PRICE-ADJUSTMENT COSTS AND ADJUSTMENT FREQUENCY: AN ANALYSIS WITH INDIVIDUAL DATA*

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Abstract

Different models have stressed the importance of the costs of price-adjustment given that its existence justifies the possibility of some real effects caused by changes in nominal variables. This paper is focused on the evaluation of these costs from a microeconomic perspective. Using a database of Spanish manufacturing firms, the relationship between the frequency of price adjustment and the price diffusion mechanism (and then, the adjustment-cost) in analysed, taking into consideration other control variables as the figure and sign of the price variation, or the position in the market. The nature of the dependent variable (discrete) and the upper censorship in the database (all those firms which change the price more than three times during the year have the same indicator) makes necessary the use of some non-usual econometric techniques, such as ordered probit, and censored discrete dependent variables models. The results show an asymmetric behaviour for positive and negative price variations, as well as the fact that firms which will incur in monetary costs to adjust its price (because they announce them by catalogues or similar methods) will do it less frequently, with the figure of the price variation controlled. Besides, the results allow a comparison of the different econometric techniques to estimate models with discrete dependent variables.

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INTRODUCTION

The existence of some mechanisms that avoid the continuous price adjustment (in goods as well as in labour) has given the theoretical basis for macroeconomic models that establish the existence of real effects derived from changes in nominal variables. In this framework, to know the factors that cause rigidities in the price-formation process is in the core of their theoretical foundamentation. Studies on the labour market and of the mechanisms of wage formation have shown the importance that rigidities to reduce nominal wages, arranged wages for several periods, etc. have to generate mismatches in this market. The analysis of price-formation mechanisms in goods' markets has highlighted the importance of costs in changing prices to explain differences between the optimum price and the actual one. These costs are linked to re-labelling, printing catalogues, but also to goodwill erosion in the case of habit-formation.

Sheshinki and Weiss (1977) show that with adjustment costs, the optimal behaviour will be established by (s, S) rules, in such a way that larger adjustment costs favour less frequent price changes. In this way, they will cause larger differences between the optimal price (in the case of zero adjustment costs) and the actually observed one; so, changes in real prices when nominal variables change will be larger and for a longer period. Then, at the extent that some price-diffusion mechanisms imply a longer period until the adjustment takes place, there is a possibility that changes in nominal variables generate real effects on the economy.

The importance of price adjustment-costs on the whole economy is captured in models such as Rotemberg (1983), that studies the effects on the aggregate output of (s, S) rules of price adjustment. Another important consequence of price adjustment-costs is due to the price dispersion caused. It deteriorates the information that prices provide, which is very important when acquisitions are repeated in time, allowing inefficient producers to survive and reducing social welfare (Tommasi (1994)).

These non-continuous adjustments generate price dispersion which is possible only with imperfect competition. Different theoretical models on this question have approached differently (clients that follow a firm/brand, product differentiation, etc.). Notwithstanding, highly sophisticated market structures are not needed to hold this kind of behaviour. Van Hoomissen (1987) shows that the cost of getting information on behalf of the potential buyers (a highly realistic assumption for industrial products) may be enough to allow this variability.

Empirical papers developed from these models have traditionally used an indirect approach, centred in the relationship between the increases in prices and its variability among sectors, periods, etc. (Danzinger (1987), Domberger (1987), Van Hoomisen (1988), Cancutt, Ghosh and Kelton (1994)). The use of individual data allows a more direct approach to the conclusions of the theoretical models, as Kashyap (1995), Asplund *et al*. (1997), Levy *et al*. (1997), Slade (1998) do.

This paper evaluates empirically the importance that monetary adjustment costs have on the frequency they are modified. With this aim, several of the hypotheses raised in the microeconomic models will be tested, analysing the relationship between the number of changes in price and the amount of the change, taking into consideration whether to announce the price implies a monetary cost (as it happens when the firm uses catalogues, lists and similar means). The use of firm data allows a direct estimation of this relationship by means of a discrete dependent variable model. Besides, it is necessary to isolate individual effects and consider the censored character of the available information.

The paper is organised as follows: In the second section, the main conclusions of the theoretical analysis of the relationship between adjustment costs and the frequency of price adjustment are presented. In the third section, the empirical application of the question is presented and in the fourth the database and the different econometric approaches to be used. The fifth section discusses the results, and the paper finishes with the conclusions.

PRICE ADJUSTMENT COSTS IN THE ECONOMIC THEORY

2.1 Firm changes of price: Relevance of adjustment costs

In the absence of any rigidity, or change in the market structure, the optimal firm price fixation rule will be a continuous adaptation of its selling price, in order to keep it constant in real terms. Notwithstanding, with price adjustment costs, firm behaviour will be different: they will adjust it in some moments of time, separating form the constant real price path.

Sheshinski and Weiss (1977) present a price fixation model derived from the dynamic optimisation problem, where firms (which are maximisers of the discounted flow of future profits) face a demand with downward slope on the real price of the good (this is, imperfect competition with the rest of goods are the alternative to the firm's product). These firms need to determine the optimal price fixation rule in a non-stochastic framework with a constant inflation rate, production marginal costs different from zero, all of them known and constant in real terms. The optimal solution is a (s, S) rule that indicates to the firm that when the price (of firm's product) reaches *s*, it must be changed to *S*. Then, the price will evolve as Figure 1 shows. The (s, S) thresholds are determined by the parameters of the model (rate of growth in general level of prices, discount rate, adjustment costs, etc.). This behaviour rule indicates that the period between two price changes will be larger (and then the frequency of price adjustment lesser) the lesser the growth in prices[1] and the larger the adjustment costs[2].

[Insert figure 1 here]

Other models, as for example Danziger (1983) or Sheshinski and Weisss (1983) generalise the described model because they consider that the inflation rate includes some stochastic elements. They conclude that it is equivalent to the determinist case, so the optimality of (s, S) rules hold.

Most of the (theoretical and empirical) studies that have evaluated price adjustment costs depart from the fact that the main determinant of price changes is the economy-wide change in prices at the extent it affects to firm's costs[3]. They neglect the possibility that price variations are consequence of strategic interactions or to changes in the competitive situation of the market. It is possible to include in the firm's behaviour model different increases in the input costs across firms, but the conclusions will not change at short term. Evidently, this situation will not be sustainable at long term for firms producing the same kind of good because, in this case, those ones whose costs grow more will finish out of the market. This paper follows this line, and nor the causes of the price increase (whatever they are: changes in costs of imported inputs, in the money supply by the central bank, etc.) nor feed-back processes will be considered.

2.2.- Market structure that makes possible the variability

As the price changes in different moments of time, there will be different prices for the same good in the market. Evidently this conclusion of the model is consequence of the imperfect competition assumed in it. Since the paper of Sheshinski and Weiss (1977), the necessity of facing a downward slope demand to get the referred solution has been remarked. The empirical studies on this question is the arena where the variables capable to capture the market structure that allows this kind of price variability were evaluated (see, for example, Caucutt, Ghosh and Kelton (1994), or Walsh and Whelan (1999)).

In this line, Van Hoomissen (1988) shows empirical results that support the hypothesis that the price increases makes possible *per se* some degree of price dispersion. This is possible due to buyers' behaviour, given that they need to collect information on prices before choosing their provider, which supposes some costs. In this case, the larger the price increases, the more costly will be for the buyers the information collection process (information becomes obsolete more quickly) then they will be less exhaustive, making possible larger price dispersion.

