UNDERSTANDING PRICE-REVIEWING STRATEGIES USING FIRM-LEVEL DATA*

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1. INTRODUCTION

In recent years, a substantial amount of theoretical and empirical research, devoted to improving the microeconomic foundations of macroeconomic behaviour, has made clear that a thorough understanding of the extent and causes of the sluggish adjustment of nominal prices is crucial to the design and conduct of monetary policy.

In this regard, an important conclusion that emerges from the literature is that firms differ from each other with respect to their price-reviewing or price-setting strategies, and that the different strategies are all widespread in the economy.[1] A second important conclusion is that the effects of monetary policy may depend crucially on the underlying mechanism of firms' price adjustment, namely on whether firms follow state-dependent or time-dependent price-setting rules.[2] Understanding the factors that lie behind firms' choice of different price-reviewing strategies is thus an issue of paramount importance.

This article adds to this strand of the literature by studying the determinants of the choice of the price-reviewing strategies followed by firms. On the theoretical front, there is now a significant literature that directly addresses this issue, but a corresponding empirical contribution is virtually nonexistent.

Using the information from a firm-level survey, this article investigates the main reasons that lead firms to select time-dependent, state-dependent or a combination of both price-reviewing practices, which we shall denote by time- and state-dependent price-reviewing strategy.[3] Specifically, we explore the information available on firms' pricing decisions using a multinomial probit model to study

(1) For instance, Fabiani *et al.* (2006) find that in the Euro Area about 34 percent of the firms follow time-dependent rules, 20 percent follow state-dependent rules and the remaining 46 percent follow a combination of both, i.e., follow time-dependent rules under normal circumstances, but change to state-dependent price-reviewing rules upon the occurrence of specific events.

(2) In general prices tend to react faster to monetary policy shocks in state-dependent frameworks as compared to time-dependent models leading to less persistent effect on real output in the former models. See, among many others, Sheshinski and Weiss (1977), Chaplin and Spulber (1987), Dotsey *et al.* (1999), Bonomo and Carvalho (2004), Dotsey and King 2005, Burstein and Hellwig (2007), Midrigan (2007), Golosov and Lucas (2007), Bils *et al.* 2009 and Woodford (2009).

(3) When the timing of a firm's price-reviewing (or price-setting) strategy does not depend on the current or expected state of the economy, either because it is assumed to be exogenous or conditional on some underlying fixed parameters, it is said the firm follows a time-dependent strategy. In contrast, a state-dependent firm is one in which the timing of the price-reviewing (or price-setting) rule varies according to current or expected economic conditions.

the link between their price-reviewing strategies and a number of their characteristics. The identification of such characteristics will allow us to anticipate changes in firms' behaviour, i.e., changes from time- to state-dependent and vice-versa, as a reaction to changes in economic conditions and therefore to anticipate changes in monetary policy transmission. In addition, our exercise will also allow us to answer several interesting questions, from which the following are just some examples: How do the lags of price reaction to shocks and the frequency of price changes vary between time- and state-dependent firms? How important are menu and/or information costs for the choice between time- and state-dependent price-reviewing rules? Does the type of price-reviewing strategy vary with the size of the firms? Does the cost structure matter for the firm's strategy? How does uncertainty affect firms' choice? Are firms more likely to be state-dependent when they operate in more competitive environments?

A potential disadvantage of using survey data for this type of investigation is that, in our case, these are reported, not actual data, and thus, it is impossible to know how accurate the answers provided in the survey are. However, in this particular case, this is likely to be the single available approach for the purpose at hand as there does not seem to be a valid alternative to identify the price-reviewing strategies at the firm level.[4]

In this article we document that the type of price-reviewing strategy followed by firms has important consequences for the frequency of price changes and the speed of price reaction to shocks. In particular, firms that follow state-dependent price-reviewing rules change their prices more frequently and react more quickly to demand and cost shocks than firms following time-dependent strategies.

We also find that the type of price-reviewing strategy varies significantly with those firm characteristics used to measure the importance of information costs, the variability of the optimal price and the sensitivity of profits to sub-optimal prices. Menu costs, i.e. costs of changing prices (such as the cost of printing and distributing new price lists), do not seem to play a significant role in explaining the different price-reviewing strategies. In particular, we document that smaller firms, firms for which changes in prices of raw materials are important factors for pricing decisions or that operate in competitive environments are more likely to follow state-dependent price-reviewing rules. In turn, larger firms, firms for which information costs or changes in wages are important factors for pricing decisions, or that operate in the services sector are more likely to follow time- or time- and state-dependent price-reviewing strategies. Interestingly, we also find that the time- and state-dependent rule is closer to the time-, than to the state-dependent price-reviewing strategy. Yet, the two price-reviewing strategies are very distinct. In fact, for many regressors, the magnitude of the impact on the likelihood of the two categories is different and, moreover, the probability of a firm choosing between one of the two strategies sometimes goes in the opposite direction as, for instance, in the case of a firm for which changes in the competitors' prices are important for pricing decisions.

