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Abstract

We estimate a model that integrates sticky prices and sticky information using Spanish data following Dupor et. al (2008). The model yields three empircal facts: a-) the frequency of price changes (around one year), b-) the firm's report that sticky information is no too important for nominal rigidities and c-) the inflation's persistence, the latter with more microfoundations than the Hybrid Model. We found that both types of stickiness are present in Spain, but the most important is the stickiness in prices.

1 Introduction

Most empirical work uses some kind of stickiness to model the interaction between real activity and inflation. The most popular framework is the price setting scheme that was proposed by Calvo (1983) [5], where firms reset prices each period with a fixed probability. The inflation dynamics in this setting relates current inflation to expected future inflation. The main problem with this approach, as noted by Mankiw and Reis (2002) [10] , is that it fails to account for inflation persistence and to explain the delayed and gradual effect of monetary shocks on inflation. The most popular extension to Calvo's model is the Hybrid Model by Galí and Gertler (1999) [8] which models the inflation persistence assuming a fraction of pure backward looking firms. The Hybrid Model can explain most of the stylized facts but at the cost of assuming, with no microfoundations, that there is a fraction of backward looking firms. In the last years a new approach have surged, that is consistent with the inflation persistence and the gradual effect of monetary shock on inflation. Dupor, Kitamura and Tsuruga (2006 & 2008) [6] [7], and Bruchez (2007) [4] have shown theoretical and empirically that integrating sticky prices and sticky information in one single model explain the facts that Calvo's model fails to explain, and with more microfoundations than the Hybrid Model.

In this paper we estimate and assess the empirical fit of this new model, the Dual Stickiness Model, for Spanish inflation process during the period 1980:I-2009:IV. We first check if there is some kind of breaks in inflation's volatility for the whole period because this could affect market expectation and we need to assume that these expectations remain constant for the whole period we are analyzing. Then we estimate and compare the non closed form solution of four models Sticky Prices, Sticky Information, Hybrid Model and Dual Stickiness Model.

The findings are summarized as follow. There exist a break in inflation mean and volatility around the end of the 80's that could affect the market expectations, so we decided to use a more stable period 1991:II-2009:II. The expected duration of prices is around one year in line with Spanish stylized facts (see Álvarez and Hernando (2004) [2], Álvarez, Burriel and Hernando (2005) [1]). Both kinds of stickiness are present in Spain but the most important for inflation dynamics is the sticky prices.

The present paper is organized as follow. Section 2 explains the Dual Stickiness model deriving some key equations to understand the connection between sticky information and inflation persistence. Section 3 revises some Spanish stylized facts and previous work. Section 4 explains the empirical implementation and presents the main findings. Section 5 concludes.

2 The new Phillips curve: Background theory and extensions

One of the oldest questions in macroeconomics is why a change in the money supply cause real output and employment to change in the short run, but not in the long run. This question has been placed under the lens of rational expectations and micro-founded dynamics assuming some kind of stickiness. The empirical work has focused on the aggregated Euler equation from a rational expectations sticky price model, often called New Keynesian Phillips-Curve (NKPC). The main problems of the NKPC cited by Mankiw and Reis (2002) [10] are the followings:

1. Yields that announced, credible disinflations cause booms rather than recessions.
2. Cannot explain why inflation is so persistent.
3. It has trouble explaining why shocks to monetary policy have a delayed and gradual effect on inflation.

These problems appear to arise from the same source: although the price level is sticky in this model, the inflation rate can change quickly (in this framework inflation is a jump variable, do not have nothing to do with past values).

Mankiw and Reis's model has its shortcoming too. It yields a hump-shaped inflation response at the cost of assuming that prices change every period, which does not match the microeconomics stylized fact that nominal prices typically remains the same for around 1 year (see Álvarez, Burriel and Hernando (2005) [1] , Álvarez and Hernando (2004) [2]).