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[1] falta una nota

[2] Another models, such as Mussa (1981) and Romer (1989) get simmilar conclusions in their studies of price adjustment.

[3] An exception is Slade (1998) that introduce the dynamics through erosion/accumulation of the goodwill as a function of the time since the last price change.

2.3.- Relationship to test

The described theoretical framework establishes the relationship to test empirically. The frequency of price adjustment will be determined by variables capturing the price variation, competition degree on the market of the firm and the discount rate of future profits. Under the usual assumption that the discount rate equals to interest rate, and then it is the same for the whole population of firms, the relationship to test in the empirical analysis becomes:

Frequency = *f* (Price variation, Adjustment costs, Market competition)

The analysis of the relationship between the price variation and the frequency of adjustment (lesser frequency as the larger variation in absolute terms) has raised the possibility of asymmetries between positive and negative price variations, even with the same monetary cost in the adjustment. The *kinked demand* hypothesis implies that firms will be more reluctant to reduce than to increase prices in order to avoid a price war. Besides, Kuran (1983) indicates that the same costs in increases or reductions of prices may induce an asymmetric behaviour, with a less frequent adjustment for price reductions given that the cost of sub-optimal price is not symmetric. In order to make possible to test these asymmetries, the empirical analysis will distinguish positive and negative price changes.

EMPIRICAL APPROACHES

The relationships established by the theoretical models link the frequency of price variations with different variables; notwithstanding the difficulty in obtaining data on this frequency has favoured an indirect strategy to test these hypotheses. At the extent that in an inflationary process, firms do not adjust continuously their prices, not only some dispersion on prices will be observed, but also in their growth rate between two moments of time. This variability in price variations in function of the variation is in the basis of the larger part of the empirical literature on this topic. Evidently those tests that measure the degree of relationship between the price increases and their variability (or their variation rates) among sectors or time periods, imply the assumption that adjustment costs are the same across sectors or time periods. Analysing this relationship the effect of adjustment costs can be detected, but not its importance given that firms with different costs would be needed.

From a theoretical perspective, results such as Mussa (1981), Kuran (1983) or Romer (1989) establish the relationship between the frequency of price adjustment and the amount of the variation, considering specially the concentration degree in each market[4]. Empirical analysis have studied the relationship between variability on price increases and the mean value using price indexes for different goods, getting results that support these hypotheses. In these works, the influence of the degree of market competition has also been considered, usually by means of concentration indexes[5]. A more detailed attention to market competition is paid in Cancutt, Ghosh and Kelton (1994), which consider product differentiation or the (possible) barriers to entry to characterise the market structure and demand to estimate the relationship between mean growth and price variability across sectors.

Danzinger (1987) criticism indicates that the relationship between mean growth and its variability will not present necessarily a linear relationship. Besides, the consideration of a price index supposes an important limitation at the extent that in the theoretical models this relationship departs from adjustment costs in the firms. Sheshinski and Weiss (1977), as well as the subsequent models that establish the relationship between the frequency of price adjustment and the variation, depart from individual and independent decisions of firms in a market that allow it (by monopolistic competition, costs of search by the clients, etc.). But departing from sector data, the similarity among all the firms is assumed, not only concerning the cost of price adjustment (the key variable to explain the fact that the adjustment is not continuous) but also on the market power they

[4] A different perspective is the one of Hercowitz (1981). He bases the relationship between the dispersion on price variations and inflation rate on the different demand elasticities estimated for each sector.

[5] See, for example Danzinger (1987), Domberger (1987), Van Homisen (1988), Cancutt, Ghosh and Kelton (1994).

have, in the amount they change their prices, etc. The existence of different mechanisms to divulge prices, which are present differently across sectors or even in the time, becomes an argument to carry on the analysis departing from the price of each firm product. Besides, the heterogeneity within each sector stress this requirement.

All this arguments have promoted the development of a new empirical approach focused on the individual behaviour of firms. The first work in this line is Cecchetti (1986) that directly tests the conclusions of models such as Sheshinski and Weiss (1977) analysing the relationship between the frequency of price adjustment and its growth. He estimates a logit model on the decision to change the price in each year with data of a set of 36 American magazines[6] during the period 1953-1979, finding a positive relationship between the inflation rate and the adjustment frequency; at the same time, he finds that the adjustment cost is, in real terms, are decreasing with the adjustment frequency (or increasing with the magnitude of the change, in real terms). A more recent work in this line is Kashyap (1995) that, with data of different final consumption goods, sold through catalogues in USA during the period 1953-1987 shows the existence of additional costs to those ones of printing new catalogues. Levy *et al.* (1997) evaluate the magnitude of the adjustment costs departing from the information of the labelling process in American supermarket chains. Finally, Slade (1998) studies the price adjustment mechanisms, considering the possibility of fixed and variable costs, when they need to me changed, using the retail price for several branches of biscuits in USA.

This paper fits in this new line, testing directly the propositions raised by the theoretical models, searching the relationship between the frequency of price adjustment and the explanatory variables with firm data. It supposes two important advantages in comparison to the traditional analysis. On the one hand, it will be possible to determine the importance that some observable elements have as price-adjustment costs; on the other hand it will possible to determine whether the relationship between dispersion and price growth is really caused by more frequent adjustments.

DATA AND ESTIMATION TECHNIQUES

4.1.- The data

In order to analyse the importance that the factors described in the second section have on the frequency of price adjustment, the Survey on Business Strategies of the Spanish Ministry of Industry *(Encuesta Sobre Estrategias Empresariales, ESEE*) for 1998. This survey collects information of a sample of near 2,000 manufacturing firms on different aspects. Since very often firms produce more than one product, and in these cases it is not possible to determine whether the number of price changes is for the whole set of products, or the main one, these firms have been excluded[7]. A firm is considered as non-diversified on the basis of the Spanish 3-digit classification.

Concerning the theme of this paper, data on the price diffusion mechanisms are included in the survey. The firm is questioned about its price diffusion mechanism, choosing between “catalogues and similars” or “in the direct contact with the client”. The first alternative is associated to larger adjustment costs, given the need to print new ones, sending them, etc. every time prices are changed. Of course they do not exhaust all the adjustment cost, but covers most of the monetary costs linked to a price change.

In the first place, it is necessary to present some descriptive data on the relevant variables. Table 1 contains some data on the price changes[8]. As it can be seen, the observed price variations cover a wide range of cases, with negative values in more than 15% of the cases.

[Insert Table 1 here]

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[6] The assumption of equal adjustment costs across firms (magazines) seems adequate in this case.

[7] Using only non-diversified firms makes the analysis equivalent to the set of products those firms produce.

[8] In order to avoid that missing values for some variables could bias some result, only those firms which answered to all the questions were considered.

The results presented in Table 1 show that the price variations are slightly greater in the case of firms that use catalogues (it holds when the absolute values of the price variations are considered) and with a greater variability.

Thanks to the information on the number of times that each firm changes its price, the relationship established by theoretical models between the frequency of price adjustment and the cost to change the price can be studied. Table 2 presents the distribution of firms according the number of price changes they have done during the year. To analyse the importance of the announcement mechanism on the number of price changes, this distribution is presented for the two considered cases.

