheaper with prices 10 and 15; two goods expensive with prices 40 and 45 and two goods in the middle with prices 25 and 30. Prices then go up according to treatments we choose for the study purpose. The prices in period 1, optimum quantities according to the profit function in Eq. 1 and optimum profits are shown in Table 2.

Note that the optimum profit for a good in the last column of Table 1 could be obtained only by choosing the optimum quantity of that good, for example, for period 1 by choosing goods equal to the 3rd column of the Table 1.

For the purpose of the study, we choose two treatments in the experiment. In treatment 1, all prices go up by same percentage points from period to period. There is no change in relative prices thereby. A good is as cheap or as expensive compare to other goods as before. Individual does not have to reoptimize her quantity choices thereby in this treatment, since from Eq. 1, we show that the optimum quantity can be written as:

$$Q_i = \beta - \eta (P_i/\bar{P}_{-i}) \quad (2)$$

From Eq. 2, it is clear that the optimum quantity, Q_i is inversely related with relative price of that good, $P_i/\bar{P}_{-i}$. As relative price falls that is $\Delta (P_i/\bar{P}_{-i}) < 0$, the optimum quantity, Q_i, increases and vice versa.

In treatment 1, once the price changes are seen by the subject, she can perceive that this is just an absolute increase in all prices with relative prices remain unchanged. According to the hypothesis, the efficiency loss due to reoptimization task from shopping goods should be close to zero here. In treatment 2, prices go up by different rates for different goods from one period to another. There are thus, changes in the relative price of a good comparing to all other goods. The good becomes cheaper or expensive than it is before. Individual then has to reoptimize her choices. Optimum quantity of a good increases when price of it increases by less than the average increase of all other prices and vice versa.

Table 2: Prices and quantities in period 1, both treatments

Goods	Prices in period 1	Optimum quantity	Optimum profit
A	40	200	100
B	25	500	100
C	30	400	100
D	15	700	100
E	45	100	100
F	10	800	100

The relative price change in treatment 2 thus, implies that individual has to reoptimize her decisions in every period for all different goods. Once individual fails to correctly reoptimize her choices, she will suffer losses. If individual fails to correctly notice the variability of the price change, this reoptimization task can leads to efficiency losses from shopping goods.

Exploring inflation perception: In the second part of the experiment, we ask individual about the rate of inflation from the first period to the last. By correctly answering the rate of inflation individual can earn 1000 points. The profit function is given as:

$$\Pi = \beta - (\rho - \rho_i)^2 \quad (3)$$

Where:

Π = Profit from answering the question relating to inflation and $\Pi \geq 0$
ρ = Actual inflation rate
ρ_i = Individual inflation rate and
β = 1000

Any deviation of individual inflation rate from the actual $(\rho - \rho_i)$ will reduce profit from the optimum 1000 as is evidenced by the profit function. Note that we have used Laspeyre's price index to calculate actual inflation rate, which is simply given as:

$$P_{on} = (\Sigma P_n Q_o / \Sigma P_o Q_o) 100 \quad (4)$$

Where:

P_{on} = Price index in period n based on period o
P_n = Price in the current period n
P_o = Price in the initial period o
Q_o = Quantity in the initial period o

Clearly, Laspeyre's index measures the expenditures on goods at current period if the same basket of goods consumed at the initial period would be bought at current prices.

In the experiment, we have the same actual inflation rate in both treatments. However, the increasing patterns of prices are different. As we mention, treatment 1 consists of a synchronic increase in all prices while treatment 2 observes variation in price increase. The hypothesis is that with synchronic increase in prices it is relatively easier for the subject to notice the price change.

Individual can take price of a good and follow the increase over time. In treatment 2, with relative price changes, this representativeness of price of a good disappears. This might lead to bias in inflation perception by the individual depending on which price or prices she is following. Also, failure to reoptimize correctly with relative price variability in treatment 2 can to lead misperception of inflation. And if there is any deviation of inflation perception from the actual one, the profit function in Eq. 3 indicates that this will result in efficiency losses for the subject.