Dupor, Kitamura and Tsuruga (2008) [7] have empirically estimated for USA a model that integrates two kinds of rigidities (sticky information and sticky prices). Bruchez (2007) [4] showed that this dual stickiness model is able to deliver a hump-shaped inflation response to monetary shocks without counterfactually implying, as in Mankiw and Reis, that individual firms's prices change each quarter (responding or not to the shock).

We will present the theoretical background of this new model that integrates this two kinds of stickiness (Dual Stickiness Model).

2.1 The Baseline Models:

We will consider as baseline models the Hybrid Model and the Dual Stickiness Model[1].

2.1.1 The Dual Stickiness Model

Let's consider the following assumptions:

- Continuum of firms engaged in monopolistic competition.
- Each firm is ex ante identical and faces infrequent price setting. The probability to reset prices in each period is $(1-\gamma)$
- In each period, a fraction $1-\phi$ of firms obtains new information about the state of the economy and computes a new path of optimal prices.
- The opportunities to change a price and to update information are assumed to be uncorrelated over time and with each other.

Due to Dixit-Stiglitz aggregation and the log-linearization around the steady state it is possible to show that the price level p_t evolves according to

$$p_t = \gamma p_{t-1} + (1-\gamma) q_t \tag{1}$$

Where q_t is the index for all newly set prices in period t

We can rewrite (1) to derive an inflation equation. Substract p_{t-1} to both sides of (1) and use $\pi_t = p_t - p_{t-1}$

$p_t - p_{t-1} = -(1-\gamma)p_{t-1} + (1-\gamma)q_t$

$$\pi_t = (1-\gamma)(q_t - p_{t-1}) \tag{2}$$

This equation show that only newly set prices matter for inflation because other prices are fixed.

The negative of inflation $-\pi_t = p_{t-1} - p_t$ can be interpreted as the relative price of non-price-setting firms in period t. Using again equation 1 but now substracting γp_t from both sides:

$p_t - \gamma p_t = \gamma p_{t-1} + (1-\gamma)q_t - \gamma p_t$

$p_t - \gamma p_t = \gamma(p_{t-1} - p_t) + (1-\gamma)q_t$

$(1-\gamma)p_t = -\gamma\pi_t + (1-\gamma)q_t$

$$-\gamma\pi_t + (1-\gamma)(q_t - p_t) = 0 \tag{3}$$

Equation 3 show us that the weighted sum of non-price-setting firms and price-setting firms in period t relative to the aggregated price index (p_t) must sum to zero.

From this equation 3 we have a second equality that gives us a relationship between the newly set relative prices and overall inflation under sticky prices with random duration.

[1] This derivations follow Dupor, Kitamura and Tsuruga (2008)

$$\pi_t = \frac{(1-\gamma)}{\gamma}(q_t - p_t) \tag{4}$$

Equation (4) tell us that inflation is higher when newly set prices are higher than overall price level. Inflation is proportional to newly relatives prices.

The optimal price for the firms that have the opportunity to change is given by:

$$p_t^f = (1-\gamma)\sum_{j=0}^{\infty}\gamma^j E_t[mc_{t+j}^n] \tag{5}$$

Firms sets its nominal price to the weighted average of current and future nominal marginal costs.

This decision is forward-looking because of infrequent opportunities for price changes.

The newly prices index is going to be a weighting average of attentive and inattentive firms:

$$q_t = (1-\phi)\sum_{k=0}^{\infty}\phi^k E_{t-k}(p_t^f) \tag{6}$$

We can approximate this equation by setting K large enough. Because in reality it is quite difficult to find a firm that takes decisions with information of three years old.

We can rewrite (6) as a first order difference equation, using the following identity $p_t^f = \Delta p_t^f + p_{t-1}^f$

$q_t = (1-\phi)\sum_{k=0}^{\infty}\phi^k E_{t-k}(\Delta p_t^f + p_{t-1}^f)$

$$q_t = (1-\phi)\sum_{k=0}^{\infty}\phi^k E_{t-k}\Delta p_t^f + (1-\phi)\sum_{k=0}^{\infty}\phi^k E_{t-k}p_{t-1}^f \tag{7}$$

Let's work with the second element of the right hand side of the last equation.

