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Time-dependent or state-dependent pricing? Evidence from firms' response to inflation shocks*

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Abstract

This paper proposes a test for distinguishing between time-dependent and state-dependent pricing based on whether the timing of pricing changes is affected by realized or expeted inflation. Using Brazilian data and exploring a large discrepancy between realized and expected inflation surrounding the election of President Lula in 2002-3, we obtain a strong relation between expected inflation and duration of price spells, but little effect of inflation shocks on the frequency of price adjustment. The results thus support models with time-dependent pricing, where the timing for following changes is optimally chosen whenever firms adjust prices.

KEYWORDS: state-dependent pricing, time-dependent pricing, expected inflation, inflation shocks.

JEL CLASSIFICATION: E31, E32.

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1 Introduction

In state-dependent models, firms reajust prices whenever the discrepancy between desired and practiced prices is large enough (examples are Caplin and Spulber (1987) and Golosov and Lucas (2007)). One implication is that fims may immediately react to monetary shocks, which dampens the real effects of monetary policy.[1] In a time-dependent model, firms make pricing decisions at predetermined points in time. In its simplest versions (e.g., Calvo (1983)), the timing of price adjustment is exogenous, but in more elaborate models, firms optimally choose the time of the next price change when they adjust prices (Bonomo and Carvalho (2004, 2010)). One implication is that the real effects of monetary shocks and the costs of disinflation are larger in those models.

This paper proposes an empirical test to distinguish between time-dependent and state-dependent models and applies it to the Brazilian economy. The idea is the following: if pricing is state dependent (as in Caplin and Spulber (1987) and Golosov and Lucas (2007)), the duration of a price spell depends on realized inflation, but expected inflation at the beginning of the period should not matter much. In contrast, in a world with time-dependent pricing as in Bonomo and Carvalho (2004, 2010), the duration of the price spell will be determined when a firm changes its price, i.e., at the beginning of the price spell, so shocks after that cannot affect the duration of the price spell. In particualr, expected inflation for the next months will be an important variable in determining the time between price changes, but controlling for that, realized inflation should not matter at all.

In order to test this prediction, we need (i) micro data on pricing; (ii) data on inflation expectations; and (iii) enough discrepancy between realized and expected inflation. Brazil is a particularly suitable country for this test. As shown in Figure 1, in the period between July 2002 and July 2003 there was a large divergence between expected and realized inflation. In the second half of 2002, a pronounced currency depreciation took place, with a significant pass-through to inflation. In effect, between October 2002 and January 2003 inflation surpassed expectations (formed in the beginning of October 2002) by 7%. Lula was elected and took power in January 2003, but contrary to pessimistic expectations, his government was keen on keeping inflation down. In May-August 2003, the difference between realized and expected inflation was -2.42%. Such differences are important in our identification strategy for allowing us to identify whether the timing of pricing decisions was mostly influenced by realized or expected inflation.

The results show that the duration of price spells strongly depend on expected inflation,

[1] Gertler and Leahy (2008) add some important qualifications to this claim.