[Insert Table 2 here]

The percentage of firms that do not change their price during the year is larger in those firms that have to incur in monetary costs to change them (near 46% of the firms that use catalogues do not change their price in the year, while this percentage reduces to 35% among those ones that do use them), as it is expected. Notwithstanding, when the price variation is controlled the results are not so clear. Unexpectedly, the use of catalogues and similar mechanisms seems to be associated to a more frequently price adjustment.

4.2.- Econometric estimation procedures

For the empirical analysis between the number of price changes and the set of explanatory variables, it is necessary to take into account that the dependent variable has discrete character. It requires the use of econometric techniques adapted to this characteristic[9].

The estimation of the econometric relationship between a discrete variable and a set of explanatory variables is usually done through an ordered probit. This model introduces an error term, ε (assumed to be normally distributed) additively on the empirical specification $\mathbf{X}\beta$. The value $y^* \equiv \mathbf{X}\beta + \varepsilon$ is linked to the observed variable according in order to show the discrete character it has. Let be Y the observed variable, which can take k values $\{y^1, y^2, ... y^k\}$, then:

$$\Pr(Y = y^1) = \Pr (-\infty < \mathbf{X}\beta + \varepsilon < \mu_1) = \Pr (-\infty < \varepsilon < \mu_1 - \mathbf{X}\beta) = \Phi (\mu_1 - \mathbf{X}\beta)$$
$$\Pr(Y = y^2) = \Pr (\mu_1 < \mathbf{X}\beta + \varepsilon < \mu_2) = \Pr (\mu_1 - \mathbf{X}\beta < \varepsilon < \mu_2 - \mathbf{X}\beta) = \Phi (\mu_2 - \mathbf{X}\beta) - \Phi (\mu_1 - \mathbf{X}\beta)$$
$$.....$$
$$\Pr(Y = y^k) = \Pr (\mu_{k-1} < \mathbf{X}\beta + \varepsilon < \infty) = \Pr (\mu_{k-1} - \mathbf{X}\beta < \varepsilon < \infty) = 1 - \Phi (\mu_{k-1} - \mathbf{X}\beta)$$

Among the k-1 parameters which determine the thresholds (μ_1 , μ_2 , ... ,μ_{k-1}), it is necessary to normalise one of them, being the most usual $\mu_1 = 0$. In this problem, the dependent variable can only have four different values, given that the observed data are censored, $\{0, 1, 2, \geq 3\}$, so the estimation of an ordered probit implies the estimation of three thresholds, normalising the first one to 0. In order to guarantee that the obtained values in the maximum likelihood estimation accomplish $\mu_1 < \mu_2 < \mu_3$ it has been considered that $\mu_2 = \mu^2$, $\mu_3 = \mu_2 + (k_1)^2$. To get coherent estimations of the ordered probit model, it is necessary that the estimated value of μ be positive (otherwise the first two values of the dependent variable 1 and 2, would not be distinguished in the estimation) as well as k_1 (to distinguish between 2 and ≥3).

Besides those econometric techniques that, as the ordered probit, deal with a discrete variable model assigning intervals of a dependent variables of each of the possible values, there is another kind of specifications to treat this models, called “count data models”. They raise a discrete statistical distribution as the source of the observed variable. In this way, the discrete nature of the dependent variable is a consequence of the statistical distribution. One of the first applications of this kind of models is Hausman, Hall and Griliches (1984) to analyse the relationship between R&D expenditures and the number of patents.

9 The assumption that the dependent variable is continuous and defined between $-\infty$ and $+\infty$ is clearly unrealistic in this case.

The natural distribution for this kind of variables is a Poisson, where $E(n_i) = \lambda_i$. It must me remembered that a random variable that measures the number of times that an event has happened in a period of time (with a determined duration) follows the Poisson distribution when the probability that the event occurs just once in an interval is proportional to the spell of the period, and that the probability the event happens in non-overlapping intervals is independent. Then, assuming that the probability to observe a price variation in the interval be a proportion of its duration (as it is derived from (s, S) rules with continued increases in the general level of prices), the number of observed price variations in a period of time (i.e. one year) could be assumed to be Poisson distributed.

The econometric specification on the relationship between the number of price variations and the explanatory variables is captured in $E(y_i) = \lambda_i = \exp(\mathbf{X}\beta)$ (the expected number of price variations is given by the parameter of the distribution λ_i which is a linear combination of the explanatory variables). Among the reasons to chose an exponential relationship with $\mathbf{X}\beta$ is that it provides naturally non-negative values of λ_i, which is a requirement of the Poisson distribution.

The data provided by the Survey on Business Strategies are censored for those firms that change their price three or more times along the year. To estimate by maximum likelihood this specification, it is necessary to assign to the observed values that correspond to the censorship (because the price has changed three or more times) the probability of this event departing from the probability function of a Poisson distribution (as Tobit models for continuous variables)[10].

Then, the probability that the variable Y takes the value y_i considering that values over three are censored, will be given by:

If $y_i = 0, 1, 2$

$$\Pr(Y = y_i / X_i) = \frac{\exp(-\lambda_i)\lambda_i^{y_i}}{y_i!} \qquad \text{with} \quad \lambda_i = \exp(X_i\beta)$$

If $y_i \geq 3$ (as the data do not indicate the observed value)

$$\Pr(Y = y_i / X) = 1 - \Pr(Y = 0 / X) - \Pr(Y = 1 / X) - \Pr(Y = 2 / X)$$

RESULTS

To test the different hypothesis that the theoretical model raises, several empirical specifications were considered. Besides the constant and the dummy variable STANDARD, a variable that values 1 if the firm uses catalogues and similar as the mechanism to announce the sales price, the price variation (in percentage) was considered. This variable has been included separately for increases and decreases of prices (column 1), distinguishing when the firm announces its price by catalogues and similars or in the direct relationship with the client (column 2), and introducing the squared value (column 3) to allow for a non-linear relationship. In the appendix a detailed description of the used variables can be seen. In any case the null hypotheses of equality of the parameters for positive and negative price variations, or between the two ways to announce the prices were tested, presenting the Wald tests in the second part of Table 3.

[Insert Table 3 here]

The results contained in Table 3 support the effect of adjustment costs and the frequency of price adjustment as predicted by the theory. Although the dummy variable CATALOGUE is not significant, specifications (2) and (3) show that the effect of the price variation is different according the employed price diffusion method.

[10] Terza (1985) presents the estimation of a Poisson model where one observed value resumes a set of the values of the dependent variables. This is, a censored case as in this problem.

Besides, hypothesis tests on symmetry between positive and negative price variations are presented. They confirm that firms follow a different behaviour for price increases and decreases as indicated by Kuran (1983).

Concerning the results for the other set of variables we may conclude that the relationship with the client derived from a standar/tailor-made product does not introduce any additional adjustment cost on prices. Besides, smaller firms change prices less frequently, which could be due to the existence of other costs which are not proportional to firm's size (as reputation's losses) or to a higher client concentration. Finally, market's share does not have any significant effect.

Results interpretation

In order to show, as clearly as possible, the results from the estimations, estimated relationship between the price variation and the (expected) number of price changes in the year will be plotted.