$(1-\phi)\sum_{k=0}^{\infty}\phi^k E_{t-k}p_{t-1}^f = (1-\phi)p_{t-1}^f + (1-\phi)\sum_{k=0}^{\infty}\phi^k E_{t-k}p_{t-1}^f$

$= (1-\phi)p_{t-1}^f + \phi(1-\phi)\sum_{k=0}^{\infty}\phi^k E_{t-k-1}p_{t-1}^f$

$= (1-\phi)p_{t-1}^f + \phi q_{t-1}$

$=(1-\phi)(p_t^f - \Delta p_t^f) + \phi q_{t-1}$

$= (1-\phi)p_t^f - (1-\phi)\Delta p_t^f + \phi q_{t-1}$

Replacing the last equality again in (7).

$q_t = (1-\phi)\sum_{k=0}^{\infty}\phi^k E_{t-k}\Delta p_t^f + (1-\phi)p_t^f - (1-\phi)\Delta p_t^f + \phi q_{t-1}$

$= (1-\phi)\phi\sum_{k=0}^{\infty}\phi^k E_{t-k-1}\Delta p_t^f + (1-\phi)\Delta p_t^f + (1-\phi)p_t^f - (1-\phi)\Delta p_t^f + \phi q_{t-1}$

$$q_t = \phi q_{t-1} + (1-\phi)p_t^f + (1-\phi)\phi\sum_{k=0}^{\infty}\phi^k E_{t-k-1}\Delta p_t^f \tag{8}$$

The intuition is that some firms that are changing their prices today, they are acting as yesterday newly set prices firms. This give us the persistence in the model.

We can better see the persistence if we work with the following identity:

$\pi_t = p_t - p_{t-1}$
$p_t + \phi\pi_t = \phi p_t - \phi p_{t-1} + p_t$
$p_t = (1-\phi)p_t + \phi p_{t-1} + \phi\pi_t$

Remember that from equation (4) inflation is a one to one mapping of $(q_t - p_t)$. With the latter identity and equation (8) we can rewrite $(q_t - p_t)$ as a first order difference equation :

$q_t - p_t = \phi q_{t-1} + (1-\phi)p_t^f + (1-\phi)\phi\sum_{k=0}^{\infty}\phi^k E_{t-k-1}\Delta p_t^f - (1-\phi)p_t - \phi p_{t-1} - \phi\pi_t$

$$q_t - p_t = \phi(q_{t-1} - p_{t-1}) - \phi\pi_t + (1-\phi)(p_t^f - p_t) + (1-\phi)\phi\sum_{k=0}^{\infty}\phi^k E_{t-k-1}\Delta p_t^f \quad (9)$$

The last equation can be rewritten using (5), (11) and (4)

$$\pi_t = \rho^D\pi_{t-1} + \zeta_1^D(1-\gamma)\sum_{j=0}^{\infty}\gamma^j E_t(mc_{t+j}^n - p_t) + \zeta_2^D(1-\phi)\sum_{k=0}^{\infty}\phi^k(1-\gamma)\sum_{j=0}^{\infty}\gamma^j E_{t-k-1}(\delta mc_{t+j} + \pi_{t+j}) \quad (10)$$

where $\rho^D = \frac{\gamma\phi}{\phi+\gamma-\gamma\phi}$, $\zeta_1^D = \frac{(1-\phi)(1-\gamma)}{\phi+\gamma-\gamma\phi}$, $\zeta_2^D = \frac{\phi(1-\gamma)}{\phi+\gamma-\gamma\phi}$, $mc_t = mc_t^n - p_t$

As we can see in the last equation, lagged inflation appears endogenously. Sticky price assumption generate the one to one relationship between π_t and $q_t - p_t$ and sticky information assumption generates persistent dynamics of $q_t - p_t$

