Reference-dependent preferences, loss aversion and asymmetric price rigidity

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Abstract

In this paper we propose a simple behavioral model to explain some of the stylized facts of asymmetric price rigidity, which are observed empirically. We assume that consumer-producers maximize reference-dependent utility, which is characterized by loss aversion. Depending on which parameter is taken as a reference point, we will observe different directions of the asymmetry. Thus, we explain why some companies are reluctant to cut prices, while others do it quite often.

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The advantage of a bad memory is that one enjoys several times the same good things for the first time.
Friedrich Nietzsche (1844 – 1900)

1. Introduction

Economic decisions are made by human beings. But humans are not necessarily rational. They have feelings, emotions, memory, habits. All these can influence their behavior. For example, once you go to a hairdresser and observe a price increase. The hairdresser explains that the price of vegetable oil has increased and she needs to cover her additional costs[1]. The other day the price of vegetable oil falls, but the price of a haircut does not. You ask why. And the hairdresser explains that vegetable oil has nothing to do with a haircut… In fact, the hairdresser just enjoys higher her own consumption, while she does not agree to cut it in the other case.

Indeed, there is a growing body of experimental literature which shows that individuals are not symmetric utility or profit maximizers as we think of them. In particular, two main deviations from this rule are observed. First, individuals compare their outcomes to some reference point, which can be either their previous outcome, or their expectation about the outcome, or something else. Second, individuals are much more averse to losses than comparable gains. This theory, initially proposed by Kahneman and Tversky (1979) and named "prospect theory" has become extremely popular[2] and influential, since it helps to explain numerous experimental findings of individual behavior going at odds with the traditional theory of rationality. For example, Masatlioglu and Uler (2007) find in their experiments that while the classical choice theory can explain around 58% of their data, the general model of Tversky and Kahneman (1991) explains approximately 90% of it.

Such deviations from classical rationality can explain why the hairdresser changes her prices asymmetrically. When the prices for her consumption goods rise, having the same revenues she will be able to consume less. This undesirable situation is avoided by raising her price as well. When the opposite situation happens, she can afford to consume more and she is happy with it. Also, having sufficiently inelastic demand, her price, being the observable characteristics of her performance to her, may serve as a reference point. Thus, a mere decrease in the price may be considered psychologically as a loss (in spite of the fact that her

[1] This comes from the personal experience of the author in fall 2007 when the price of vegetable oil suddenly increased sharply, and this was widely broadcasted on TV. This only fact created a wave of price increases.

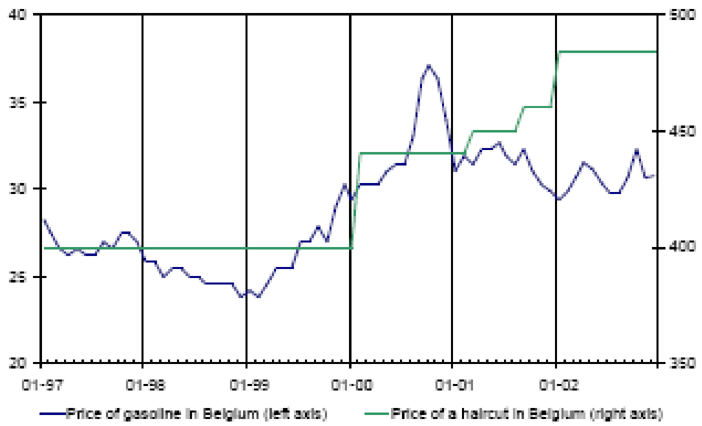
[2] According to Kim, Morse and Zingales (2006), the paper by Kahneman and Tversky "Prospect Theory: An Analysis of Decision under Risk" is the second most cited paper in Economics.

costs may have fallen) which is more painful than a satisfaction from a comparable price increase. Therefore, she will be reluctant to cut her price in response to a deflationary shock while she will easily increase her price in the other case.

Although asymmetric price rigidity is a widely documented phenomenon, the direction of the asymmetry is sometimes debated. One of the most extensive studies concludes that "The odds are better than two to one that the price of a good will react faster to an increase in the price of an important input than a decrease" (Peltzman, 2000). But Levy et al. (2006) find that while "small price increases occur more frequently than small price decreases for price changes of up to about 10 cents, there is no such asymmetry for larger price changes". Indeed, price decreases are found to be quite common (around 40% of all price changes in the Euro area and 42% in the USA), and are usually observed to be larger (Álvarez et al., 2005, for the Euro area and Klenow and Kryvtsov, 2005, for the USA).

The frequency and the magnitude of price adjustments is found to differ significantly across different sectors. The most striking contrast is documented between prices of services and manufacturing goods (services prices being much stickier) in both Euro area and the USA. Also price reductions in the service sector are very uncommon (only 20% of all price changes - see Dhyne et al., 2005). Figure 1 illustrates this difference in price adjustments well, using an example of prices for gasoline and a haircut in Belgium. We see that while the price of gasoline falls during some periods, the price of a haircut does not. Also the price of gasoline is quite volatile, while the price of a haircut increases only occasionally.