The rest of the article is organised as follows. Section 2 presents the theoretical background which

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(4) In particular, quantitative data on the frequency of price changes or the duration of price spells does not allow addressing the issue. On the one hand, these data do not distinguish between price changes and price reviews, the latter being the variable of interest in this article. On the other hand, time-dependent rules as implied by the models with information costs, are not distinguishable, in practice, from state-dependent rules, as the frequency of price changes or of price reviews depends on the underlying relevant parameters that may change over time (see ch.8).

underlies the estimated model. section 3 describes the dataset used in the article and presents some preliminary results. section 4 presents the estimated model and discusses the main results. section 5 contains some concluding remarks, and finally an Appendix provides an explanation of how the different variables were constructed.

2. THEORETICAL BACKGROUND

The process of charging an optimal price by firms may be thought of as usually involving price-reviewing and price-setting as two distinct activities. Price reviewing may be defined as the activity of assessing whether the firm's current price is appropriate or not, and in general precedes the price-setting decision which involves adjusting the price to the optimal level. In practice, a price review may or may not be followed by a price adjustment, so that if the two activities entail different types of costs it may be the case that the firm follows distinct price-reviewing and price-setting strategies.[5]

This section briefly reviews the literature on firms' price-reviewing strategies and discusses the implications for those strategies stemming from changes in the relevant parameters.

We start by summarizing the implications for the firms' price-reviewing strategies of the models suggested see Caballero (1989) and Alvarez *et al.* (2010), which assume that firms do not have access to costless information about current economic conditions.

In order to make the presentation easier let us start by assuming that i) the efficiency loss of the firm (out-of-equilibrium cost) may be captured by a quadratic function, $L = \theta \ [p(t)-p^*(t)]^2$, where θ measures the sensitivity of profits to deviations of the actual price, $p(t)$, from the optimal price, $p^*(t)$; and ii) the optimal price follows a random walk with Gaussian innovations with variance σ^2 per unit of time.[6] If we further assume that the firm has to pay a fixed information cost, ρ, in order to review its price, it may be shown (see) that it is optimal for the firm to follow a time-dependent price-reviewing strategy, where the optimal price-reviewing interval is given by:

$$\tau = \sqrt{\frac{2\rho}{\theta\sigma^2}} \tag{1}$$

According to equation (1), the optimal length for price-reviewing is increasing on the information costs and decreasing on the parameters measuring efficiency loss from sub-optimal prices and the variability of the underlying optimal price.

In the model suggested in Caballero (1989) there are no menu costs, so that every price review implies a price change. In a recent contribution, Alvarez *et al.* (2010) generalise Caballeros's model by assuming that the firm has to pay an information cost to review the price and a menu cost if it decides to change the price. In this model, price reviews and price changes are separate activities:

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(5) Survey data indicate that firms review their prices infrequently, and that not all price reviews yield a price adjustment. For instance, for the Euro Area, Fabiani *et al.* (2007) document that the frequency of price reviews is generally higher than the frequency of price changes. The surveys show that in most Euro Area countries the modal number of price reviews lies in the range from one to four times a year, but most firms actually change their prices only once a year. In the case of Portugal, these figures are 2 and 1, respectively.

(6) Note that θ depends on the parameters of the demand and costs functions and that, in particular, θ is increasing with the elasticity of demand faced by the firm. The variance σ^2 may be seen as measuring the volatility of demand and cost functions.

a firm may assess the adequacy of its current price, i.e., conduct a price review, and decide not adjust if the current price is inside the inaction band (stemming from the presence of menu costs). The timing of each price review is predetermined as it is decided on the previous revision date. Nevertheless the process of price reviewing is also state-dependent, because the optimal time between price reviews is a function of the expected price gap (i.e., the difference between the actual and the optimal price) at the time of price-reviewing.[7]

In contrast to Caballero (1989) and Alvarez *et al.* (2010) there are models where firms are assumed to have access to partial information at no cost, as in the contributions by Woodford (2009) and Bonomo *et al.* (2010).