From the OLS estimation, the expected value of the variable will be $Y^*_{OLS} = X \ \beta^*_{OLS}$. Then the expected number of prices changes n^*_{OLS} $(PV=pv_i)$ could be determined by the closest integer to $|Y^*_{OLS}|$

From the probit estimation, the expected value of the number of price adjustments will be $Y^*_{PROBIT} = X \ \beta^*_{PROBIT}$ and the expected number of prices changes n^*_{PROBIT} $(PV=pv_i)$ will be

≥ 3	if	$Y^*_{PROBIT} \in [1.433, \infty)$
2	if	$Y^*_{PROBIT} \in [0.602, 1.433]$
1	if	$Y^*_{PROBIT} \in [0, 0.602]$
0	if	$Y^*_{PROBIT} \in (-\infty, 0]$

For its part, according to the poisson estimation, the expected value of the mean will be $Y^*_{POISSON} = X \ \beta^*_{POISSON}$. Then $n^*_{POISSON}$ $(PV=pv_i)$ could be determined considering that

$$\Pr(n = n_i / X_i) = \frac{\exp(-\lambda_i)\lambda_i^{n_i}}{n_i!} \qquad \text{with} \quad \lambda^*_i = \exp(Y^*_{POISSON})$$

As it is known $E(n_i) = \lambda^*_i$ and then $E(\ n^*_{POISSON}\ (PV=pv_i)\ ) = \lambda^*_i = \exp(Y^*_{POISSON}) = \exp(X\ \beta^*_{POISSON})$.

In order to plot the relationship between the two variables of interest, some values need to be assigned to the other explanatory variables. A large firm, with standard output and a 2% of market share has arbitrarily been considered. For the price variation the range (-10%, +10%), which includes 96% of the observations, has been displayed. In the graphs the values of Y* for each of the three estimation procedures are presented, besides it has been distinguished the schedule for the catalogues and the direct contact estimations as mechanisms of price diffusion. The estimations are the ones collected in column 3 of Table 3, which allows for differences in positive/negative price variations as well as for catalogues/direct contact mechanisms.

The two panels of Figure 2 show the expected values of the number of price changes respectively for the case of catalogue diffusion and for direct-contact price diffusion. Each of the three schedules displayed in the panel corresponds to the OLS, ordered probit and poisson estimation. As it can be seen there are not important differences between the ordered probit and the poisson estimations. The OLS expected values are the ones more different, but it must be considered the strong non-accurate assumptions of the OLS for this problem (the dependent variable only takes the values $\{0, 1, 2, \geq 3\}$).

[Insert Figure 2 here]

Going to the economic question addressed in the paper, we can see graphically the consequences of the differences statistically detected. Although the asymmetry becomes a bit harder to detect at first sight, a more detailed analysis shows that for a positive variation requires a larger number of price adjustments than a negative one of the same magnitude (except in the OLS estimation). This is an important result that deserves further (theoretical and empirical) research, given the possibility of deflation in some economies.

On the other hand, the comparison on the number of price adjustments between the two considered mechanisms of price diffusion, shows that it is larger when the price is announced in the direct contact, specially when the amount of price variations overpasses, in absolute values 5%. For price variation below this level, the expected number of price adjustment is slightly larger when the catalogues are used, but the difference is not statiscally significant. The fact that monetary adjustment costs are more important for large price variations could be explained because in this case, when a firm decides to change the price, it must be very sure of that. So it saves money doing it less gradually. Notwithstanding, firms that do not need to incur in monetary costs to adjust the price will be closer during the whole period to the constant real price path. In the three panels of Figure 3, it can be seen clearly that this difference holds for the three estimation procedures.

[Insert Figure 3 here]

CONCLUDING REMARKS

Price adjustment costs are in the basis of macroeconomic models that raise the possibility of real effects derived from changes in nominal variables. This paper has analysed empirically the importance of such costs using detailed individual firm-product data.

While a large part of the empirical tests on this question have addressed it indirectly, here the relationship between the price adjustment frequency and the existence of adjustment costs has been estimated. Econometric techniques that deal with discrete dependent variables that are censored have been used.

The results confirm empirically the influence that adjustment costs have for price variation over ± 5%. Besides an asymmetric behaviour for positive and negative price variation has been detected showing that price reductions are done with a smaller number of price variations. Implications for macroeconomic models are straightforward: adjustment costs increase their relevance when price change over ± 5%, and asymmetric behaviours for inflation/deflation need to be considered.

APPENDIX

Variables definition

Dependent variable

Frequency of price change in the year. The firm indicates how many times has changed its price along the year {0, 1, 2, ≥3}.

Explanatory variables

The set of covariates tries to capture the variables suggested by the theoretical framework that sustains the hypotheses to test.

The dummy variable STANDARD values 1 for those firms whose product is the same for every client and 0 when it is tailor-made

To control for market power, the variable SHARE is included. It collects the share that the firm says it has on (what it considers) its relevant market.

To capture the mechanism of price diffusion, firms distinguish whether they do it by means of catalogues and similar methods or if they do it in the direct contact with their clients. Obviously the firs case requires of adjustment costs to change the price. The dummy variable CATALOGUE values 1 when the firm uses those means, and 0 otherwise.

Total variation in the sales price during the year is measured in percentage. In the econometric estimations some interactions between this variables, the diffusion mechanism and the sign of the variation were considered. The set of included variables is:

PV+	Price variation if it positive
PV–	Price variation if it negative
PV-CAT+	Price variation if it is announced by catalogues and is positive
PV-CAT–	Price variation if it is announced by catalogues and is negative
PV-NEG+	Price variation if it is announced in the negotiation and is negative
PV-NEG–	Price variation if it is announced in the negotiation and is negative

To allow a wider specification the squared values of these variables has also been included.

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Table 1: Distribution of the price changes

	All		Catalogues		Direct contact	
	Number	%	Number	%	Number	%
Price variation in the year						
<-25	2	0,19%	2	0,26%	0	0,00%
[-25, -10)	22	2,13%	14	1,81%	8	3,05%
[-10, -5)	37	3,58%	30	3,89%	7	2,67%
[-5, -3)	27	2,61%	19	2,46%	8	3,05%
[-3, 0)	75	7,25%	64	8,29%	11	4,20%
= 0	449	43,42%	357	46,24%	92	35,11%
(0, 3]	299	28,92%	195	25,26%	104	39,69%
(3, 5]	75	7,25%	54	6,99%	21	8,02%
(5, 10]	36	3,48%	29	3,76%	7	2,67%
(10 25]	12	1,16%	8	1,04%	4	1,53%
>25	0	0,00%	0	0,00%	0	0,00%
All	1034	100%	772	100%	262	100%
Mean	0,40		0,29		0,74	
Mean of |pv|	2,34		2,31		2,45	
Variance	19,52		20,69		16,01	