Figure 1. Dynamics of prices of gasoline and a haircut in Belgium



Source: Álvarez et al. (2005). Actual examples of price trajectories from the Belgian CPI database. The prices are in Belgian Francs.

Another interesting observation is that big supermarket chains change prices much more often than small "corner shops" (e.g. Baudry et al., 2004), and prices for food in supermarkets are more volatile than prices in restaurants, while both may buy the food from the same distributor for the same wholesale price. Clearly, menu costs alone will not explain this difference.

There seems to be some pricing threshold within which prices do not change, and this threshold may be different for different sectors. Álvarez et al. (2005) find that it is around 8-10% of the retail price. Pricing threshold is consistent with the menu cost hypothesis and other explanations for price stickiness, the most popular of which, according to survey data, are implicit[3] and explicit contracts for the Euro area (Fabiani et al., 2005) and judging quality by price for the USA (Blinder et al., 1998).

Although the above 'pricing anomalies' have been documented by numerous empirical studies, the theoretical explanations for them are rather limited. One of the main explanations of higher downward price rigidity, found in the literature, is a drift in the desired nominal price, which could be caused by a positive trend inflation (e.g. Ball and Mankiw, 1994). But although inflation explains partially the observed asymmetries, it is not the whole story, since the same asymmetries were also observed in periods of low inflation and even deflation (Levy et al, 2006)!

Other explanations of downward price rigidity include a positive trend in desired mark-ups (Dhyne et al., 2006), consumer search with reference prices (Lewis, 2003), tacit collusion among firms with the past price serving as a focal price (Borenstein, Cameron and Gilbert, 1997), implicit coordination among firms in an industry to rise prices after a positive cost shock while not to reduce prices after a negative one (Bhaskar, 2002). Such explanations may indeed be relevant in some cases, but it is not clear why they might exist in the first place. For instance, why should the desired mark-up have a positive trend?

Motivated by the empirical findings described above, in this paper we pay attention to psychological issues which may affect pricing decisions significantly, but have been neglected in the literature. If individuals are not completely rational from the 'classical point of view', then the standard pricing rules coming from profit maximization principle do not work anymore. Thus, we propose a simple model where consumer-producers are behavioral and set prices which maximize their reference-dependent utility. In this model we show that

[3] Companies may prefer to change prices rarely in order to win customers' loyalty, since the customers prefer certainty.

asymmetric price rigidity will take place, and the direction of the asymmetry will depend on what is taken as the reference point. We show that when past consumption is taken as the reference, then we will observe higher upward price rigidity. But when either past money holdings or past labor supply is taken as the reference, we will observe higher downward price rigidity. Then, depending on which effect dominates, we will observe different directions of the asymmetry. Thus, our model helps explain why, for example, in the services industry we usually observe higher downward price rigidity, but for big customer-oriented corporations the opposite may sometimes be true.

The paper proceeds as follows. In section 2 we lay out the theoretical model, describe the equilibrium and analyze different types of reference-dependence and their implications for the asymmetric price rigidity. Section 3 is devoted to discussion and conclusion.

2. The model

2.1. Set-up of the model

Assume an economy populated by *n* identical consumer-producers, indexed by *i*, each of them producing her own differentiated good *j* (thus, n goods are produced). The goods are imperfect substitutes and the market is monopolistically competitive, so that each producer can set a price for her good, depending on the demand for it, which in turn depends on the competitors' prices.

Each consumer-producer extracts utility from her consumption $C_{i,t}$ and real money balances $M_{i,t}/P_t$, but gets disutility from producing her good $Y_{i,t}$. Following Kőszegi и Rabin (2006), who generalize the prospect theory of Kahneman и Tversky (1979), we assume that the utility function consists of two parts:

$$U_{i,t} = u(C_{i,t}, \frac{M_{i,t}}{P_t}, Y_{i,t}) + v(C_{i,t} \left| R^C, \frac{M_{i,t}}{P_t} \right| R^M, Y_{i,t} \left| R^Y \right.) \tag{1}$$

where the first component is the direct utility from current consumption, real money balances and work, while the second one is a behavioral reference-dependent utility, which represents additional gains or losses from deviation from a corresponding reference point R.