RESULTS AND DISCUSSION

At the end of each treatment in the experiment, we ask subjects to indicate the rate of inflation. By indicating correct inflation rate subjects could earn as much as 1000 points as given in the profit function for this part of the experiment in Eq. 3. We test the results with two-sample Wilcoxon rank-sum test (Mann-Whitney) test. The test results show that treatment manipulation made no difference in inflation perception, which means that there is no significant difference in perceiving the inflation rate in two treatments. The results are summarized in Table 3.

We have ten observations in each treatment, as shown in second column of the box. According to the hypothesis 1 inflation perception in treatment 2, with non-synchronic price increase should be higher than in treatment 1. But the p-value of 0.73332 does not confirm this. The p-value here simply suggests that we cannot accept the hypothesis that the two distributions are significantly different (http://www.graphpad.com/articles/interpret/Analyzing_two_groups/mann_whitney.htm). It thus implies that perception of inflation is not significantly different in treatment 2 with non-synchronized price increase comparing to the treatment 1 where price increases is synchronic.

To have a clear and through idea we can look into the distributions of inflation perception in two treatments, as shown in Fig. 1and 2 in the following. The Fig. 1 and 2 clearly, does not show any tendency that inflation perception by individuals is converging to the actual one in either of the two treatments. As we mentioned in Table 1 in page 5 that the actual inflation rate is 160 percent in each treatment. The Fig. 1 and 2, here present wide variation of inflation indicated by the subjects from the actual one in both treatments. The figures display a considerable deviation of inflation perceived by the subjects from the actual and also there are no systematic deviations seen in either of the two treatments.

Perceived inflation in treatment 2 is however, relatively dispersed, although not significant statistically

Table 3: Inflation perceptions (two-sample Wilcoxon rank-sum (Mann-Whitney) test)

Variables	Observation	Rank sum
Treatment 1	10	100.5
Treatment 2	10	109.5
Combined	20	210.0

H_0: var2 (var1==1) = var2 (var1==2); z = -0.341; Prob > |z| = 0.7332

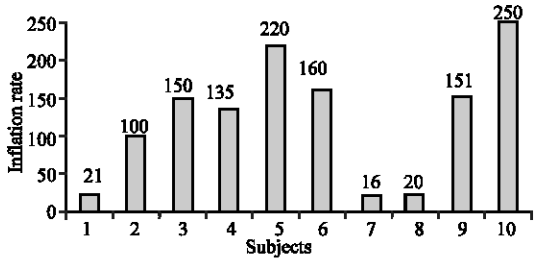

Fig. 1: Inflation perception in treatment 1

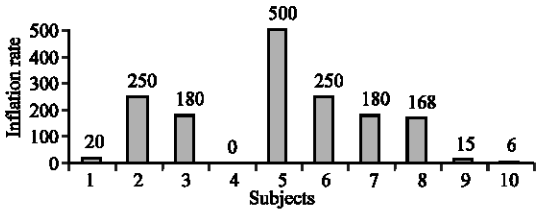

Fig. 2: Inflation perception in treatment 2

as we mentioned earlier, comparing to treatment 1. This can be seen from Table 4. The mean, median and the standard deviations of inflation are all larger in treatment 2 comparing to those of treatment 1.

There are some points to note about the factor behind this misperception of inflation by the individuals:

Optimization error in the initial period: Misperception of inflation could come from the optimization error in the initial period. This is because we use Laspeyre's formula to measure actual inflation, which uses initial quantity as the weight for the price index. However, the data shows that this is not the case. Almost all but two subjects have correctly chosen their quantities at the beginning. The two subjects who missed are just missed in one good each.

Representativeness: In non-synchronic price increase in treatment 2, the representativeness of a good disappears. This might lead to misperception of inflation in this treatment. However, this is not the case in synchronic price increase in treatment 1. But the results in box 1 do not reflect that.