Source: Own elaboration on SBS-98

Table 2: Frequency of price adjustment

Price variation in the year	Mechanism	# cases	Price changes in the year (%)	Zero		One		Two
<-25	Contact	0	0	--		--	--	--
	Catalogue	2	0	0,0	0	0,0	0	0,0
[-25 -10)	Contact	8	0	0,0	3	37,5	1	12,5
	Catalogue	14	0	0,0	0	0,0	2	14,3
[-10 -5)	Contact	7	0	0,0	3	42,9	1	14,3
	Catalogue	30	0	0,0	8	26,7	6	20,0
[-5 -3)	Contact	8	0	0,0	4	50,0	0	0,0
	Catalogue	19	0	0,0	5	26,3	3	15,8
[-3 0)	Contact	11	0	0,0	7	63,6	1	9,1
	Catalogue	64	0	0,0	34	53,1	7	10,9
=0	Contact	92	92	100,0	0	0,0	0	0,0
	Catalogue	357	357	100,0	0	0,0	0	0,0
(0 3]	Contact	104	0	0,0	88	84,6	12	11,5
	Catalogue	195	0	0,0	163	83,6	15	7,7
(3 5]	Contact	21	0	0,0	16	76,2	4	19,0
	Catalogue	54	0	0,0	37	68,5	3	5,6
(5 10]	Contact	7	0	0,0	5	71,4	2	28,6
	Catalogue	29	0	0,0	13	44,8	5	17,2
(10 25]	Contact	4	0	0,0	2	50,0	0	0,0
	Catalogue	8	0	0,0	4	50,0	0	0,0
>25	Contact	0	0	--		--	--	--
	Catalogue	0	0	--		--	--	--
ALL	Contact	262	92	35,1	128	48,9	21	8,0
	Catalogue	772	357	46,2	264	34,2	41	5,3
	All	1034	449	43,4	392	37,9	62	6,0

Source: Own elaboration on SBS-98

Table 3: Results from the estimations

	1			2			3		
Variables	OLS	Probit	Poisson	OLS	Probit	Poisson	OLS	Probit	Poisson
Constant	0,860311 ***	0,1807	-0,094828	0,863025 ***	0,130933	-0,155615 *	0,563903 ***	-0,220247	-0,732097 ***
	10,6791	1,5972	-1,11602	10,1707	1,10461	-1,65112	8,02102	-1,60956	-6,57269
Standard	-0,004861	-0,014264	-0,070404	-0,006146	-0,008219	-0,045477	0,030922	0,099608	0,136156
	-0,08835	-0,15978	-0,883819	-0,108965	-0,090689	-0,559685	0,679899	1,01381	1,564
Small	-0,481094 ***	-0,713651 ***	-0,573546 ***	-0,482313 ***	-0,699414 ***	-0,556714 ***	-0,382042 ***	-0,747975 ***	-0,56593 ***
	-7,18174	-8,01364	-7,70573	-7,20453	-7,74662	-7,34438	-6,48151	-7,80854	-7,11692
Share	-0,082229	0,021217	-0,028622	-0,083332	-0,015724	-0,036361	-0,123934	-0,171528	-0,194986
	-0,626717	0,099165	-0,141467	-0,631903	-0,073392	-0,17684	-1,1157	-0,732881	-0,89945
Catalogue	-0,053617	-0,027893	-0,118864	-0,060752	0,079155	-0,069909	-0,029163	-0,046298	-0,006518
	-0,98714	-0,273277	-1,32054	-0,745328	0,608026	-0,545377	-0,534458	-0,233064	-0,031693
PV+	0,173887 ***	0,293001 ***	0,123515 ***						
	7,39499	41,3875	29,4661						
PV-	-0,154705 ***	-0,297072 ***	-0,167986 ***						
	-8,33623	-21,6367	-19,693						
PV-CAT+				0,182939 ***	0,308076 ***	0,159642 ***	0,379643 ***	0,896802 ***	0,500412 ***
				5,78694	13,2393	9,19011	11,8377	8,43939	5,23696
PV-CAT-				-0,145441 ***	-0,209297 ***	-0,132855 ***	0,420777 ***	-0,766824 ***	-0,450877 ***
				-6,52485	-8,01964	-7,45322	-5,25102	-7,37054	-5,60131
PV-NEG+				0,171541 ***	0,294646 ***	0,120955 ***	-0,020958 ***	-0,053859 ***	-0,030324 ***
				5,94908	39,386	26,1694	-5,69001	-5,99031	-3,61066
PV-NEG-				-0,157143 ***	-0,363538 ***	-0,198448 ***	-0,021361 ***	-0,039349 ***	-0,022086 ***
				-6,67841	-18,7886	-16,9764	-3,45183	-4,66972	-3,46748
(PV-CAT+)**2							0,38003 ***	0,758318 ***	0,49239 ***
							10,9066	22,5153	16,365
(PV-CAT-)**2							-0,325461 ***	-0,607332 ***	-0,336883 ***
							-7,36029	-23,6196	-18,2586
(PV-NEG+)**2							-0,16822 ***	-0,034194 ***	-0,025572 ***
							-4,47491	-21,6607	-12,5383
(PV-NEG-)**2							-0,007573 **	-0,013232 ***	-0,006974 ***
							-2,52909	-13,3438	-9,45499
1st threshold		0,582394 ***			0,587559 ***			0,6016 ***	
		15,675			15,723			15,7419	
2nd threshold		1,27416 ***			1,28384 ***			1,43258 ***	
		46,5587			43,4114			39,7748	
Log. lik. funct.	-1082,3	-815,469	-954,16	-1081,93	-805,637	-946,287	-941,059	-675,795	-849,606
Tests									
Ho:									
Equality + / -	0,5191	0,02484	15,24731 ***	1,33072	407,1631 ***	30,55317 ***	8,4763 *	85,05675 ***	35,41133 ***
Equality C/N	-	-	-	0,22697	19,7392 ***	15,43654 ***	20,26071 ***	42,99218 ***	19,08819 ***
R^2	0,428624		0,4297	0,429067		0,16199	0,57414		0,1049
% correct pred.		73,36	59		74,19	59,521		78,56	61,707