Woodford (2009) developed a model with information costs where the assumptions about information availability have important implications for the strategy of price reviews. In this model it is assumed that: *i*) the firm obtains full information about the economy's state at the moment when it decides to pay the information costs and review the price; *ii*) partial information about current conditions is available between the occasions when the fixed information cost is paid, which allow firms to decide whether or not to review prices; and *iii*) the memory of the firm (information on the time at which the firm last reviewed its price) is as costly as information about current conditions external to the firm. Under these circumstances, it is shown that the optimal timing of price reviews follows a state-dependent rule. However, when the information cost is sufficiently large, the dependence of the optimal hazard (that indicates the probability of a price review) on the current state is attenuated, so that in the limit when the information cost becomes unboundedly large, the resulting model approaches one with a constant hazard rate as assumed in Calvo (1983). If, instead, memory is costless, the optimal hazard also depends on the number of periods since the last price review. If, memory is costless and the information costs are unboundedly large, the model becomes one in which prices are reviewed at deterministic intervals as in Caballero (1989).

In the model suggested in Woodford (2009) there are no menu costs dissociated from information costs, so that every price review implies a price change, as in Caballero's model. More recently, Bonomo *et al.* (2010) developed a model that allows for dissociated menu and information costs and assumes a continuous flow of partial information which may be factored into pricing decisions at no cost, together with some information that is only incorporated infrequently due, for instance, to gathering and processing costs. Nevertheless, the price-reviewing process emerges as having both time- and state-dependent components, as in Woodford (2009)'s memory costless case.

In summary, according to the models surveyed above, we may aggregate the different price-reviewing strategies into three categories: time-dependent (as in Caballero (1989)), state-dependent (as in Woodford (2009)) and time- and state-dependent (as in Alvarez *et al.* (2010) and Bonomo *et al.* (2010)).

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(7) In a similar approach Abel *et al.* (2009) address consumption portfolio problems under the assumption of separate observation (information) and adjustment (transaction) costs. Interestingly, the authors show that for sufficiently small fixed transaction costs the two processes of "observation" and "transaction dates" will eventually converge to pure time-dependent rules. Intuitively, when the fixed transaction costs are not too large compared to the observation costs, the agent will find it optimal to synchronize observation and transaction dates, in order to avoid "wasting" observation costs without using the new information to undertake a transaction.

We have seen that in some of the models surveyed above changes in the importance of menu and information costs may alter the nature of the price-reviewing strategy. In particular, in the context of the time-and state-dependent model suggested in Alvarez *et al.* (2010) and Abel *et al.* (2009) a decrease in the importance of menu costs makes the model converge towards a time-dependent rule. The intuition is that a decrease in menu costs makes the width of the inaction band to converge to zero, making the source of the state-dependent component in the price-reviewing strategy to vanish. In turn, an increase in information or observation costs makes the state-dependent model in Woodford (2009) to converge to a pure time-dependent rule with a constant hazard rate as assumed in Calvo (1983)or, in the absence of memory costs, one in which prices are reviewed at predetermined intervals as in Caballero (1989). The intuition is similar: an increase in the information costs attenuates the dependence of the optimal hazard on the current state, making the optimal time between two consecutive price reviews to converge towards a pure time-dependent rule as information costs become unboundedly large.

The impact on the optimal price-reviewing strategy of changes in the variability of the optimal price (σ^2) and the sensitivity of firm's profits to sub-optimal prices (θ) may be discussed in a context of a model in which firms have access to partial information about current conditions, as in Woodford (2009). In this model, an increase in θ or in σ^2 may be thought of as bringing about both a decrease in the information costs (an increase in the uncertainty about the price gap or on the costs associated to a given price gap makes information more valuable, reducing its relative cost) and an increase in the relative cost of firm's memory (the higher is σ^2 or θ the less valuable the memory will be). Thus, an increase in θ or in σ^2, to the extent that it decreases the information costs on the current conditions and increases the memory costs of the firm, may be expected to increase the probability of a firm following state-dependent price-reviewing strategies as opposed to time-dependent or time- and state-dependent rules.

In this article, we will look into the factors that may explain why firms follow state-dependent, time-dependent or time- and state-dependent price-reviewing strategies. For that purpose, in section 4 we will consider an econometric model that relies on the theoretical approaches presented in this section, whose relevant factors, in face of the discussion above, include the menu costs, the information costs, the variability of the optimal price and the sensitivity of firm's profits to sub-optimal prices. Overall, in our estimated model, we expect high menu-costs, small information costs, large variability of the optimal price and high sensitivity of profits to sub-optimal prices, *ceteris paribus,* to increase the likelihood of state-dependent price-reviewing. Similarly, low menu costs, high information costs, small variability of the optimal price and low sensitivity of profits to sub-optimal prices, are expected to increase the likelihood of time-dependent price-reviewing strategies.