2.1.2 The Hybrid Phillips Curve

This model, due to Galí and Gertler (1999), depart from the pure sticky price model by assuming the presence of two types of firms. A fraction $(1-\phi)$ adjust its price at t and set its price optimally. The remaining firms are backward-looking and use a simple rule of thumb. Then, the price index q_t is expressed as a linear combination of the price set by forward-looking firms (p_t^f) and the price set by backward-looking firms (p_t^b)

$$q_t = (1-\phi)p_t^f + \phi p_t^b \quad (11)$$

where p_t^f is the price chosen by firms if they have to change it (see equation (5))

$$p_t^b = q_{t-1} + \pi_{t-1} \quad (12)$$

where mc_t^n is nominal marginal cost in period t

If we substitute (5) and (12) into (11) we get

$$q_t = (1-\phi)((1-\gamma)\sum_{j=0}^{\infty}\gamma^j E_t[mc_{t+j}^n]) + \phi(q_{t-1} + \pi_{t-1}) \quad (13)$$

Substracting p_t from (13) and using (4) we get

$q_t - p_t = (1-\phi)((1-\gamma)\sum_{j=0}^{\infty}\gamma^j E_t[mc_{t+j}^n]) + \phi(q_{t-1} + \pi_{t-1}) - p_t$

$\frac{\gamma}{1-\gamma}\pi_t = (1-\phi)((1-\gamma)\sum_{j=0}^{\infty}\gamma^j E_t[mc_{t+j}^n]) + \phi(q_{t-1} + \pi_{t-1}) - p_t$

3 Price Setting Behaviour in Spain: Micro and Macro evidence

We can find evidence about the inflation dynamics in Spain within the research conducted by the Inflation Persistence Network (IPN). IPN is a team of Eurosystem economists undertaking joint research on inflation persistence in the euro area and its member countries. The research of the IPN combines theoretical and empirical analyses using three data sources: individual consumer and producer prices: surveys on firms' price-setting practices; aggregated sectorial, national and area wide price indices. Patterns, causes and policy implications of inflation persistence are addressed.

Outside IPN we can also find more Independent research. Gali and López-Salido (2000) provide evidence on the fit of the New Phillips Curve (NPC); Bentolila, Dolado and Jimeno (2008) shows that if labor supply elasticities and bargaining power differ between natives and immigrants the New Keynesian Phillips curve is shifted by immigration. They estimated this curve for Spain and found that without immigration the inflation would have been higher (2.5% in contrast with the roughly constant rate).

3.1 Micro evidence

We can find micro evidence from producer and consumer price setting behaviour for Spain in the research conducted by IPN.

Using Consumer Price Micro Data (70% of the expenditure of the CPI basket, covering the period 1993-2001) Álvarez and Hernando (2004) [2] concluded that:

1- Consumer prices are moderately sticky. The average duration is slightly over 1 year.

2- Heterogeneity in the frequency of price adjustment. Unprocessed food prices with the highest change frequency and services with the highest degree of price stickiness.

3- They do not find signs of a higher degree of downward rigidity.

4- Even though prices do not change often, they typically change by a large amount (8.6% on average). Moreover, the size of price decreases tend to be somewhat higher than that of price increases.

Using Producer Price Micro Data (99.4% of the PPI, covering the period 1991-1999) Álvarez, Burriel and Hernando (2005) [1] main conclusions are:

1- Producer prices are moderately sticky. The average duration is slightly less than 1 year.

2- Heterogeneity in the frequency of price adjustment. The flexibility of prices is greatest for energy, other intermediate goods and food products and the highest degree of price stickiness is observed for capital goods and consumption durables.

3- They don't find strong signs of a higher degree of downward rigidity.

4- Even though prices of most products do not change often, they typically change by a large amount (4.8% on average). There are no asymmetries between price increases and decreases.

Concluding this subsection we can say that the average duration for whole the prices is around 1 year with heterogeneity across products and with almost the same degree of rigidity and amount of changes for price increases and decreases.