We assume a standard direct utility function of the following form:

$$u(C_{i,t}, \frac{M_{i,t}}{P_t}, Y_{i,t}) = \left(\frac{C_{i,t}}{\alpha}\right)^{\alpha} \left(\frac{M_{i,t}/P_t}{1-\alpha}\right)^{1-\alpha} - \left(\frac{d}{\beta}\right) Y_{i,t}^{\beta}, \qquad 0 < \alpha < 1, d > 0, \beta \geq 1 \tag{2}$$

where $C_{i,t}$ is a consumption index with a constant elasticity of substitution θ, $\theta > 1$:

$$C_{i,t} = n^{1/1-\theta}\left(\sum_{j=1}^{n} C_{ji,t}^{(\theta-1)/\theta}\right)^{\theta/(\theta-1)},$$

and P_t is the corresponding price index:

$$P_t = \left(\frac{1}{n}\sum_{j=1}^{n} P_{j,t}^{1-\theta}\right)^{1/(1-\theta)}$$

The direct utility function (2) is characterized by diminishing marginal utility of consumption and real money balances and increasing marginal disutility of labor. High value of θ means the goods are close substitutes.

From the CES property follows the demand for good j of individual i:

$$C_{ij,t} = \frac{1}{n}\left(\frac{P_{j,t}}{P_t}\right)^{-\theta} C_{i,t} \tag{3}$$

We assume that the second gain-loss part of the utility function is additive and linear in deviations of a variable from the corresponding reference point:

$$v(C_{i,t}\middle|R^C, \frac{M_{i,t}}{P_t}\middle|R^M, Y_{i,t}\middle|R^Y) \equiv \gamma_C(C_{i,t} - R^C) + \gamma_M(\frac{M_{i,t}}{P_t} - R^M) - \gamma_Y(Y_{i,t} - R^Y) \tag{4}$$

where $\gamma_C \equiv \begin{cases}\delta^{up}\tilde{\gamma}_C, C_{it} > R^C\\ \delta^{down}\tilde{\gamma}_C, C_{it} < R^C\end{cases}$, $\gamma_M \equiv \begin{cases}\delta^{up}\tilde{\gamma}_M, \frac{M_{it}}{P_t} > R^M\\ \delta^{down}\tilde{\gamma}_M, \frac{M_{it}}{P_t} < R^M\end{cases}$, $\gamma_Y \equiv \begin{cases}\delta^{down}\tilde{\gamma}_Y, Y_{it} > R^Y\\ \delta^{up}\tilde{\gamma}_Y, Y_{it} < R^Y\end{cases}$,

$0 < \delta^{up} < 1$, $\delta^{down} > 1$, and all $\tilde{\gamma}$'s are non-negative.

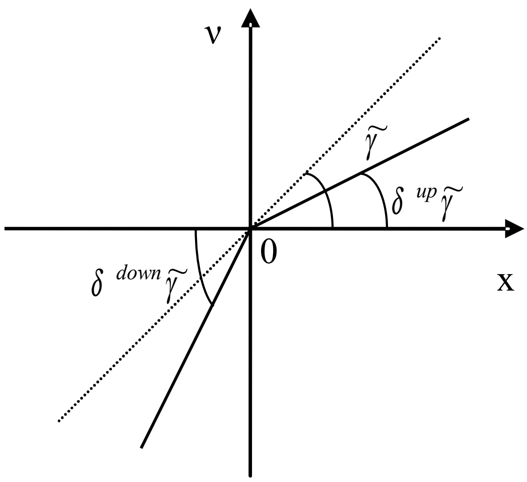
Each component of the gain-loss function (4) satisfies all the properties, specified in Kőszegi и Rabin (2006): for $v(X|R^X) \equiv v(X - R^X) \equiv v(x)$, $v(x)$ is

1. continuous for all x, twice differentiable for $x \neq 0$ and ν(0)=0;
2. ν(x) is strictly increasing;
3. $\mu''(x) = 0$ for all $x \neq 0$;
4. if y>x>0, then ν(y)+ν(-y)<ν(x)+ν(-x);
5. $\frac{v'_-(0)}{v'_+(0)} > 1$, where $v'_+(0) \equiv \lim_{x\to 0} v'(|x|)$ and $v'_-(0) \equiv \lim_{x\to 0} v'(-|x|)$.

Property 3 assumes the constant marginal gain or loss from deviation of a variable from its reference point[4], while properties 4 and 5 assume loss aversion – a higher variable than its reference point yields lower gain than the loss from a similar negative deviation from the reference. In particular, our gain-loss function (4) means that the consumer gets lower additional utility from increased consumption, real money balances and decreased labor, than the additional disutility coming from decreased consumption, real money balances and increased labor.

Figure 2 plots such gain-loss function (the solid line) as well as a symmetric gain-loss function (the dashed line) as a benchmark.

Figure 2. The gain-loss functions with and without loss aversion



It has been estimated empirically, that, on average, the losses are 2-2.5 times as high as the gains (references). Such loss aversion is a widely documented phenomenon, which has been supported by numerous experiments on people and even animals[5].

We further assume that people form habits, so that they compare the current performance with the previous period performance. In other words, the reference for a variable is defined as the realization of this variable in the previous period:

$$R^C = C_{i,t-1}, \; R^M = \frac{M_{i,t-1}}{P_{t-1}}, \; R^Y = Y_{i,t-1}$$

[4] Kőszegi и Rabin (2006) propose a more general function, characterized by diminishing marginal gain or loss: $v''(x) \le 0$ for x>0 and $v''(x) \ge 0$ for x<0. Here we assume the linear function for simplicity.