3. THE DATA

3.1. Data sources

The data used in this study come from a survey about price setting practices carried out by the Banco de Portugal.[8] In this survey, firms were asked about their price-reviewing strategies through the following question:

The price in your company is reviewed (without necessarily being changed):

1) *at a well-defined frequency (annually, quarterly,..),*

2) *generally at a defined frequency, but sometimes also in reaction to market conditions (change in the price of raw materials or in demand conditions) or*

3) *without any defined frequency, being reviewed in reaction to market conditions (changes in price of raw materials or in demand conditions).*

The responses to this question, the dependent variable in our model, are interpreted as reproducing time-dependent, time- and state-dependent, and state-dependent price-reviewing practices by Portuguese firms, respectively.

Besides the question on price-reviewing practices, the survey also contains information on a large number of firms' characteristics. These include information on the size and sector of the firm, destinations of sales (wholesalers *vs*. retailers, private *vs*. public sector), number of competitors, importance of changes in different factors for price adjustments (price of raw materials, wage costs, demand), and reasons for postponing price changes (the risk that competitors do not follow, existence of implicit or written contracts, cost of changing prices, costs of collecting information, absence of significant changes in variable costs, preference for maintaining prices at psychological thresholds, etc...).

In total, for estimation purposes, we have detailed information on 906 firms from different areas of economic activity. More specifically, our sample includes firms with 20 or more employees, from which almost 90 percent belong to Manufacturing (NACE - classification of economic activities - 15 to 37) and the remaining to Services (NACE 60 to 64, 80 and 85 - Transport, Storage and Communication, Education and Healthcare). Sectors such as agriculture, construction, or wholesale and retail trade are not included.

3.2. Preliminary data analysis

As above-mentioned, the type of price-reviewing strategy by Portuguese firms is our variable of interest. Table 1 summarises some useful information on this variable by displaying the distribution of the observed price-reviewing strategies in our sample, as well as comparable figures for other

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(8) Further details on this survey may be found in Martins (2010).

Table 1

PRICE-REVIEWING STRATEGIES - INTERNATIONAL EVIDENCE Share of firms, per cent							
	PT	ES	DE	NL	BE	IT	AT
Time-dependent	32	33	26	36	26	40	41
Time- and state-dependent	25	28	55	18	40	46	32
State-dependent	43	39	19	46	34	14	27

Source: Fabiani *et al.* (2007).
Note: PT-Portugal, ES-Spain, DE-Germany, NL-Netherlands, BE-Belgium, IT-Italy and AT-Austria.

European countries taken from Fabiani *et al.* (2007).[9]

Table 1 reveals that in Portugal 32 percent of the firms in the sample follow time-dependent rules, while 43 percent follow state-dependent rules, and the remaining 25 percent follow time- and state-dependent price-reviewing strategies, i.e., generally review prices at a defined frequency, but some-times also in reaction to market conditions. From Table 1, we can also see that figures for Portugal do not differ significantly from the general picture obtained from several European countries. Even though the distribution of the price-reviewing strategies varies somewhat across countries, we no-tice that the three alternative price-reviewing strategies are equally important, as none emerges as clearly dominating the others. For instance, from Table 1 we see that the proportion of time-depend-ent firms is above 25 percent in all countries, and that the importance of time- and state-dependent strategy varies between 18 percent (NL) and 55 percent (DE).

Table 2 considers the breakdown by sector and firm size of the different price-reviewing strategies. The table suggests the existence of strong heterogeneity in these two dimensions. Indeed, the share of firms following time-dependent rules is higher in services than in manufacturing, and tends to increase with the size of the firms.

As in similar studies, the survey data also contains information on the frequency of price changes and the speed of price reaction to shocks. Table 3 reports the average frequency of price changes as reported by the firms in the sample. From the table it can be seen that on average, time-, time-and state- and state-dependent firms have different frequency of price changes. In particular, state-dependent firms emerge as adjusting prices more frequently than firms following time-dependent price-reviewing strategies. Indeed, 17 percent of firms following state-dependent rules change their

Table 2

PRICE-REVIEWING STRATEGIES - SECTORAL AND SIZE BREAKDOWN Share of firms, per cent					
		Sectors		Size	
	Total	Manufacturing	Services	Small	Large
Time-dependent	32	30	47	30	41
Time- and state-dependent	25	25	25	22	35
State-dependent	43	45	28	48	24

Source: Survey on price setting behaviour.
Note: Small and large firms are firms with up to 250 employees and more than 250 employees, respectively.