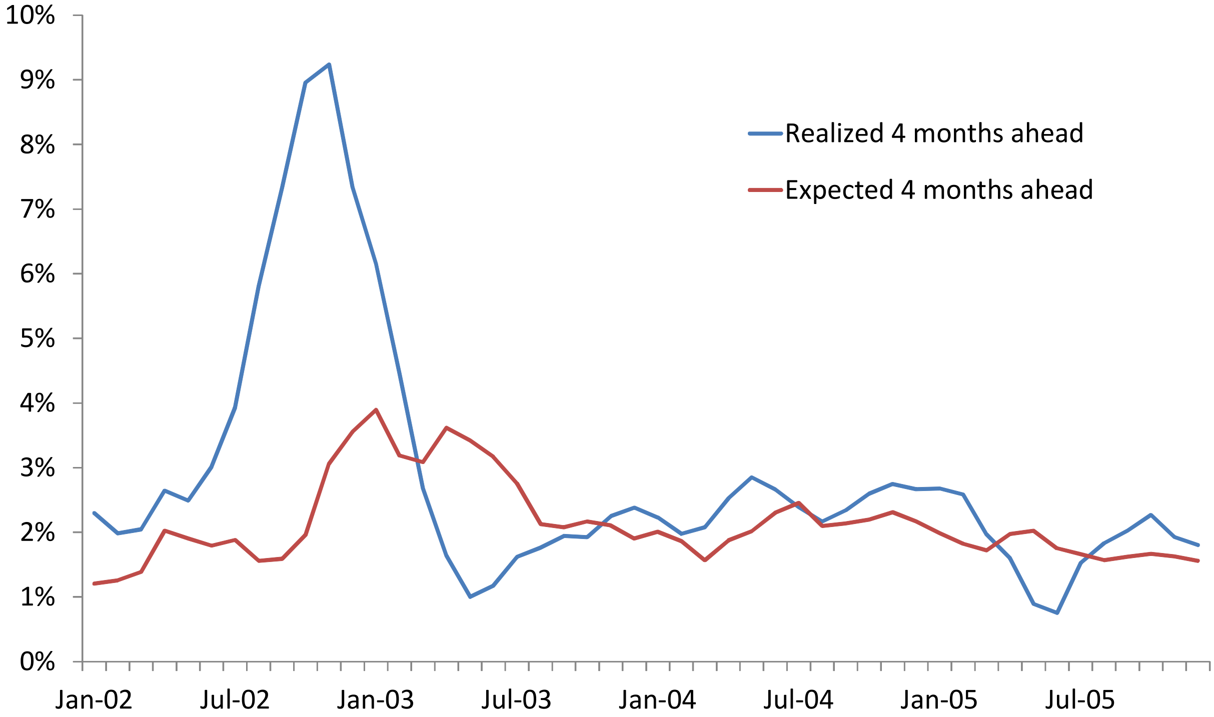

Figure 1: Expected and Realized Consumer Price Index

while the effect of realized inflation is relatively small. The magnitude of changes is affected by realized inflation (and not at all by expected inflation). The results are consistent with time-dependent models such as Bonomo and Carvalho (2004). Taking into account the role of expectations in firm's price-setting decisions substantially affect the observed negative relation between inflation and length of price spells.

There is some empirical work trying to distinguish between time-dependent and state-dependent models. Midrigan (2010) notes that in models with state-dependent pricing, firms are more likely to change prices if idiosyncratic and aggregate shocks are positively correlated. Using data from the US and exploring the sectoral variation in the correlation between idiosyncratic and aggregate shocks, he finds support for this prediction, and proposes a state-dependent model that matches some features of the US microprice data. Closer to the spirit of this paper, Feltrin and Guimaraes (2014) study how the frequency and magnitude of price changes behave around the large devaluation of the Brazilian *Real* in 1999. In accordance to the predictions of state-dependent models, the shock leads to a sharp increase in the frequency of price adjustment of tradable goods but has no effect on its magnitude.

Some papers take the relationship between inflation and the frequency of price changes as evidence for state-dependent models. For example, using Mexican data, Gagnon (2009) shows that when inflation is above a certain threshold, higher inflation corresponds to shorter price spells, which leads him to conclude that firms' pricing is state dependent. However, models with endogenous time-dependence also generate a strong correlation between frequency of price adjustment and inflation under the plausible assumption that realized and expected inflation are strongly correlated. In other words, the analysis in Gagnon (2009) allows us to distinguish between Calvo-type models where the timing of price changes is exogenous, and models where (realized or expected) inflation affect the timing of price changes, but not between state-dependent models as Golosov and Lucas (2007) and models with endogenous time dependence as Bonomo and Carvalho (2004).[2]

2 Data

The three datasets used in this paper are:

- Monthly inflation series, measured by the monthly percentage variation of the consumer price index (IPCA) issued by IBGE (Brazilian government).
- Inflation expectation series for the consumer price index (IPCA), measured by the average of market expectations compiled in the FOCUS report issued weekly by the Central Bank of Brazil (BCB).
- Microeconomic data on price quotes used to calculate the consumer price index of the Getulio Vargas Foundation (FGV), collected by IBRE-FGV.

Our analysis covers the period of January 2002 to December 2005 owing to data availability. It turns out that this is an interesting period for our analysis, since expected inflation has markedly differed from realized inflation between mid-2002 and mid-2003.

The monthly inflation data is standard, we discuss the other two datasets below.

2.1 Data on inflation expectations

The FOCUS report compiles market participant's expectations on several key variables and is issued weekly by the Central Bank of Brazil (BCB) through its GERIN department. This data has been compiled since January 2002. Market participants are asked to forecast inflation from the 1^{st} day of the following month to the 1^{st} day of every month for a period

[2] See also Klenow and Kryvtsov (2008).

of over a year – which is enough for our purposes given the frequency of price changes in Brazil.