[5] Loss aversion appears to be linked to affect:
– loss aversion disappears in patients with brain lesions in regions related to affect,
– loss aversion is present in monkeys, who share our affective system but have a more limited cognitive system,
– people predict that individuals experience more emotion if they fall short of a goal or reference point (David Huffman, IZA Bonn lecture notes, 2006).

So, the consumer's utility function (1) means, for example, that the consumer gets utility not only from the consumption itself, but also from the deviation of the consumption from the previous period consumption. If this deviation is positive, the consumer gets some additional satisfaction. If this deviation turns out to be negative, the consumer is more unhappy since she is used to this level of consumption already and treats this as a loss. Thus, the individual will behave asymmetrically putting more effort to escape negative deviations of consumption and real money balances and positive deviations of labor supply.

The consumer-producer's budget constraint is the following:

$$\sum_{j=1}^{n} P_{j,t} C_{ji,t} + M_{i,t} = P_{i,t} Y_{i,t} + \overline{M}_{i,t} \equiv I_{i,t} \tag{5}$$

where the left-hand side represents the consumer's spending while the right-hand side represents her wealth, which is equal to the sales revenues $P_{i,t}Y_{i,t}$ plus endowment $\overline{M}_{i,t}$.

2.2. Equilibrium

Assume for the moment that the wealth $I_{i,t}$ is given. The consumer-producer maximizes the utility function (1) with respect to consumption and real money balances subject to the budget constraint (5). Then the demand functions for consumption and money are the following:

$$C_{i,t} = \frac{\alpha I_{i,t}}{\kappa P_t} \tag{6}$$

$$C_{ij,t} = \left(\frac{P_{j,t}}{P_t}\right)^{-\theta} \frac{\alpha I_{i,t}}{n\kappa P_t} \tag{7}$$

$$M_{i,t} = \frac{(\kappa - \alpha) I_{i,t}}{\kappa} \tag{8}$$

where $\kappa \equiv 1 - \alpha(1-\alpha)(\gamma_C - \gamma_M)$, $\kappa > 0$. It should be noted than if $\gamma_C = \gamma_M = 0$ (there is no reference dependence) or $\gamma_C = \gamma_M$, then $\kappa=1$ and the demand functions are standard. In general, consumption is decreasing in κ while money demand is increasing in κ. But κ in turn depends on the difference $(\gamma_C - \gamma_M)$. The higher is this difference, the higher is the consumption demand and the lower is the money demand since these coefficients show additional marginal utility from consumption and money respectively.

From equations (6) and (8) it follows that if income increases from the previous period, consumption and money demand increase proportionally with the coefficient

$\kappa^{up} \equiv 1 - \alpha(1-\alpha)\delta^{up}(\tilde{\gamma}_C - \tilde{\gamma}_M)$. But if income falls, then consumption and money demand fall with the coefficient $\kappa^{down} \equiv 1 - \alpha(1-\alpha)\delta^{down}(\tilde{\gamma}_C - \tilde{\gamma}_M)$. If $\tilde{\gamma}_C > \tilde{\gamma}_M$ (the consumer cares about a change in consumption more than about a change in money), then $\kappa^{down} < \kappa^{up}$ and consumption will fall more by the absolute value and the money demand will fall less than in the case of a similar increase. If $\tilde{\gamma}_C < \tilde{\gamma}_M$, then $\kappa^{down} > \kappa^{up}$ and consumption will fall less and the money demand will fall more. Thus, we see that the demand functions are asymmetric depending on the sign of the money supply change.

From the individual demand for good *j*, represented by equation (7), we can find the aggregate demand for good *j*, that is the aggregate demand for producer *i*[6]:

$$Y_{i,t} = \sum_{i=1}^{n} C_{ji,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\theta} \frac{\alpha}{n\kappa} \sum_{i=1}^{n} \frac{I_{i,t}}{P_t} \tag{9}$$

where $\sum_{i=1}^{n} \frac{I_{i,t}}{P_t} \equiv \sum_{i=1}^{n} \frac{P_{i,t}Y_{i,t} + \overline{M}_{i,t}}{P_t} = Y_t + \frac{\overline{M}_t}{P_t}$ is the total real wealth in the economy, where Y_t is the total real output and $\overline{M}_t$ is the total nominal money supply.