(9) Figures for Portugal in Table 1 do not strictly coincide with those reported in Fabiani *et al.* (2007) due to differences in the samples used.

Table 3

FREQUENCY OF PRICE ADJUSTMENT Share of firms, per cent			
Frequency of price adjustment	**Time- dependent**	**Time- and state-dependent**	**State-dependent**
1 - Once per month or more	3	5	8
2 - Once per quarter	5	9	9
3 - Twice a year	16	14	17
4 - Once a year	61	57	40
5 - Less than once a year	16	15	26

Source: Survey on price setting behaviour.

prices at least once in a quarter, while 8 percent do it at least once in a month. On the other hand, only 8 percent of firms following time-dependent rules change their prices at least once in a quarter. The frequency of price changes for time- and state-dependent firms seems to be somewhere in between that of time- and state-dependent firms. The analysis based on visual inspection of Table 3 is corroborated by a formal non-parametric χ^2 homogeneity test, which rejects the null hypothesis of equal frequency of price changes across the three types of firms.[10]

Table 4 reports the lags or price reaction to significant positive cost and demand shocks.[11] Simple visual inspection of the table suggests that the speed of price adjustment to shocks varies according to the type of price-reviewing strategy. In particular, in both cases, time-dependent firms seem to be slower to adjust than firms following state-dependent price-reviewing strategies. Indeed, 26 percent of firms with state-dependent price-reviewing rules adjust their prices in the first month after a positive cost shock, while 58 percent do it in the first three months. The corresponding figures for time-dependent firms are 14 and 38 percent, respectively. The results for firms with time- and state-

Table 4

SPEED OF PRICE RESPONSE TO POSITIVE DEMAND AND COST SHOCKS Share of firms in each category			
Price adjustment lag	**Time-dependent**	**Time- and state -dependent**	**State-dependent**
Positive cost shocks:			
1 - Less than one week	3	6	6
2 - From one week to one month	11	16	20
3 - From 1 month to 3 months	24	28	32
4 - From 3 to 6 months	19	21	18
5 - From 6 months to one year	33	24	18
6 - More than one year	10	5	7
Positive demand shocks:			
1 - Less than one week	3	4	4
2 - From one week to one month	7	11	15
3 - From 1 month to 3 months	17	18	23
4 - From 3 to 6 months	13	21	13
5 - From 6 months to one year	22	21	14
6 - More than one year	38	26	31

Source: Survey on price setting behaviour.

(10) The outcome of the test is $\chi^2(8) = 42.4$, so that the null hypothesis is rejected at 1 percent level.

(11) This information was explored by Dias *et al.* (2010) to investigate the firms' characteristics that explain why some firms react to shocks faster than others.

dependent rules suggest that the speed of price adjustment is somewhere in between that of time- and state-dependent firms. Once again, the analysis based on visual inspection is corroborated by formal non-parametric χ^2 homogeneity tests, which clearly reject the null hypothesis of identical adjustment lags across the three types of firms.[12]

Overall, Tables 3 and 4 show that whether firms follow time-, time- and state-, or state-dependent price-reviewing strategies has important consequences for the frequency of price changes and the speed of price reaction to shocks. This, in turn, may be expected to have important consequences for monetary policy, as its effects would depend on the distribution of firms in terms of their price-reviewing strategies. Thus, anything that changes this distribution will affect the speed with which prices react to monetary policy shocks. In particular, one may expect the effects of monetary policy to depend on the firm size distribution or the importance of the services sector in the economy (see Table 2). Countries with a higher share of larger firms and/or with a larger services sector may be expected to display a larger proportion of time-dependent firms and thus to be stickier than otherwise identical countries. But, the factors that may change the effects of monetary policy include monetary policy itself: changes in monetary policy rules aimed at stabilizing the economy, to the extent that they alter the proportion of firms in each category, will change the frequency of price changes and the speed of price reaction to monetary policy shocks.[13]

4. AN ECONOMETRIC MODEL FOR THE PRICE-REVIEWING STRATEGIES

In order to gauge the impact of the different covariates on the type of price-reviewing strategy, we estimate a multinomial probit model, where the dependent variable, $y_{i,j}$, $j=1,\ 2,\ 3$ indicates one of the three response categories: time-, time- and state- , or state-dependent price-reviewing strategy.