The Central Bank of Brazil seeks to stimulate accurate forecasts by market participants through its "top 5 ranking", which is made public on a monthly basis and is arguably seen as a valuable signal for financial institutions and consultancies. Survey data typically prompt questions about whether they are really reflecting market participants' beliefs or not. In our regressions, expected inflation ends up being much more important than realized inflation in explaining the duration of price spells, hence one cannot dismiss the data as pure noise.

The deviations between inflation expectations from the FOCUS survey and realized inflation do not seem to be systematic. For the January 2002 – August 2011 period, the average error was 0.07%, with a standard deviation of 0.31%, but that is severely affected by the unexpected inflation spike at the end of 2002. In the less volatile period of August 2003 – August 2011 the average error was 0.03%, with a standard deviation of 0.17%, and we cannot reject the null hypothesis that the average error is equal to zero at the 5% significance level.

2.2 Micro data on pricing

There are several consumer price indices in Brazil. IPCA is the index to which the Central Bank's inflation target refers. The Getulio Vargas Foundation (FGV) issues a few other inflation indices and its general price index (IGP) currently comprises 180,000 different products collected in 2,500 outlets in 12 of Brazilian largest cities. These products are grouped in seven different sectors. Our data refers to price quotes and store-level information covering 100% of the general price index, collected by FGV's staff via palmtops or by filling out forms.

We will focus on services, the product category with the largest degree of price rigidity.[3] As highlighted by Barros *et al* (2009) and Gouvea (2007), the median price spell in Brazil is relatively short, and there is little hope to find significant differences between inflation and expected inflation in goods with a median price spell of about 2 months. In case of longer spells, there is a greater discrepancy between expected and realized inflation ex-post, which might allow us to infer which of them is more important to pricing decisions.

Our database goes until early 2006, and price collections prior to 2002 have to be discarded owing to the lack of inflation expectation data for that period. That gives us

[3] Gouvea (2007) shows that prices in the service group have the largest duration among goods for which we have data. Klenow and Malin (2010) survey papers on price rigidity using microdata from 24 countries and find that the service sector is the one with the largest degree of price rigidity.

585.820 observations using a broad definition of services, where each observation refers to an *item* sold at a specific outlet.[4] For some products, there is more than one collection a month, and we removed those from our database as well, reaching 366.953 observations.[5]

From our treated base with 366.953 observations we go on to spell creation. A spell is the time period counted in months in which an item's price remains the same. A right censored spell is one in which its termination date cannot be observed (that is, a price change is not observed in the last price collection). A left censored spell defined in the same way. Excluding censored spells, we end up with 50.251 spells, with an average length of 4.3 months. Figure 2 provides an example of spells for a particular item in our database.