In equilibrium total output equals total consumption:

$$Y_t = \sum_{i-1}^{n} \sum_{j=1}^{n} \frac{P_{j,t}C_{ji,t}}{P_t} = \frac{\alpha}{\kappa}\left(Y_t + \frac{\overline{M}_t}{P_t}\right)$$

Then, the equilibrium total output equals:

$$Y_t = \frac{\alpha}{\kappa - \alpha} \frac{\overline{M}_t}{P_t}$$

and the total real wealth equals:

$$\sum_{i=1}^{n} \frac{I_{i,t}}{P_t} = \frac{\kappa}{\kappa - \alpha} \frac{\overline{M}_t}{P_t} \tag{10}$$

Substituting (10) into the demand function (9) we get the demand for producer *i* as a function of the total real money balances in the economy and her relative price:

$$Y_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\theta} \frac{\alpha}{n(\kappa - \alpha)} \frac{\overline{M}_t}{P_t} \tag{11}$$

We see that the equilibrium output is decreasing in κ in a similar way as the consumption in equation (6) does. The higher is γ_C and the lower is γ_M, the lower is κ and the

[6] Note that $P_j \equiv P_i$ according to the model set-up since each producer i produces her own good j.

higher is equilibrium output due to higher consumption. The change in the equilibrium output due to a change in the money supply depends on the direction of the change and the relative values of γ_C and γ_M. If, for example, $\tilde{\gamma}_C > \tilde{\gamma}_M$, then $\kappa^{down} < \kappa^{up}$ and a rise in the money supply leads to a smaller increase in output than the fall in the output due to a monetary contraction by the same size. This finding goes in line with the empirical evidence on asymmetric output reaction to positive and negative money supply shocks (e.g. Cover, 1992).

Since each consumer-producer is a price-maker, she will choose the price for her product P_i that will maximize her utility (1) subject to the demand constraint (11). Thus, plugging the consumption demand (6), the money demand (8), and then the demand for the output (11) into the utility function (1) and maximizing it we obtain the optimal price of a producer as a function of the money supply.

As above, the analysis crucially depends on the relative values of all three γ's and becomes messy. Therefore, we will analyze the implications of reference-dependence in each component of the utility function (consumption, money and labor) separately.

2.2.1. Reference-dependence in consumption

In this part we assume that $\tilde{\gamma}_C > 0$ and $\tilde{\gamma}_M = \tilde{\gamma}_Y = 0$. This means that the consumer only cares about a change in consumption, especially a negative change.

Substituting the consumption demand (6) and the money demand (8) into the utility function (1), we get the target function of consumer-producer i given her optimal choices of consumption and money:

$$U_{i,t} = \left(\lambda + \gamma_C \frac{\alpha}{\kappa}\right)\left(\frac{P_{i,t}}{P_t} Y_{i,t} + \frac{\overline{M}_{i,t}}{P_t}\right) - \frac{d}{\beta} Y_{i,t}^{\beta} - \gamma_C C_{i,t-1} \tag{12}$$

where $\lambda \equiv \frac{1}{(1-\alpha)\kappa}\left(\frac{\alpha}{\kappa - \alpha}\right)^{\alpha - 1}$ and $\kappa \equiv 1 - \alpha(1-\alpha)\gamma_C < 1$.

Function (12) is similar to a standard profit function, except for the real money balances term and the past consumption term, which come from being a consumer as well.

Maximizing the utility function (12) with respect to the relative price subject to the demand constraint (11), we get the optimal price of consumer-producer *i*:

$$P_{i,t}^{*} = \mu_C^{\frac{1}{1+\theta(\beta-1)}} P_t^{1-\xi}\, \overline{M}_t^{\xi} \tag{13}$$

where $\mu_C \equiv \frac{d\theta}{\theta - 1}\left(\frac{\alpha}{n(\kappa - \alpha)}\right)^{\beta - 1} \frac{1}{\lambda + \gamma_C \alpha / \kappa}$, $\xi \equiv \frac{\beta - 1}{1 + \theta(\beta - 1)}$, $0 < \xi < 1$.

Since all producers are symmetric, in general equilibrium $\frac{P^*_{i,t}}{P_t} = 1$. Substituting this into equation (13) we get the equilibrium price level in the economy as a function of the money supply:

$$P_t = \mu_C^{\frac{1}{\beta - 1}} \overline{M}_t \tag{14}$$

Using numerical methods we find that the derivative of μ_C with respect to γ_C is positive (see appendix 1). This means that the higher is the marginal utility from increased consumption, the higher is the price level for any level of the nominal money supply.

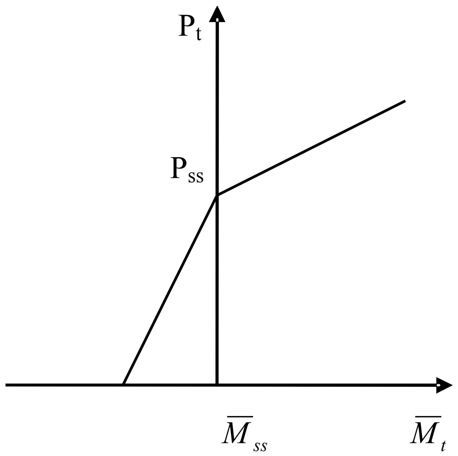
As a benchmark case let us consider a situation when there is no reference dependence at all ($\tilde{\gamma}_C = 0$). Letters with primes denote the parameters in this case. Then, $\kappa' = 1 > \kappa$, $0 < \lambda' = \frac{\alpha^{\alpha - 1}}{(1 - \alpha)^{\alpha}} < \lambda$ and $P'_t = \mu'^{\frac{1}{\beta - 1}} \overline{M}_t$, where $0 < \mu' \equiv \frac{d\theta}{\theta - 1}\left(\frac{\alpha}{n(1 - \alpha)}\right)^{\beta - 1} \frac{1}{\lambda} < \mu_C$. In such a case the price level depends positively and symmetrically on changes in the money supply in the economy.