The choice of the set of regressors used in the empirical model was based on the literature on price-reviewing strategies summarized in section 2. As discussed there, the relevant factors determining the type of pricing policy may be divided into four categories: menu costs, information costs, variability of the optimal price and the sensitivity of profits to sub-optimal prices. As direct quantitative data is not available, we use proxies as the regressors for each one of the four categories. The different regressors are described in the Appendix together with some summary statistics.

Table 5 presents the average marginal effects of each of the covariates on the probability of a firm following either a time-, a time- and state- or a state-dependent price-reviewing strategy, computed from the estimated parameters of the multinomial probit model.[14]

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(12) For the positive cost and demand shocks the results of the tests are $\chi^2(10) = 34.26$ and $\chi^2(10) = 32.25$, respectively, so that the null hypothesis is rejected at 1 percent level for the two tests. The results for negative cost and demand shocks, as regards the price adjustment lags for the three type of price-reviewing strategies, including the χ^2 homogeneity tests, are qualitatively similar.

(13) For instance, by reducing inflation uncertainty it is likely that monetary policy will reduce the variability of firms' optimal price, which, according to the discussion in section 2, is likely to increase the probability of firms following time- or time- and state-dependent rules.

(14) Figures in Table 5 refer to the output of an independent multinomial probit. We note that by construction the average marginal effects for each regressor in Table 5 add up to zero. As a robustness check, we also estimated a multinomial probit allowing for the possibility of correlated errors. However, the estimates for the average marginal effects were virtually unchanged.

Tabela 5

MULTINOMIAL PROBIT Average marginal effects			
Regressors	**Time-Dependent**	**Time- and State- -Dependent**	**State-Dependent**
Menu costs	0.0136	-0.0213	0.0077
	(-0.0345)	(-0.0337)	(-0.0366)
Information costs	0.0270	0.0612*	(-0.0882)**
	(0.0352)	(0.0340)	(0.0370)
Variability of the optimal price:			
Changes in prices of raw materials	-0.1905***	0.0451	0.1455**
	(0.0669)	(0.0550)	(0.0608)
Changes in wages	0.0868**	-0.0127	-0.0741*
	(0.0398)	(0.0402)	(0.0456)
Changes in demand	-0.0200	0.0230	0.0030
	(0.0393)	(0.0376)	(0.0423)
Efficiency loss:			
Number of competitors	-0.0818**	0.0023	0.0841**
	(0.0370)	(0.0337)	(0.0380)
Changes in competitors' prices	-0.1439***	0.0841**	0.0598
	(0.0398)	(0.0332)	(0.0401)
Services	0.1398**	0.0087	-0.1485***
	(0.0552)	(0.0486)	(0.0510)
Intermediate goods	-0.1019***	-0.0268	0.1287***
	(0.0315)	(0.0304)	(0.0349)
Size	0.0962**	0.1272***	-0.2234***
	(0.0410)	(0.0397)	(0.0384)

Number of observations: 906

Source: Survey on price setting behaviour.
Note: Robust standard errors are in parenthesis; ***,**,* denote significance at 1, 5 and -5pt 10 percent level, respectively.

Menu costs

According to the theoretical models surveyed in section 2, we may expect high menu costs to increase the likelihood of state-dependent price-reviewing. However, in our estimated model, menu costs do not emerge as a relevant factor to discriminate among the three alternative price-reviewing strategies. This of course, may stem from the type of regressor we use. In our model, menu-costs are measured by a dummy variable that is equal to one if the firm considers that such costs are important or very important to explain the existence of price rigidity and is zero otherwise. But, it may be the case that two firms, with a very different degree of price stickiness attach the same degree of importance to menu costs. Under such circumstances, our measure of menu costs would be unable to discriminate among firms with different price-reviewing strategies. Of course, it may also be the case that in most firms menu costs do not play an important role for the decision on the type of price-reviewing strategy, if they are very small when compared to information costs (see , Ball and Mankiw (1994) Zbaracki *et al.* (2004) and Woodford (2003, 2009)).

Information costs

According to the theoretical models, we may expect high information costs to increase the likelihood of time-dependent or of time- and state dependent price-reviewing strategies, as opposed to state-dependent rules. From Table 5 we see that firms for which information costs are important,

are less likely to follow state-dependent price-reviewing strategies. In particular, for a firm for which information costs are important or very important, the probability of following a state-dependent price-reviewing strategy is 8.8 percentage points (pp) lower than the probability for an otherwise identical firm. The results for this covariate are in line with theoretical predictions, but they lack some statistical strength.

Variability of the optimal price

This category includes a group of variables deemed to affect directly or indirectly the variability of the optimal price of the firm: "changes in the prices of raw materials", "changes in wages" and "changes in demand". These covariates measure the importance of changes in the prices of raw materials, in wages and in demand for the firm's decision of a price change.