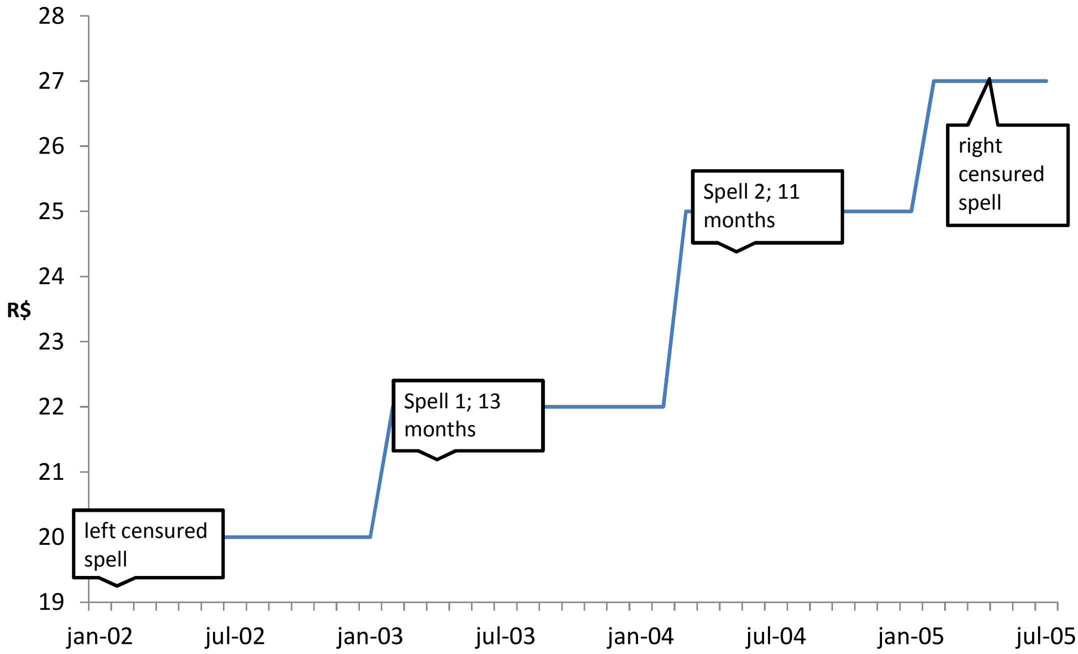

Figure 2: Mens Haircut without Washing, Sao Paulo (input # 39233)

The micro data on pricing does not tell us exactly the date of a price change, so we assume that prices change on the first day of each month, in order to match data on inflation and inflation expectations. For instance, if in the August 20^{th} collection and

[4] An example of an item: Foreign language course – Basic Spanish, Monthly tuition, sold in establishment 16790 in Recife, Pernambuco.

[5] Guimaraes and Sheedy (2011) argue that temporary sales should not be considered in this type of analysis, but we ended up not excluding temporal sales because (i) sales are not prevalent in the services sector and (ii) Queiroz da Silva (2009) calibrates a model with temporary sales based on Guimaraes and Sheedy (2011) to fit the Brazilian data (where prices change very often) and shows that the filters used in the literature to detect sates do not work well in the Brazilian case.

September 20^{th} collection prices are different, and then the price remains constant until the December 15^{th} collection, we assume that there has been a change on September 1^{st} and another change on December 1^{st}, with a three month spell comprising the months of September, October and November. That price spell will correspond to realized and expected inflation on September 1^{th} for the three months ahead.

3 Methodology

With microdata on prices, data on inflation and inflation expectations, we use panel fixed effect regressions in order to disentangle the effects of realized and expected inflation on the duration of price spells and magnitude of price changes. More specifically, we regress the length of spell j (months) in monthly inflation and expected monthly inflation for spell j:

$$\lambda_{ij} = \phi_i + \beta_1 \pi_j^m + \beta_2 E\left(\pi_j^m\right) + \delta Z + \varepsilon_{ij} \tag{1}$$

where λ_{ij} is the size of spell j of product i in months, ϕ_i is a fixed effect that captures non-observed idiosyncratic factors affecting price rigidity of product i, π_j^m is inflation for the length of spell j, $E\left(\pi_j^m\right)$ is expected inflation for the length of spell j at its beggining, Z is a set of controls and ε_{ij} is an error term. We use the average inflation for any period of n months in order to avoid a spurious relationship between long spells and higher accumulated inflation in that spell, since inflation is always positive in our sample.

In case of (endogenous) time dependent models, β_1 should be 0 and β_2 should be negative and significant. In case of state-dependent models, β_1 should be negative and important because higher inflation would lead to ealier price changes.

We also regress the size of the price change (percentage change at the end of the spell) in inflation and expected inflation for spell j

$$\mu_{ij} = \psi_i + \gamma_1 \pi_j^m + \gamma_2 E\left(\pi_j^m\right) + \delta Z + \eta_{ij} \tag{2}$$

where μ_{ij} is the magnitude of price change for product i at the end of spell j, ψ_i is a fixed effect that captures non-observed idiosyncratic factors affecting price rigidity of product i, π_j^m is the monthly inflation for the lenght of spell j, $E\left(\pi_j^m\right)$ is the monthly expected inflation for the lenght of spell j at its beggining, Z is a set of controls and η_{ij} is an error term. In the simplest state-dependent models (as Caplin and Spulber (1987)), the magnitude of price changes is independent of inflation but that prediction does not hold in other models with state-dependent pricing. In case of time-dependent models, the magnitude of price changes should be affected by inflation.

Our control variables include the expected inflation n months forward at the end of spell j, the average industrial capacity utilization during spell j, the average consumer confidence in the period and the average level of unemployment.

4 Results

4.1 Benchmark regressions

We start by imposing $\beta_2 = 0$ in (1) and $\gamma_2 = 0$ in (2) in order to understand how frequency and size of price adjustment are related to inflation when expected inflation is not included in the regression. The tables in figures 3 and 4 show how inflation correlates with the the spell size and the magnitude of price changes, respectively, without controlling for expected inflation.