3.2 Macro evidence

Galí and López-Salido (2000) provide evidence on the fit of the New Keynesian Phillips Curve (NKPC) for Spain over the period 1980-1998. They found that NKPC fits the data well, however, the backward-looking component of inflation is important but the price stickiness implied by the model is plausible. They also found that the price of imported intermediate goods affects the measure of the firm's marginal cost and thus also inflation dynamics, and finally labour market frictions appear to have also played a key role in shaping the behaviour of marginal costs, but do not affect significatively the structural parameters

Rumler (2005) has estimated an open economy version of the NKPC for Euro area countries. He found also that the price rigidity is systematically lower in the open economy specification. Comparing his results for Spain to those obtained by Gali and Lopez-Salido (2000), Rumler (2005) found lower sticky prices and lower firms with backward rule of thumb price setting, the discount factor is also higher. Rumler found that the coefficient of price rigidity for Spain (also Greece and Austria) are basically unaffected by the introduction of open economy effects . All these results are closer to the stylized facts. Both models differ in the assumption about return to labor in production (Gali and Lopez-Salido only consider constant returns to labor in production and Rumler assume decreasing returns to labor (and imported intermediate goods).

Bentolila, Dolado and Jimeno (2008) introduce immigration to explain the flat Phillips curve for Spain over 1995-2006.

4 Empirical Implementation

4.1 Estimation strategy

Campbell and Shiller (1987) propose a framework to assess the fit of forward-looking present-value models. This approach does not involve making assumption about the structure of the whole economy in the application of maximum likelihood methods or the choice of appropriate instruments in an instrumental variables estimation.

Our estimation strategy follow the following steps

1. We check for an unknown structural break in inflation's volatility.
2. We use VAR projections as a proxy for market expectations.
3. Given the VAR process, we then minimize the variance of a distance between the model's and actual inflation.

The details of the estimation procedure are as follows.

First, Assume that any break in inflation's volatility affects market expectations. We then use Quandt-Andrews unknown breakpoint test. The idea behind the Quandt-Andrews test is that a single Chow Breakpoint Test is performed at every observation between two dates. The test statistics from those Chow tests are then summarized into one test statistic for a test against the null hypothesis of no beakpoints between this two dates.

Second, we specify the forecasting model by introducing the vector X_t in the following VAR:

$$X_t = AX_{t-1} + \varepsilon_t \tag{14}$$

The vector X_t includes labor share, inflation and the output gap. It also includes lags of the three variables. In general, X_t is given by a $(3p \times 1)$ vector of $[x'_t, x'_{t-1}, ..., x'_{t-p+1}]'$,where $x_t = [mc_t, \pi_t, y_t]'$ and y_t is the output gap.

Next, we calculate a series of theoretical inflation given the forecasting process (14). Ordinary least squares produces a consistent estimate of the coefficient matrix $\widehat{A}$. Let e_{mc} and e_π denote the selection vectors with $3p$ elements. All elements are zero except the first element of e_{mc} and the second element of e_π,which are unity. Given the definitions, we express labor share and inflation as $e'_{mc}X_t$ and $e'_\pi X_t$, respectively.

Consider the case $\gamma = 0$

$$p^b_t = (1-\phi)\Sigma\phi^k E_{t-k-1}p^f_t \tag{15}$$

Given the definitions of selection vectors, $E_{t-k-1}(\Delta mc_t + \pi_t) = (e'_{mc}(A-I) + e'_\pi A)A^k X_{t-k-1}$. Then 15 can be written as

$$\pi^m_t(\theta, A) = \frac{1-\phi}{\phi} mc_t + (1-\phi)(e^{'}_{mc}(A-I) + e'_\pi A)\sum_{k=0}^{\infty}\phi^k A^k X_{t-k-1} \tag{16}$$

where $\pi^m_t(\theta, A)$ denotes the inflation predicted by the model and θ denotes the parameter vector to be estimated. In this particular case, $\theta = \phi$. By introducing an arbitrary truncation value of K, we approximate this equation by

$$\pi^m_t(\theta, A) = \frac{1-\phi}{\phi} mc_t + (1-\phi)(e^{'}_{mc}(A-I) + e'_\pi A)\sum_{k=0}^{K-1}\phi^k A^k X_{t-k-1} \tag{17}$$