Destruction due to re-optimization: Destruction due to re-optimization in each period in treatment 2 could lead to misperception of inflation. This should not be the

Table 4: Inflation perception in two treatments

Inflation	Treatment 1	Treatment 2
Mean of perceived inflation	122.30	156.90
Median of perceived inflation	142.50	174.00
Actual inflation	160.00	160.00
Standard deviation of perceived inflation	78.45	149.16

Table 5: Profits from inflation perception (Two-sample Wilcoxon rank-sum (Mann-Whitney) test)

Variables	Observation	Rank sum
Treatment 1	10	112.5
Treatment 2	10	97.5
Combined	20	210.0

H_o: var 2 (var1==1) = var 2 (var1==2); z = 0.666; Prob > |z| = 0.5055

case in treatment 1 as with unchanged relative prices optimum quantities are also unchanged. But the results above do not show any compelling evidence that inflation perceptions in two treatments are significantly different.

As the perceptions of inflation are not statistically different across two treatments, the same is equally manifested in earning profits from inflation perception part of the experiment. This is shown in Table 5. The p-value of 0.5055 does confirm the conclusion that the two distributions are not significantly different.

In the first part of the experiment, we have the shopping game in which subjects are asked to shop 6 goods in 11 periods. As explained in this study, choosing an optimum quantity gives a profit of 100 points. So, from shopping a subject could earn a maximum of 6, 600 points in total. Here we present the results from the shopping goods in two treatments.

Table 6 summarizes the two-sample Wilcoxon rank-sum (Mann-Whitney) test for profits from shopping in two treatments. We have the p-value 0.2562 shown in the last row, which means that we have no compelling evidence that the two distributions are significantly different. Based on this result, we cannot say that the median of profits from shopping in treatment 2 are statistically significantly different from that of treatment 1.

We can see the distributions of the profit earned in each treatment. Figure 3 presents the profits earned by subjects in treatment 1 with synchronized price increase. Subject 1 earned a profit of 6500 out of maximum total 6600 while all others earned optimally.

In Fig. 4, we show the profits earned by subjects in treatment 2 with non-synchronic price increase. Seven out ten subjects are optimizing their shopping profits, closely followed by another subject with profit 6500 out of total 6600 points. All these show that the treatment variation does not make any significant differences in re-optimizing shopping goods in treatment 2 comparing to treatment 1.

Table 6: Profits from shopping (Two-sample Wilcoxon rank-sum (Mann-Whitney) test)

Variables	Observation	Rank sum
Treatment 1	10	115.5
Treatment 2	10	94.5
Combined	20	210.0