Dependent Variable: Spell Size Months									
	Baseline	Control 1				Control 2			
Cons	4.20***	2.66***	3.52***	3.17***	2.64***	11.15***	-0.31	3.85***	8.06***
	(0,02)	(0,06)	(0,05)	(0,05)	(0,05)	(1,15)	(1,02)	(0,16)	(0,31)
Monthly inflation	-63.01***	-104.90***	-81.05***	-91,43	-105.33***	-83.31***	-62.43***	-61.85***	-73.33***
	(1,42)	(2,44)	(2,02)	(2,03)	(2,39)	(2,05)	(1,41)	(1,47)	(1,72)
Expected inflation 1 month forward		-3,43	74.53***						
		(5,70)	(4,99)						
Expected inflation 4 months forward		-9.29**		49.83***					
		(3,95)		(2,16)					
Expected inflation 6 months forward		59.48***			52.42***				
		(3,41)			(1,86)				
Capacity utilization						0,00	0.06***		
						(0,26)	(0,01)		
Consumer confidence						-0.01***		0.00**	
						(0,00)		(0,00)	
Unemployment						0.46***			-0.32***
						(0,03)			(0,03)
Standard errors in parentheses, robust for heteroscedasticity with clusters at the product level									
Superscripts *, **, *** denote statistical significance at the 10%, 5% and 1% levels respectively									

Figure 3: Spell size and realized inflation

The coefficient around -60 in the baseline regression for the spell size implies that an increase in monthy inflation by one percentage point reduces the average spell by 0.6 months. Larger expected inflation at the end of the price spell is also related to short spells. The coefficient on inflation is even larger when we add other control variables (expected inflation, average industry utilization during a spell, the average consumer confidence in the period and the average level of unemployment).

The effect of inflation on the magnitude of price changes is robust to the inclusion of several controls and around 0.3: if inflation is higher by 1 percentage point, the magnitude

Dependent Variable: Price Change Magnitude									
	Baseline	Control 1				Control 2			
Cons	0.05***	0.05***	0.05***	0.05***	0.05***	-0.44***	-0.38***	0.07***	0.05*
	(0,00)	(0,01)	(0,01)	(0,00)	(0,00)	(0,13)	(0,08)	(0,02)	(0,03)
Inflation	0.30***	0.31***	0.32***	0.31***	0.31***	0.28***	0.31***	0.28***	0.30***
	(0,05)	(0,06)	(0,06)	(0,06)	(0,06)	(0,06)	(0,05)	(0,06)	(0,06)
Expected inflation 1 month forward		-0,39	-0,35						
		(0,68)	(0,43)						
Expected inflation 4 months forward		-0,05		-0,11					
		(0,48)		(0,18)					
Expected inflation 6 months forward		-0,06			-0,07				
		(0,39)			(0,13)				
Capacity utilization						0.01***	0.01***		
						(0,00)	(0,00)		
Consumer confidence						-0.00**		-0.00	
						(0,00)		(0,00)	
Unemployment						0,00			-0.00
						(0,00)			(0,00)
Standard errors in parentheses, robust for heteroscedasticity with clusters at the product level									
Superscripts *, **, *** denote statistical significance at the 10%, 5% and 1% levels respectively									

Figure 4: Magnitude of price change and inflation

of price changes increases by 0.3 percentage points. If the duration of price spells was unaffected by inflation, we should expect a one-to-one relationship. The coefficient is substantially smaller than one, indicating that inflation also affects the frequency of price changes.

The negative relation between inflation and spell duration is consistent with state-dependent pricing. For instance, Gagnon (2009) interprets similar evidence as support for state dependent pricing. While this shows that the state of the economy (and, in particular, inflation) affects pricing, it does not allow us to separate between typical state-dependent models (as Caplin and Spulber (1998) and Golosov and Lucas (2007)) and models with endogenous time dependence (as Bonomo and Carvalho (2004, 2010)).

4.2 The effect of expected inflation

We now turn to the results when expected inflation is included in the regression. Tables in figures 5 and 6 show the relation between both realized and expected inflation and the dependent variables (spell size and the magnitude of price changes).