When symmetric reference-dependence is added ($\gamma_C = \tilde{\gamma}_C$ for both positive and negative changes), the price level will be higher given the same money supply. This happens because consumption and, hence, the demand for each good will be higher, given the same level of income, due to the additional marginal utility of increased consumption. Then the profit-maximizing producers will be able to charge higher prices. Also in this case positive and negative changes in the money supply will lead to the same by the absolute value changes in the price level no matter what is the direction of the change.

Now consider the loss aversion specified in (4). Assume that initially we are in the steady state when money supply does not change and the equilibrium price level is described by equation (14) with $\mu_C = \mu_C(\tilde{\gamma}_C)$. If the money supply increases (consumer *i* receives some additional money endowment), the optimal response of the consumer is to increase her consumption. Then her marginal utility of the increased consumption is $\gamma_C = \delta^{up}\tilde{\gamma}_C$, which enters the new demand function. Thus, the demand rises, but with a lower rate. As a result, the price level will rise by $\Delta P_t^+ = \mu_C^{\frac{1}{\beta-1}} \Delta \overline{M}_t^+$ where $\mu_C = \mu_C(\delta^{up}\tilde{\gamma}_C) < \mu_C(\tilde{\gamma}_C)$.

If the money supply falls, the demand will fall by a greater amount. The corresponding marginal disutility from the lower consumption is $\gamma_C = \delta^{down}\tilde{\gamma}_C > \delta^{up}\tilde{\gamma}_C$. The result of the fall in consumption is a fall in the price level by $\Delta P_t^- = \mu_C^{\frac{1}{\beta-1}} \Delta \overline{M}_t^-$, where $\mu_C = \mu_C(\delta^{down}\tilde{\gamma}_C) > \mu_C(\tilde{\gamma}_C)$. The fall in the price level will be more significant than the rise in it in order to prevent consumption from falling by the same amount as it was rising in case of the money supply increase, and to prevent consumers from suffering more because of the loss aversion. Thus, in case of the reference-dependent consumption, we will observe higher upward price rigidity, which is illustrated in figure 3.

Figure 3. The equilibrium price level under reference-dependence in consumption



2.2.2. Reference-dependence in labor supply

Here we assume $\tilde{\gamma}_Y > 0$ and $\tilde{\gamma}_C = \tilde{\gamma}_M = 0$. This means that the individual's utility is adversely affected by working more than in the previous period, because the additional work or effort is considered as a loss.

In this case $\kappa = 1$ and the consumption demand (7) and the money demand (8) are no longer asymmetric in response to positive and negative changes in the money supply. Also the demand function (11) becomes symmetric, with the level of demand lower for any level of the real money balances.

Now the utility function (12) transforms into

$$U_{i,t} = \lambda'\left(\frac{P_{i,t}}{P_t}Y_{i,t} + \frac{\overline{M}_{i,t}}{P_t}\right) - \frac{d}{\delta}Y_{i,t}^{\beta} - \gamma_Y(Y_{i,t} - Y_{i,t-1}) \tag{15}$$

Again the utility function (15) is similar to a profit function, except for the real money balances and fact that here the profit-maximizing decisions are made not by completely rational calculating machines, but by humans who suffer more from additional work than benefit from less work.

Maximizing the utility function (15) subject to the demand constraint (11) and using the equilibrium condition $\frac{P_{i,t}^*}{P_t} = 1$, we get a similar expression for the equilibrium price level:

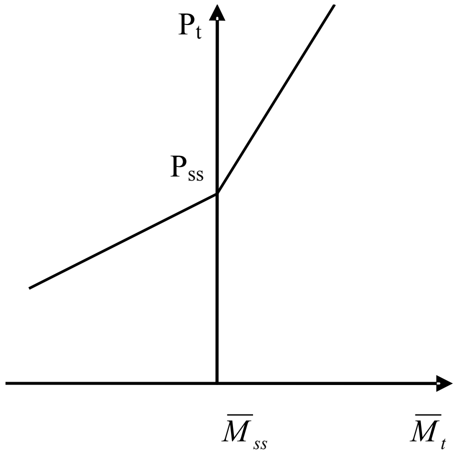
$$P_t = \mu_Y^{\frac{1}{\beta-1}}\overline{M}_t \tag{16}$$

where $\mu_Y \equiv \frac{d\theta}{\lambda(\theta - 1) - \gamma_Y\theta}\left(\frac{\alpha}{n(1-\alpha)}\right)^{\beta-1}$.