When the model explains the data well,$\pi^m_t(\theta, A)$ is close to actual inflation. Using a consistent estimate $\widehat{A}$, we choose the parameter θ by:

$$\widehat{\theta} = Arg\min_{\theta}\ var(\pi_t - \pi^m_t(\theta, \widehat{A})) \tag{18}$$

$$\pi^m_t(\theta, A) = \widehat{\rho}\pi_{t-1} + b'X_t \tag{19}$$

$$\pi^m_t(\theta, A) = \rho\pi_{t-1} + b'X_t + c'\sum_{k=0}^{\infty}\phi^k A^k X_{t-k-1} \tag{20}$$

where $b' = \zeta_1\left[(1-\gamma)\,e'_{mc} + \gamma e'_\pi A\right]\left[I-\gamma A\right]^{-1}$ and $c' = \zeta_2(1-\gamma)(1-\phi)\left[e'_{mc}(A-I) + e'_\pi A\right]\left[I-\gamma A\right]^{-1}$.

$\zeta_1 = \frac{(1-\phi)(1-\gamma)}{\phi+\gamma-\gamma\phi}$
$\zeta_2 = \frac{\phi(1-\gamma)}{\phi+\gamma-\gamma\phi}$
$\rho = \gamma\frac{\phi}{\phi+\gamma-\gamma\phi}$

The parameter vector here is $\theta = [\gamma, \phi]'$ .Once again, we choose an arbitrary large truncation parameter K and minimize the variance of the distance between model and actual inflation.

4.1.1 Model-Based Bootstrap

To make statistical inferences, we use a bootstrap method because the forecasted variables that we use as a proxy of market expectations are "generated regressors" and thus the standard asymptotic errors calculated from nonlinear least squares are incorrect. A bootstrap method is useful for making statistical inferences rather than corrected asymptotic standard errors because of the complicated estimation equation (20).

To conduct the bootstrap we first generate 9999 bootstrapped series of $X^*_{i,t}$

We will use a parametric bootstrap that imposes homoskedasticiy on the errors ε^*_t and presume that the VAR(p) structure is the truth.

The steps are the following:

1. Estimate $\widehat{A}$ and residuals $\widehat{\varepsilon_t}$
2. Fix an initial condition $[X_{-p+1}, X_{-p+2}, ..., X_0]$
3. Simulate 9999 iid draws ε^*_t from the empirical distribution of the residuals $\{\widehat{\varepsilon_1}, \widehat{\varepsilon_2}, ..., \widehat{\varepsilon_T}\}$
4. Create the bootstrap series $X^*_{i,t}$ by the recursive formula

$$X^*_t = \widehat{A}X^*_{t-1} + \varepsilon^*_t \tag{21a}$$

5. Using the resampled $X^*_{i,t}$, we estimate structural parameters θ_i by minimizing the variance of $\pi^*_{i,t} - \pi^{*m}_{i,t}(\theta_i, \widehat{A}\ )$ for $i = 1, 2, ..., 9999$
6. Compute the covariance matrix of $\widehat{\theta}_i$

4.2 Data

We use data from Spanish National Accounts produced by Intituto Nacional de Estadística (INE, www.ine.es) Base 1995, from 1980:1 to 2004:4 and then linked forward to 2009:2 using growth rates. Data are seasonally adjusted and adjusted for calendar effects by INE.

We use the data reported by INE for Real Non Farm Business (NFB) GDP until 2004:4 then we create a proxy of Real NFB GDP. Our proxy is going to be the chain-weighting GDP referenced to the mean of 1995 Nominal GDP (see INE methodological note [12]).

$Chain\_weighting\, GDP_{reference\ 1995} = Linked\_GDP\, index \times Mean\, of\, No\min al\, GDP_{1995}$

Using this proxy of Real NFB GDP we calculate the implicit deflator of NFB GDP for the entire period 1980:1-2009:4. Inflation is defined as the change in NFB GDP deflator computed as quarterly change.