H_o: var2 (var1==1) = var2 (var1==2); z = 1.135; Prob > |z| = 0.2562

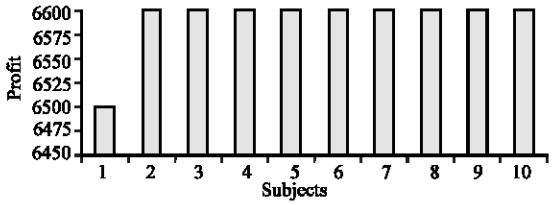

Fig. 3: Profit from shopping in treatment 1

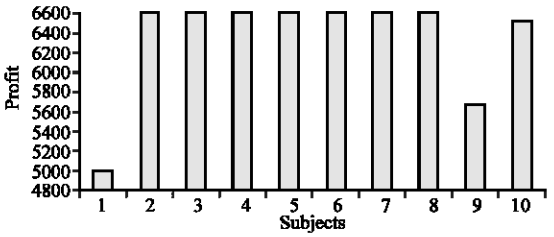

Fig. 4: Profit from shopping in treatment 2

It is clear from the test results presented in Table 3, 5 and 6 that the hypotheses are not supported by the results. There might be some limitations of the study for, which the data are not supporting the hypotheses. We would like to mention some of them for further research. The first point we like to note is that we have very small number of observations in each treatment. We can think to study with a larger number of observations. Secondly, in asking inflation rate we have recalled the quantities and prices only for the first period, which are same across treatments. Might be recalling prices and quantities for all periods, which are different across treatments, would give us a different result. Thirdly, we asked inflation rate in percent, which requires subjects to calculate the inflation rate. Instead we could ask them in objective form like if the inflation rate were low, moderate, high etc. each with a certain ranges of inflation. Fourthly, the inflation rate in the experiment was 160 percent. We could think of a smaller amount of inflation like 10 percent, which is easy to notice by the subjects. Fifthly, frequency of shopping matters in perceiving individual inflation. We could design the experimental set up in a way to study this effect too. Finally, we could take alternative distribution of prices. Prices, which are very closer to each other or vary far could be considered in different treatments.

Table 7: Efforts and Leisure in different treatment time (sec)

Treatments	Allocated time	Average effort	Average leisure	Leisure as effort (%)
1 (synchronic price increase)	2700	745	1955	262
2 (non-synchronic price increase)	3000	1373	1627	118

Further comments: beyond inflation perception: It could be seen that in treatment 1, subjects made their decisions very quickly while in treatment 2, it takes a considerably longer period of time. That is subjects in treatment 1 provide lesser efforts in shopping goods as there are no reoptimizations and enjoyed longer span of idle time as leisure. If leisure is preferred than effort and leisure could be valued, it could then be seen that the relative price variability in non-synchornized price increase would result in further economy wide efficiency losses. This could be shown from the Table 7.

Clearly there are marked differences between the two treatments shown from the 3rd and final columns of the Table 7. The average effort in treatment 1 is 745 sec, while that is 1373 sec, nearly doubled in treatment 2. It thus implies that if leisure is a preferred commodity, as it should be, non-synchronic price movement would cost more to the subjects than that of the synchronic price changes.

CONCLUSION

Individuals perceive their own rate of inflation, which is characterized by personal experience. Since individual differs in consumption habits and endowment sets it is apparent that perceived inflation varies across consumers. And very often perceived inflation is different from the actual inflation. The gap between perceived and measured inflation is an important phenomenon in various respects. The gap between actual and perceived inflation may influence inflation expectations and thus also actual inflation. It can also lead to questioning the credibility of monetary policy based upon a price index that is not publicly accepted. With higher perceptions of inflation workers are forcing for wage spiral. If perception of inflation is too high people might think that the government is functioning poorly, causing political unrest too.

If, with inflation, all prices go up by same percentage points, then it is much easier for individuals and firms to adjust their prices and quantities. The economy observes a synchronic increase in all prices and there is no change in real term, output and employment. However, the problem arises when price increase is non-synchronic as it changes relative prices of goods and services. Inflation induced relative-price variability, with non-synchronic price increase, disrupts markets where firms and customers form long-term relationships and prices are not adjusted frequently resulting from the fairness of the price they are trading at by comparing it with other prices. This requires reoptimization of consumption bundles. There might be an economy wide efficiency loss thereby with relative price variability.

In this study, we attempt to study individual's perception of inflation in two aspects: a synchronic increase in prices and a relative price change. We have studied two hypothesises 1 perception of inflation by individual is higher and varies significantly when there is relative price variability and hypothesises 2, there is an efficiency loss for the consumers due to reoptimization problem with relative price variability. We design two treatments in the experimental set up: treatment 1 consists of a synchronic increase in all prices from period to period and treatment 2 observes variation in price increase. The results, however, do not confirm the hypothesis that inflation perception is significantly different with relative price variability comparing to the synchronic increase in prices. Also the findings show that the efficiency losses in reoptimizing individual decisions due to relative price variability in treatment 2 are not statistically significantly different comparing to treatment 1. However, there are enough scopes to re-investigate the issue further.

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