Figure 1: Evolution of price in real terms

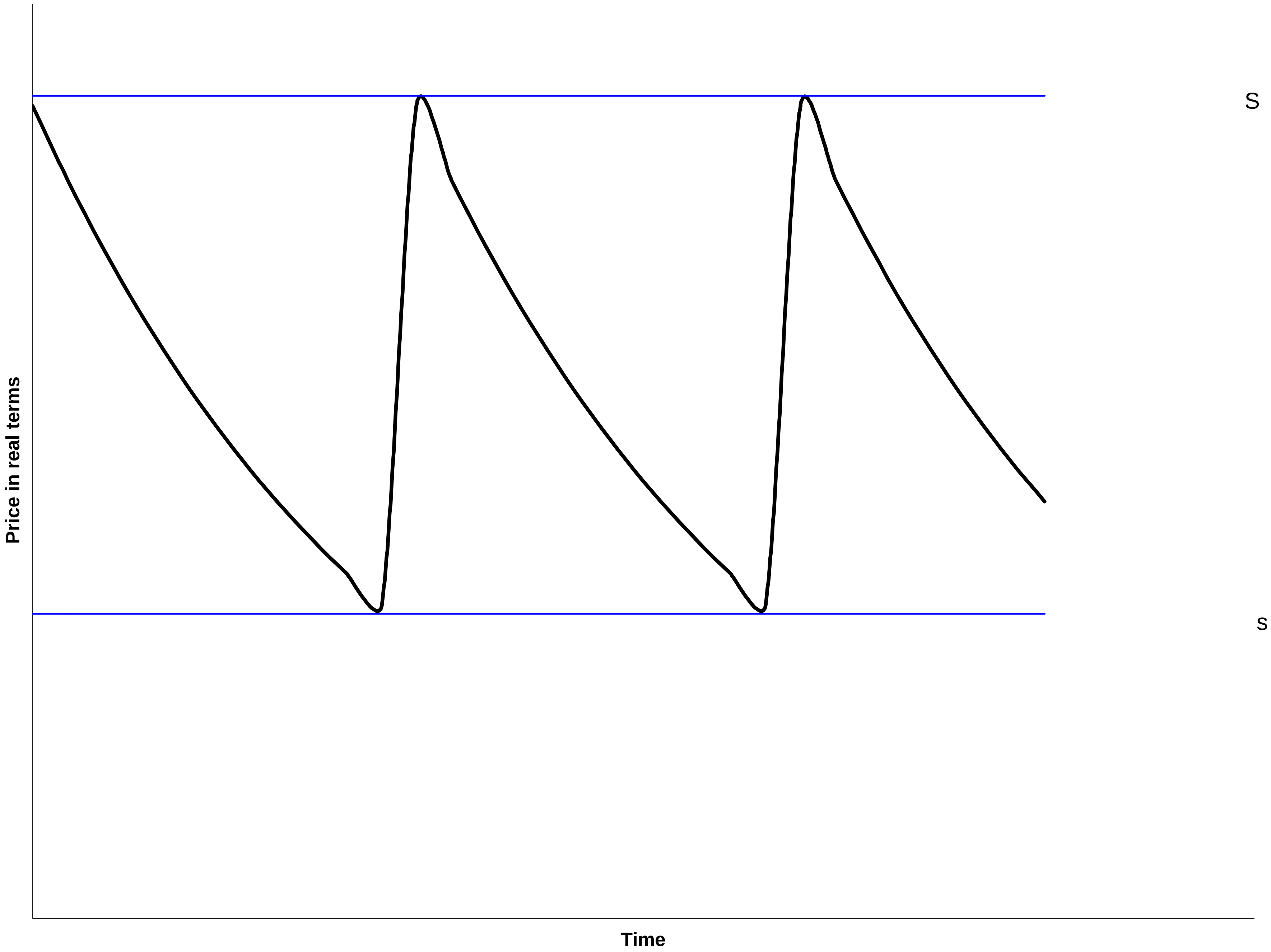

Figure 2:
Expected values of the number of price variations
(price diffusion in direct contact)

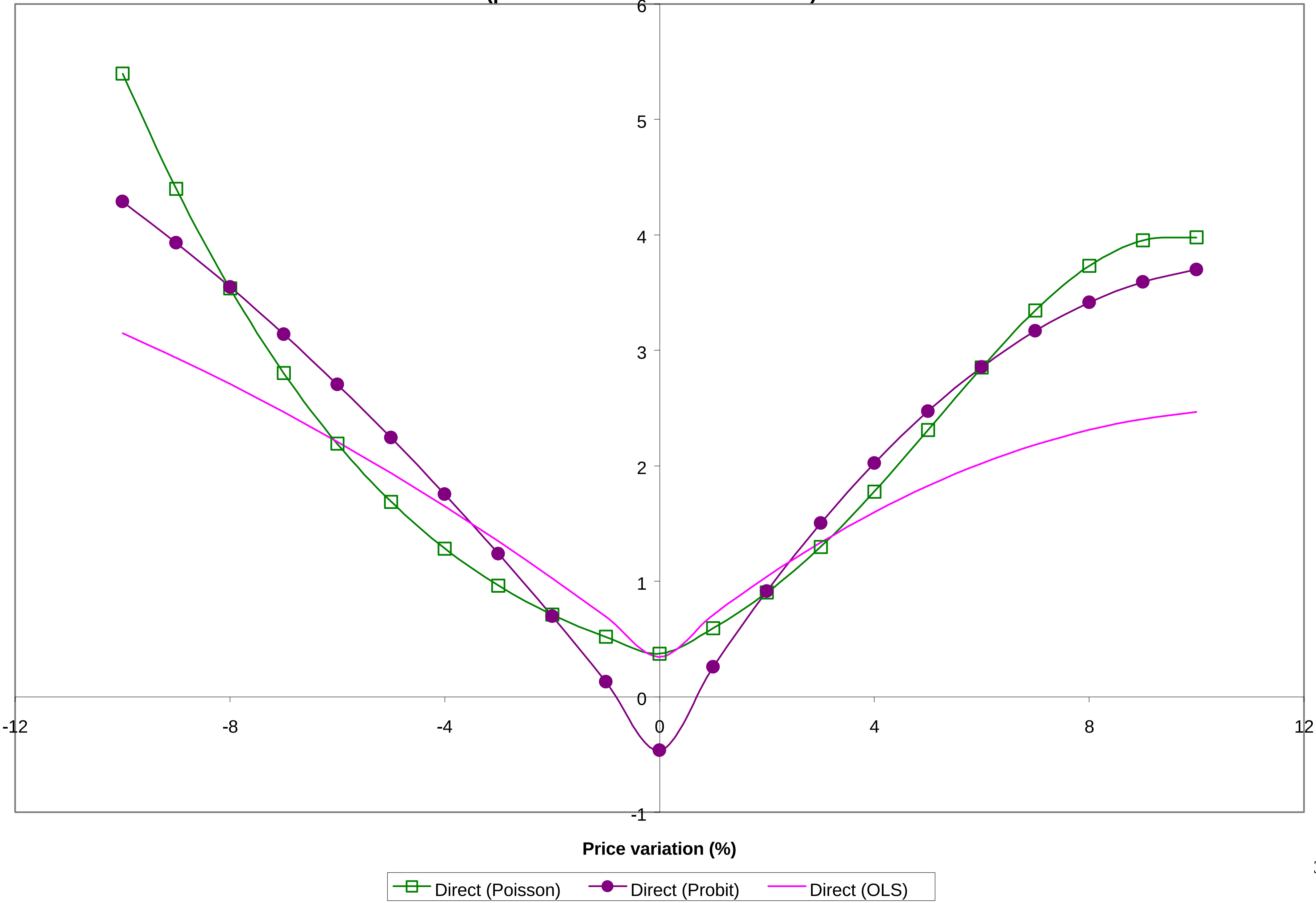

Figure 2 (cont.):
Expected values of the number of price variations
(price diffusion by catalogues)