Estimates presented in Table 5 show that firms where the prices of raw materials are considered important or very important for price changes are more likely to follow a state-dependent rather than a time-dependent price-reviewing strategy. In fact, the probability of such firms following a time-dependent price-reviewing strategy is about 19 pp lower than the probability for an otherwise identical firm. In contrast, firms that consider changes in wages as important or very important for price changes are more likely to follow time-dependent price reviewing rules, compared to state-dependent ones. In both cases the results accord with intuition: in general, the price of raw materials is highly volatile, which will increase the variability of the optimal price and thus, may be expected to increase the likelihood of state-dependent behaviour; in turn, we may expect changes in wages to occur at well-defined frequencies (once a year, usually) and thus, their importance for price changes to be negatively correlated with the uncertainty surrounding the optimal price. Interestingly, the larger importance of changes in demand for the decision of a price change does not seem to have a bearing on the type of price-reviewing strategy followed by Portuguese firms.

Efficiency loss

This category includes a group of variables expected to be related to the determinants of the sensitivity of firm's profits to deviations from the optimal price: "number of competitors", "price competitiveness", "changes in competitor's prices", "services", "intermediate goods" and "size".

The number of competitors, which is used to measure the degree of competition faced by firms, may be expected to have a significant impact on the choice of a price-reviewing strategy, because it is known that the more competitive a sector is, the more sensitive profits are to sub-optimal prices (Gopinath Itskhoki (2010)). Thus, *ceteris paribus*, firms operating in more competitive environments may be expected to prefer state-dependent practices. Our estimates show that this is indeed the case. From Table 5, we see that, for a firm operating in a more competitive environment, the probability of following a time-dependent price-reviewing rule is about 8 pp lower than the probability for and otherwise identical firm.

As regards the regressor "changes in competitors' prices", we notice that a firm for which such

changes are important or very important for pricing decisions is less likely to follow a time-dependent rule and more likely to follow a time- and state-dependent rule, but the likelihood of following a state-dependent rule is not affected. This is a very interesting finding, which may be explained in a context of strategic complementarities (see, for instance, Bonomo e Carvalho (2004)). In such a context, a firm should not be expected to follow a simple time-dependent rule, as such rule does not accommodate the possibility of a firm reacting to changes in the firms' relevant environment. In contrast, by being time- and state-dependent the firm has the possibility of generally reviewing its prices at well defined frequencies, but sometimes also in reaction to market conditions, namely changes in competitors' prices.

As earlier results suggested (see Table 2 in section 3), from Table 5 we find that firms that operate in the services sector are more likely to follow time-dependent price-reviewing strategies than firms that operate in the manufacturing sector. In fact, the covariate "services" shows up with a very large impact with estimated positive marginal effects on time-dependent behaviour of around 14 pp. The type of price-reviewing strategy also varies according to the type of market for the product and the firm size. Firms that sell their products to other firms (intermediate goods) are more likely to follow state-dependent rules than firms whose products are mainly for final demand (whose main destinations are wholesalers, retailers or consumers). In contrast, larger firms tend to prefer time- or time- and state-dependent rules in detriment of state-dependent strategies. According to our estimates, the probability of a large firm following a state-dependent price-reviewing rule is about 22 pp lower than the probability for a comparable small firm. This outcome was to be expected given the preliminary findings in section 3.

The results for the covariates "services", "intermediate goods" and "size" may reflect the fact that services, final goods and goods produced by large firms are typically goods on which the firm has a higher degree of price setting power (either through product differentiation or through a larger market share) than in the case of manufacturing, intermediate goods or goods produced by small firms, and thus face a less elastic demand, which makes profits less sensitive to non-optimal pricing.

Overall, the results in Table 5 show that the time- and state-dependent strategy is somewhat closer to the time- than to the state-dependent strategy, in the sense that changes in regressors that bring about significant changes in one of the two strategies, usually also bring about changes of the same sign in the likelihood of the other (even though in some cases not statistically different from zero). However, the results also show that time- and time- and state-dependent behaviour must be seen as two distinct choices. Indeed, for many regressors the magnitude of the impact on the two categories is different and, moreover, the probability of a firm choosing between one of the two strategies sometimes may go in the opposite direction as, for instance, in the case of a firm for which changes in competitors' prices are important or very important for pricing decisions.

5. CONCLUSIONS

This article uses firm-level data to look into the factors that may explain why firms follow time-, state-, or time- and state-dependent price-reviewing strategies.