It can be easily seen that μ_Y depends positively on γ_Y. Thus, the higher is the marginal disutility from additional work, the higher will be the price level for any level of the money supply, since producers will be tempted to increase prices rather than increase output (work) in response to an increased demand due to higher money endowment.

The relative loss aversion in labor supply also gives rise to asymmetric price rigidity. But now the asymmetry is reversed. If the money supply increases, the demand for goods increases according to equation (11). In this case producers suffer from increased work more, and they will increase prices by $\Delta P_t^+ = \mu_Y^{\frac{1}{\beta-1}}\Delta\overline{M}_t^+$, where $\mu_Y = \mu_Y(\delta^{down}\tilde{\gamma}_Y) > \mu_Y(\tilde{\gamma}_Y)$, in order to avoid some additional work. But when the money supply falls, the benefit from less work is not so significant, and the producers will be reluctant to cut prices as they would rather cut the production. Hence, the prices will fall by $\Delta P_t^- = \mu_Y^{\frac{1}{\beta-1}}\Delta\overline{M}_t^-$, where $\mu_Y = \mu_Y(\delta^{up}\tilde{\gamma}_Y) < \mu_Y(\tilde{\gamma}_Y)$, which is less by the absolute value than the corresponding price increase. Thus, we will observe higher downward price rigidity in case of reference-dependent labor supply. This case is illustrated in figure 4.

Figure 4. The equilibrium price level under reference-dependence in labor supply



2.2.3. Reference-dependence in money holdings

Now we assume $\tilde{\gamma}_M > 0$ and $\tilde{\gamma}_C = \tilde{\gamma}_Y = 0$. Such reference-dependence means that an individual extracts additional utility from holding more money than before, but she becomes very unhappy if she has less money than before.

Then $\kappa = 1 + \alpha(1 - \alpha)\gamma_M > 1$ in equation (11). First, κ s higher than in the cases of reference-dependent consumption and labor. Hence, given the same real money supply, the demand for consumption is the lowest (equations (6), (7) and (11), while the demand for money is the highest (equation (8)). This is so because the consumer now values money more than consumption (for every level of α).

Secondly, now the demand functions again become asymmetric for positive and negative changes in the money supply. A rise in the money supply increases consumption by more than the reduction in it due to a fall in the money supply. The opposite is true for the money demand.

Repeating the same steps as in the previous sections, we again get a similar expression for the equilibrium price level:

$$P_t = \mu_M^{\frac{1}{\beta - 1}} \overline{M}_t \tag{17}$$

where $\mu_M \equiv \dfrac{d\theta}{(\theta - 1)} \left(\dfrac{\alpha}{n(\kappa - \alpha)} \right)^{\beta - 1} \left(\dfrac{1}{\lambda + \gamma_M (\kappa - \alpha)/\kappa} \right)$.

Using numerical methods, we find that μ_M decreases with increasing γ_M (see appendix 2). Therefore, the higher is the marginal utility from additional money holdings, the lower is the price level due to lower consumption. In other words, relative preference for savings reduces the equilibrium price level, as opposed to the relative preference for consumption.

Now we consider the asymmetry in the resulting price rigidity. A rise in the money supply increases the money demand and consumption, thus increasing the price level by $\Delta P_t^+ = \mu_M^{\frac{1}{\beta - 1}} \Delta \overline{M}_t^+$, where $\mu_M = \mu_M(\delta^{up}\tilde{\gamma}_M) > \mu_M(\tilde{\gamma}_M)$. But a fall in the money supply reduces the money demand by more and consumption by less, thus reducing the price level by $\Delta P_t^- = \mu_M^{\frac{1}{\beta - 1}} \Delta \overline{M}_t^-$, where $\mu_M = \mu_M(\delta^{down}\tilde{\gamma}_M) < \mu_M(\tilde{\gamma}_M)$, which is less significant. This happens because the producer wants to maintain her level of income in order to have her money holdings not significantly lower. In such a case we will observe higher downward price rigidity as in the case of reference-dependent labor supply (figure 4).

3. Discussion and conclusion

The observed asymmetries in frequency and magnitude of price adjustments in response to positive and negative shocks, as well as across different sectors of the economy, are difficult to explain with the use of traditional (rational) models of price setting. Although some explanations are provided, they are rather ad hoc, and it is not obvious why they may exist in the first place.

In this paper we propose a behavioral model to explain some of the stylized facts of price rigidity. By assuming reference-dependent utility of price-setters, which is also characterized by loss aversion, we show that prices will respond by different magnitude to positive and negative shocks. Depending on which parameter is considered as the reference point, different directions of asymmetry will be observed.