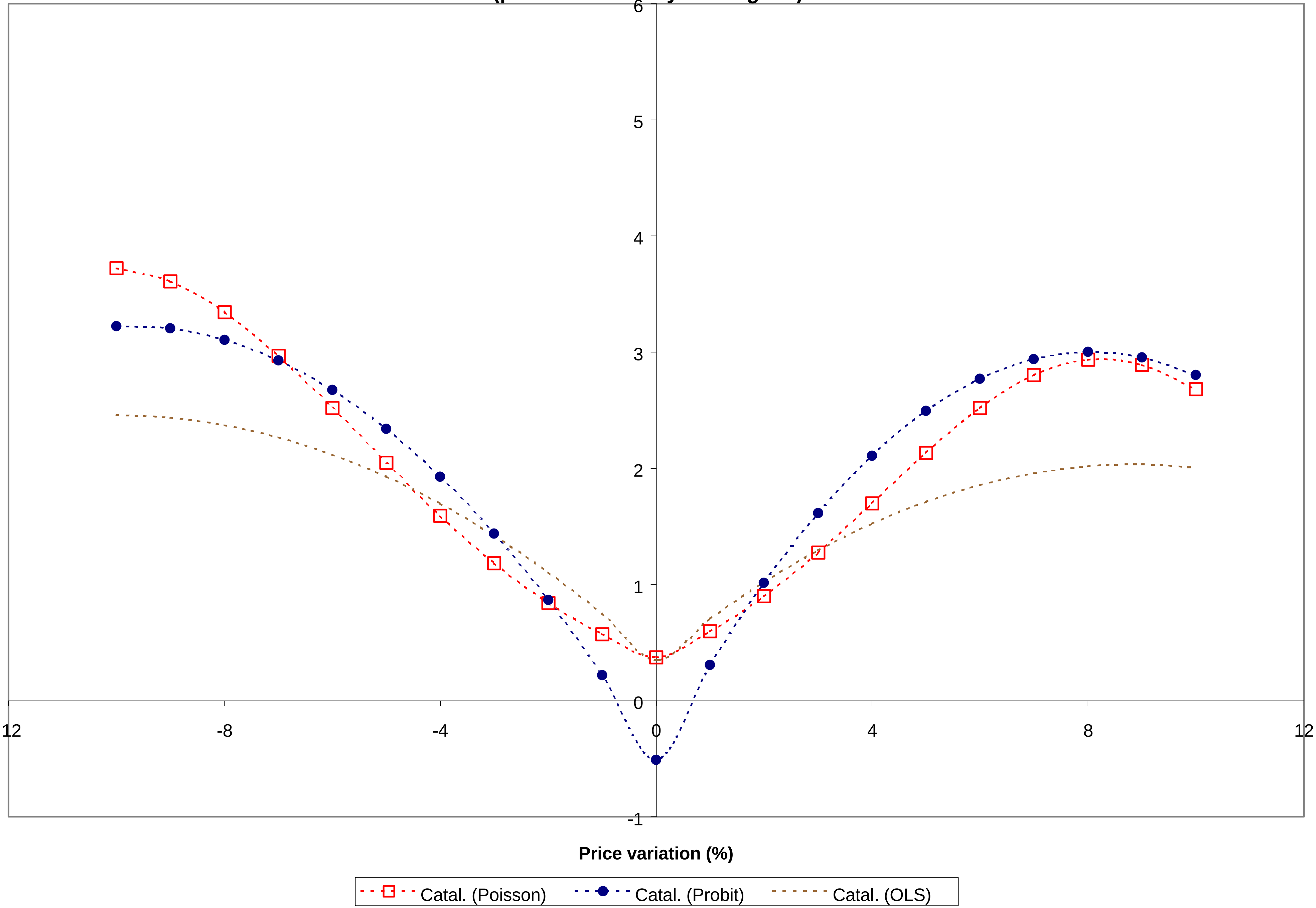

Figure 2:
Expected values of the number of price variations
(price diffusion in direct contact)

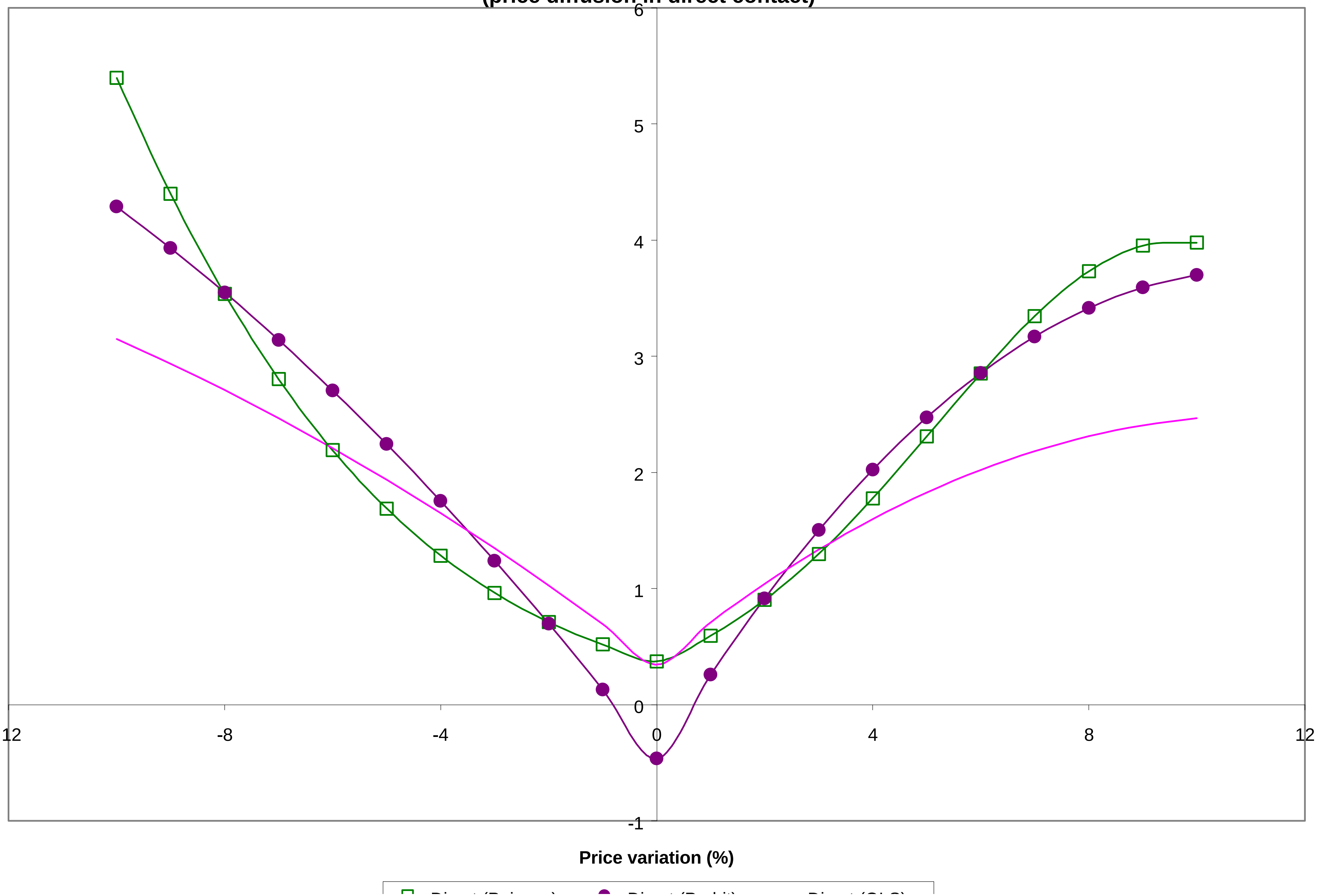

Figure 3 (A):
Expected values of the number of price variations
(OLS estimation)