The inflation volatility is defined as the absolute deviation from the mean.

Labor share (equivalent to Real Labour Cost) is defined as Remuneration of NFB employees divided by nominal NFB GDP.

Variables are expressed as deviations from mean values. We do this because our reduced form equations do not have a constant term.

4.3 Benchmark results

Table 1 shows the estimation results. We use the VAR with 3 lags and the truncation parameter $K = 12$. We report the estimates from four models: i) the dual stickiness model (DS); ii) the hybrid sticky price model (Hybrid); iii) the pure sticky price model (SP); and iv)the pure sticky information model (SI). The 95 percent confidence intervals appear in brackets.

Some features in Table 1 are worth emphasizing:

1. Absolutely all the models suggest that both types of stickiness matter for the aggregate inflation dynamics. The DS suggest that 16.1-22.7 percent of firms change prices every quarter, but only 4-76 percent of these firms use the latest information to determine prices (the uncertainty in this interval could be due to the explanatory power of the VAR, that leaves nearly 60% of variance unexplained and a downward trend in the cost of gathering information). Evaluated at the point estimates, the former is 18.24% percent an the latter is 61,2% percent, suggesting that only 11,16 percent in the economy choose the optimizing price.
2. The point estimates of γ and ϕ under the dual stickiness model are quite close to the estimated parameters under the hybrid model, regardless of the different interpretations for ϕ. Indeed, there is no substantial difference in these parameters including the coefficients of lagged inflation.

Table 1: Aggregate Euler equations estimates

b. Structural parameters, model fit				
	γ	ϕ	ω	R^2
Dual	0.8176	0.3880	-	0.4336
	[0.7727, 0.8394]	[0.2432, 0.9556]		
Hybrid	0.8273	-	0.3131	0.4300
	[0.7933, 0.8517]	-	[0.2146, 0.7823]	
SP	0.8399	-	-	0.3740
	[0.8192, 0.8756]	-	-	
SI	-	0.9562	-	0.3021
		[0.9198, 0.9594]		

4.4 Relative Importance of Information and Price Stickiness

We have seen that firms in Europe report that sticky information is not a big deal to account for rigidities. The model gives this result too (see table 1).

Introducing sticky prices assumption we increase the correlation between actual and predicted inflation in 18.8% compare to only 7% of sticky information. Adjusted R^2 is increased in 43.5% compared to only 15.9% of sticky information.

While both types of stickiness play a non-negligible role for the aggregate inflation dynamics, adding sticky prices beats adding sticky information in terms of increase in correlation and adjusted R^2.

4.5 Sub-sample Analysis

One of the key assumption of the model is the proxy for market expectation. We implicitly assume that the expectation remain the same for the period analyzed. This imply that we need to check for possibles breaks.

We choose to analyze the period 1991:2-2009:2 because we have found that, in terms of NFB GDP deflator, is the most stable period. Meanwhile for the whole sample we have found a break in 1986:4 using Quandt-Andrews test (see tables 5a, 6a and figure 1a) . One possible explanation for this break could be that Spain joined the European Community in 1986, affecting the market expectations and national policies.

We can see in table 3 that in the 90's, comparing to the 80's, the mean has been reduced in more than a half (from 1.01% to 0.48%) and a reduction in variance of almost a third (0.35% to 0.23%). Using Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test statistic we check that we cannot reject the null of stationary for the period 1990:I-2009:I (see table3a).

We conclude this section knowing that is difficult to assume that market expectation is the same for the whole period.