The inclusion of expected inflation in the regression has a very large effect on the results. In the baseline specification, the coefficient on realized inflation is -9, meaning that an increase in monthly inflation by one percentage point reduces the price spell by about 3 days. In contrast, expected inflation has a large and negative effect on the duration of price spells: an increase in expected monthly inflation of 1 percentage point

Dependent Variable: Spell Size Months									
	Baseline	Control 1				Control 2			
Cons	6.03***	4.14***	5.24***	4.76***	4.03***	30.93***	25.05***	4.51***	7.58***
	(0,04)	(0,05)	(0,06)	(0,05)	(0,05)	(1,10)	(0,97)	(0,16)	(0,27)
Monthly inflation	-9.60***	-60.55***	-30.33***	-44.35***	-63.42***	6.08***	-5.28***	-3.08**	-14.67***
	(1,32)	(1,60)	(1,56)	(1,56)	(1,62)	(1,62)	(1,30)	(2,21)	(1,54)
Expected monthly inflation	-269.87***	-315.09***	-275.07***	-288.95***	-311.14***	-328.40***	-303.94***	-276.58***	-265.60***
	(4,91)	(4,54)	(4,77)	(4,68)	(4,54)	(5,16)	(5,04)	(4,95)	(4,87)
Expected inflation 1 month forward		-28.97***	89.90***						
		(4,37)	(3,94)						
Expected inflation 4 months forward		-24.15***		67.55***					
		(3,53)		(1,85)					
Expected inflation 6 months forward		99.93***			76.77***				
		(3,05)			(1,54)				
Capacity utilization						-0.33***	-0.23***		
						(0,01)	(0,01)		
Consumer confidence						0.02***		0.01***	
						(0,00)		(0,00)	
Unemployment						-0.05**			-0.13***
						(0,02)			(0,02)
Standard errors in parentheses, robust for heteroscedasticity with clusters at the product level									
Superscripts *, **, *** denote statistical significance at the 10%, 5% and 1% levels respectively									

Figure 5: Realized and expected inflation and price spell duration

leads firms to adjust prices 2 or 3 months in advance. The effect is very large and robust to the inclusion of several control variables.

The fact that expected inflation has such a large effect on the duration of price spells, controlling for realized inflation, is not consistent with state-dependent pricing. In state-dependent models of price setting, agents know the inflation rate, hence previoulsy expected inflation adds no relevant information for price setting decisions. The result is consistent with models of endogenous time-dependent price setting, where a larger expected inflation would induce firms to get information about their optimal prices more often.

The inclusion of expected inflation does not change the pattern of the relationship between realized inflation and the magnitude of price changes.

5 Concluding remarks

This paper proposes a test to distinguish between models with time-dependent and state-dependent pricing that relies on micro data on pricing; data on expected inflation; and enough discrepancy between realized and expected inflation. Brazil is a particularly suitable country for this test because the large differences between realized and expected inflation in 2002-3 allow us to estimate the effect of each of those variables on the size

Dependent Variable: Price Change Magnitude									
	Baseline	Control 1				Control 2			
Cons	0.05***	0.05***	0.05***	0.05***	0.05***	-0.44***	-0.40***	0.07***	0.05*
	(0,00)	(0,01)	(0,01)	(0,01)	(0,01)	(0,13)	(0,09)	(0,02)	(0,03)
Inflation	0.30***	0.33***	0.33***	0.32***	0.32***	0.19**	0.28***	0.27***	0.30***
	(0,06)	(0,07)	(0,07)	(0,07)	(0,07)	(0,08)	(0,05)	(0,06)	(0,06)
Expected inflation	-0.00	-0,03	-0,03	-0,02	-0,02	0.22*	0,10	0,03	-0.00
	(0,09)	(0,09)	(0,10)	(0,09)	(0,09)	(0,12)	(0,09)	(0,09)	(0,10)
Expected inflation 1 month forward		-0,41	-0,38						
		(0,69)	(0,46)						
Expected inflation 4 months forward		-0,06		-0,12					
		(0,48)		(0,18)					
Expected inflation 6 months forward		0,06			-0,08				
		(0,39)			(0,14)				
Capacity utilization						0.01***	0.01***		
						(0,00)	(0,00)		
Consumer confidence						-0.00**		-0.00	
						(0,00)		(0,00)	
Unemployment						-0.00			-0.00
						(0,00)			(0,00)
Standard errors in parentheses, robust for heteroscedasticity with clusters at the product level									
Superscripts *, **, *** denote statistical significance at the 10%, 5% and 1% levels respectively									

Figure 6: Realized and expected inflation and magnitude of price changes

and frequency of price adjustment.

The analysis provides support for models with (endogenous) time-dependent pricing. One message of this paper is that failing to take expected inflation into account might lead us to incorrectly interpret the negative relation between spell length and inflation as evidence for state-dependency pricing.

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