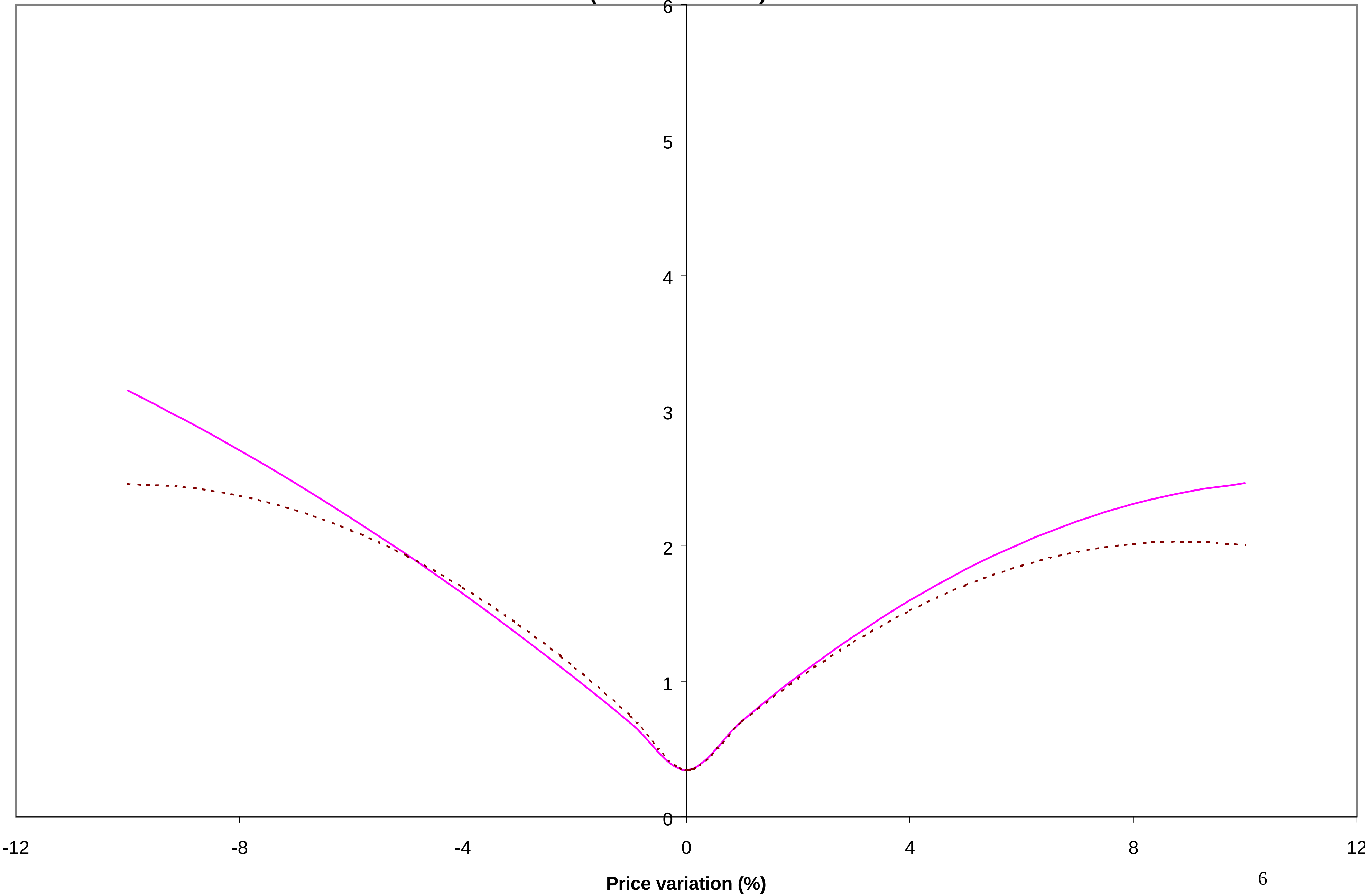

Figure 3 (B):
Expected values of the number of price variations
(Probit estimations)

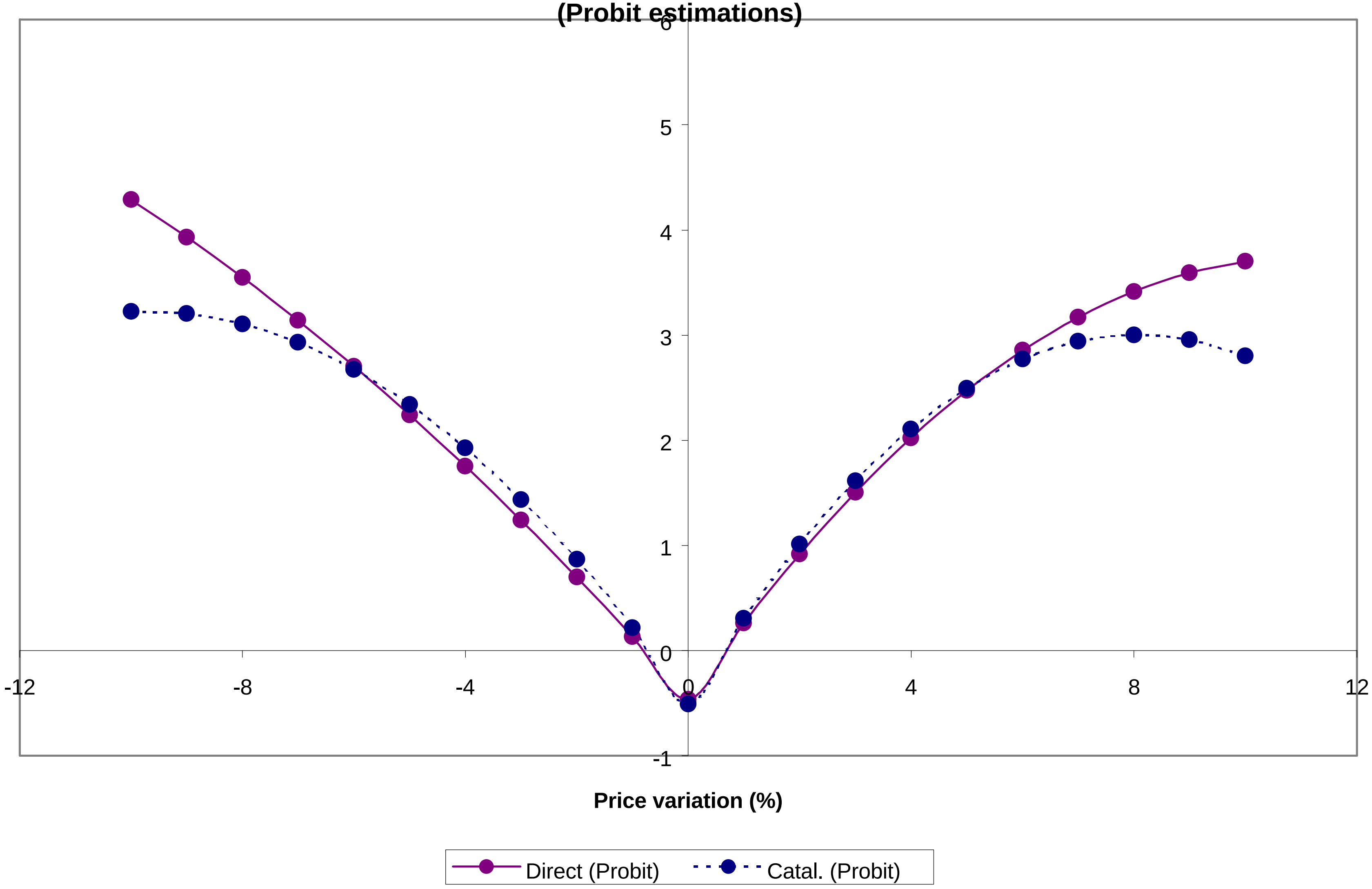

Figure 3 (C):
Expected values of the number of price variations
(Poisson estimation)