Table 3. Non Farm Business GDP Deflator change (qoq)

Periods	Mean	Standard Deviation
1980:I-2009:II	0.6%	0.4%
1980:I-1989:IV	1.01%	0.35%
1990:I-1999:IV	0.48%	0.23%
2000:I-2009:II	0.38%	0.17%
1990:I-2009:II	0.4%	0.2%

table 4. Structural parameters, model fit

	Sub-sample	γ	ϕ	ω	R²
Dual	1980:I-1989:IV	0.1000	0.8895		0.2358
		[-1.0796, 0.5615]	[-0.3037, 0.6422]		
	1990:I-1999:IV	0.7384	0.5361		0.6412
		[0.5484, 0.8541]]	[0.3310, 1.1204]]		
	2000:I-2009:II	0.8885	0.0357		0.5173
		[0.5976, 1.0282]]	[-0.9946, 0.2668]		
Hybrid	1980:I-1989:IV	0.8740		0.1111	0.2014
		[-0.5897, 1.8874]		[-0.3827, 0.7532]	
	1990:I-1999:IV	0.7844		0.3688	0.6491
		[0.6811, 0.8592]		[0.2166, 0.9312]	
	2000:I-2009:II	0.8487		0.0700	0.5981
		[0.8306, 0.8854]		[-0.4044, 0.0605]	

5 Conclusions

We have estimated the dual stickiness model for Spain and we have found that the model is not stable if we estimate for different periods. The 80's seems to have higher mean and volatility, this fact could affect market expectations, and henceforth the predictions of the model. Hence we decided to analyze a more stable period 1990:I-2009:II.

We have found that, for the period 1990:I-2009:II, every quarter 81.76% of Spanish firms do not change its prices and only 38.80% has sticky information. The latter suggest that 11.16% in the economy choose the full information optimal price every quarter. The estimates suggest that firms in Spain change prices every 9-10 months, in line with micro evidence that suggest that the average monthly frequency of price changes is around 1 year (between 6-7 months for consumer prices and slightly less than 1 year for producer prices).

We have also found that the sticky price is more relevant for aggregate inflation dynamics than sticky information. Sticky prices assumption increase in 43.5% the adjusted R^2 compared to only 15.9% of increase when we include sticky information. The latter result is consistent with the survey conducted for European firms, where one of the results is that sticky information is not too important for the stickiness of prices.

The analysis of this paper can be extended including immigration effects to this dual stickiness model or running the model with other types of marginal cost proxies. It also could be estimated using different market expectations depending of time. Finally, it could also be tested the welfare implications of the model for Spain.

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Appendix A. Appendix

Table 3.a. Null Hypothesis: INFLATION is stationary
Exogenous: Constant
Bandwidth: 6 (Newey-West using Bartlett kernel)

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.518333
Asymptotic critical values*:	1% level	0.739
	5% level	0.463
	10% level	0.347

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Table 5a. Quandt-Andrews unknown breakpoint test
Null Hypothesis: No breakpoints within trimmed data
Varying regressors: All equation variables
Equation Sample: 1980Q2 2009Q2
Test Sample: 1984Q4 2004Q4
Number of breaks compared: 81

Statistic	Value	Prob.
Maximum LR F-statistic (1986Q3)	178.8277	0.00%
Maximum Wald F-statistic (1986Q3)	178.8277	0.00%
Exp LR F-statistic	85.63691	0.00%
Exp Wald F-statistic	85.63691	0.00%
Ave LR F-statistic	88.35047	0.00%
Ave Wald F-statistic	88.35047	0.00%

Note: probabilities calculated using Hansen's (1997) method

Table 6a. Quandt-Andrews unknown breakpoint test
Null Hypothesis: No breakpoints within trimmed data
Varying regressors: All equation variables
Equation Sample: 1980Q2 2009Q2
Test Sample: 1984Q4 2004Q4
Number of breaks compared: 81

Statistic	Value	Prob.
Maximum LR F-statistic (1993Q1)	22.3716	0.01%
Maximum Wald F-statistic (1993Q1)	22.3716	0.01%
Exp LR F-statistic	7.98301	0.00%
Exp Wald F-statistic	7.98301	0.00%
Ave LR F-statistic	7.176962	0.05%
Ave Wald F-statistic	7.176962	0.05%

Note: probabilities calculated using Hansen's (1997) method

Figure 1a- Inflation Volatility