In line with the evidence found in other countries, Portuguese firms are strongly heterogeneous as regards their price-reviewing strategies. In our sample, 32 percent of the firms follow time-dependent, 43 percent state-dependent and the remaining 25 percent time- and state-dependent price reviewing strategies. Importantly, the frequency of price changes and the speed of price reaction to shocks of time-dependent firms is significantly lower than that of state-dependent firms, while firms that are both time- and state-dependent rank in between.

By estimating a multinomial probit model, we find that the type of price-reviewing strategy varies significantly with those firm characteristics that measure the importance of information costs, the variability of the optimal price and the sensitivity of profits to sub-optimal prices. In particular, we document that an increase in the information costs tend to decrease the likelihood of a firm following a state-dependent price-reviewing strategy. Factors that contribute positively to the variability of the optimal price or that increase the cost of deviations from the optimal price decrease the probability of a firm following time- and/or time- and state-dependent price-reviewing rules, as opposed to state-dependent rules. Menu costs do not emerge as playing an important role.

We also find that the time- and state-dependent price-reviewing strategy is somewhat closer to the time-, than to the state-dependent strategy. Yet, the distinction between the first two strategies is still relevant. Indeed, the probability of a firm choosing between time- and time- and state-dependent behaviour sometimes goes in the opposite direction as, for instance, in the case of firm for which changes in competitors' prices are important for pricing decisions.

The fact that the proportion of time- and state-dependent firms depends on the state of the economy has important consequences for monetary policy. Monetary policy aimed at stabilizing the economy (by reducing inflation uncertainty) might increase the proportion of time-dependent firms, which, in turn, to the extent that such firms display lower frequency of price reviews and of price changes, would tend to increase the real effects of monetary policy. A simple implication of these results is that DSGE models should be improved in order to account for the heterogeneity and endogeneity of firms' price-reviewing or price-setting strategies. Otherwise, the implications of changes in monetary policy rules generated by these models might be very misleading.

APPENDIX

In this appendix, we describe the covariates used in the multinomial probit model whose results are presented in section 4, and provide the corresponding summary statistics. All the covariates used in the model are dummy variables. The details are as follows:

Menu costs -- Equal to one if the menu costs implied by price changes are ranked as an important or a very important factor to postpone price changes.

Information costs -- Equal to one if the costs involved in collecting the relevant information for price decisions are ranked as an important or a very important factor to postpone price changes.

Changes in prices of raw materials -- Equal to one if they are considered as important or very important for the firm's decision of a price increase or a price decrease.

Changes in wages -- Equal to one if they are ranked as important or very important for the firm's decision of a price increase or price decrease.

Changes in demand -- Equal to one if they are ranked as important or very important for the firm's decision of a price increase or price decrease.

Number of competitors -- Equal to one if the number of firm's competitors is greater than or equal to 5.

Changes in competitors' price -- Equal to one if they are important or very important for the firm's decision of a price increase or price decrease.

Intermediate goods -- Equal to one if "other companies" is the main destination of sales (as opposed to wholesalers, retailers, Government, consumers).

Size -- Equal to one if the number of employees is larger than 250.

Services -- Equal to one if the firm operates in the Services sector.

Table A1 summarizes the relative importance in the sample of the covariates defined above. The entries in the table record the share of firms in each category. For instance, from the table we see that around 93 percent of the firms consider that changes in prices of raw materials are important or very important for price decisions on either price increases or price decreases, and that the distribution of such firms does not change with firms' size, but varies across sectors, being relatively more frequent in manufacturing than in services. In contrast, only about 30 percent of the firms produce intermediate goods, i.e., sell their main product to other companies (as opposed to wholesalers, retailers or the Government) and are relatively more frequent in the services sector.

Table A1

MAIN CHARACTERISTICS OF THE SAMPLE Share of firms in each category, per cent					
	Total	**Sectors**		**Firms' size**	
		Manufacturing	**Services**	**Small**	**Large**
Menu costs	57.1	57	57.3	57.9	53.5
Information costs	40.6	41.2	34.8	41.6	36.5
Changes in prices of raw materials	93.4	95.7	71.9	93.8	93.4
Changes in wages	84.8	84.9	83.1	86.3	78.2
Changes in demand	77.7	77.5	79.8	78	76.5
Number of competitors	75.7	75.6	76.4	79.9	57.6
Changes in competitors' prices	74.6	74.3	77.5	73.9	77.6
Intermediate goods	29.9	28.9	39.3	30.8	25.9
Size (large firms)	18.8	17.9	27	-	-
Services	9.8	-	-	8.8	14.1

Source: Survey on price setting behaviour.

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