For example, when past consumption serves as the reference, consumers' demand becomes asymmetric. A negative shock reduces consumption more significantly, and the optimal response of the producer is to cut prices further in order to attract some customers. But a positive shock raises consumption less, since the marginal utility gain from the increased consumption is lower than the marginal utility loss from the decreased consumption by the same magnitude. As a result, prices will rise less as well. Thus, higher upward price rigidity will be observed in pricing strategies of those companies which care a lot about their customer' loyalty, e.g. small 'corner' shops. Indeed, as noted by Blinder (1994), survey responses reveal that some companies do not adjust prices upwards in fear that they will lose their customers.

Another interesting example is when consumption decisions are made without references (and hence the demand is symmetric) but then the producer sets the price to maximize her reference-dependent utility (profit) where her own past consumption is the reference. Then the producer will be reluctant to cut her price in response to a negative shock in order not to end up in a situation with her own consumption far below her previous consumption, which serves as the reference. In such a case we will observe higher downward price rigidity. This explanation is most relevant for the service industry, as well as other labor-intensive industries.

A similar logic can be applied to companies which are thought to be rational profit maximizers. A rise it its costs for inputs reduces the mark-up, and hence may adversely affect the wages, directors' remuneration or dividends. But since the recipients of these will be unhappy with their reduced consumption, the management of the company may be forced to raise the price to keep the mark-up. But when the price for inputs falls, everyone is happy with the higher mark-up, and the price does not change, although it might be more rational to cut the price to have even higher profits. As a result, we observe that a cost change is the main force to drive prices upwards, but not downwards (Peltzman, 2000, Fabiani et al., 2005).

Such asymmetry in the treatment of mark-ups is a purely psychological phenomenon. There is sufficient empirical evidence that individuals are sick with money illusion and require periodical wage increases just in order to remain satisfied with their job (Grund and Sliwka, 2005)[7]. Therefore, there is extremely high downward wage rigidity in the labor market (e.g. Altonji and Devereux, 1999; Holden and Wulfsberg, 2004; Holzer and Montgomery, 1993), which may also be a reason for the higher downward price rigidity.

The same downward price rigidity is observed when either past labor supply or money holdings is taken as the reference. Again, this may be a good explanation for labor-intensive works, e.g. taxi drivers or hairdressers. In general, we find just one possible reason for higher upward price rigidity, while three reasons for higher downward price rigidity. This goes in

[7] Grund and Sliwka (2005) model theoretically and support empirically, that people get unhappier over time. They explain this by the fact that individuals get utility from work which depends not only on the absolute wage level, but also on the level of the wage increase. Since attaining further wage increases on the same job is more and more costly, people get less satisfied with their job over time.

line with the empirical evidence, that downward price rigidity is more often (it takes place in two out of three markets, according to Peltzman, 2000).

Ellingsen, Friberg and Hassler (2005) claim that a convex constant elasticity demand curve may be the source of the downward price rigidity since it entails relatively greater losses from negative price deviations. In this paper we make a step further and explain why such convex (kinked, in our case) demand curve may exist. Our model also gives, although implicitly, some explanation why there may be a positive drift in the desired price (Ball and Mankiw, 1994) and mark-ups (Dhyne et al., 2006), consumer search with reference prices (Lewis, 2003), tacit collusion among firms with the past price serving as a focal price (Borenstein, Cameron and Gilbert, 1997), implicit coordination among firms in an industry to rise prices after a positive cost shock while not to reduce prices after a negative one (Bhaskar, 2002). All these "frictions" have been proposed to explain asymmetric price rigidity, but nothing was said why such frictions may exist. We claim that all these may come from irrational behavior of economic agents, who compare the current outcome to a previous one and treat gains and losses differently.

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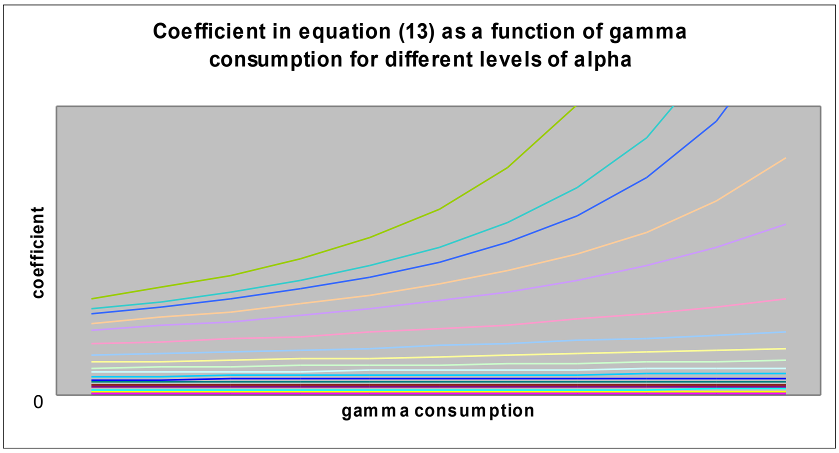
Appendix 1.



Appendix 2.