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Novella Maugeri

Money Illusion and Rational Expectations: New Evidence from Well Known Survey Data

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Abstract - This paper provides further evidence in favor of less than fully rational expectations by making use two instruments, one quite well known, and the other more novel, namely survey data on inflation expectations and Smooth Transition Error Correction Models (STECMs). We use the so called 'probabilistic approach' to derive a quantitative measure of expected inflation from qualitative survey data for France, Italy and the UK. The United States are also included by means of the Michigan Survey of Consumers' expectations series. First, we perform the standard tests to assess the 'degree of rationality' of consumers' inflation forecasts. Afterwards, we specify a STECM of the forecast error, and we quantify the strategic stickiness in the long-run adjustment process of expectations stemming from money illusion. Our evidence is that consumers' expectations do not generally conform to the prescriptions of the rational expectations hypothesis. In particular, we find that the adjustment process towards the long-run equilibrium is highly nonlinear and it is asymmetric with respect to the size of the past forecast errors. We interpret these findings as supporting the money illusion hypothesis.

JEL Classification: C 22, D 84, E 31

Keywords: Nonlinear error correction, inflation expectations, sticky expectations

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Novella Maugeri, Università degli Studi di Siena - maugeri@unisi.it

1 Introduction

Inflation expectations are kept under close watch by many: business consultants, investors, policy makers, and last, but not least, economic researchers. Yet, dealing with expectations is a very complex task since it involves two orders of difficulties. First, expectations are by nature unobservable, hence one needs to find a way to track them as closely as possible. Second, even after a good proxy for expectations is found, one still needs to understand what is the mechanism underlying their formation. More specifically, many efforts of the literature have been concentrated on understanding to which extent do expectations conform to the rational expectations hypothesis (REH) (Muth 1961, and Lucas 1987). On the other side, relatively few have dealt with investigating whether other behavioral insights other than the generic notion of 'inattentiveness' play a role in explaining inflation expectations dynamics. This paper aims at filling the gap by using some recent advances in nonlinear time series econometrics.

Recently, the problem of unobservability of expectations has partially been overcome thanks to the availability of direct survey data. These kind of data are very valuable because they yield direct observations of inflation expectations without the need of a priori assumptions on their nature.[1] Nevertheless, the literature is far from having reached a consensus on what mechanism underlies the process of expectations formation and adjustment.[2] In particular, to the best our knowledge there have been no attempts so far to study the long-run adjustment process of inflation expectations without renouncing to the assumption of linearity, implicit in the idea of perfect rationality.[3]

While the literature customarily tests the degree of rationality of expectations within the standard (linear) cointegration framework (Engle and Granger 1987, and Johansen 1991), we use a novel nonlinear cointegration approach enabling us to understand what influences the speed of adjustment of expectations in the long-run, and whether there are significant asymmetries in such adjustment process. More specifically, we use Smooth Transition Error Correction Models (STECMs), a flexible econometric specification which captures the long-run dynamics of variables with a nonlinear-asymmetric adjustment towards the equilibrium.[4] So far, STECMs have been applied to interest rates

[1] To be more precise, when using survey data one still needs a priori assumptions, but only on the form of the ditribution of aggregate inflation expectations. For example, the Carlson and Parkin's (1975) method we also employ to convert qualitative survey data into quantitative ones, assumes a logistic distribution function.

[2] The contributions on the degree of rationality of expectations are several. See for example Berk (1999, 2000), Arnold and Lemmen (2006), Forsells and Kenny (2002), Gerberding (2009) Curto and Milet (2006), and Pjafary and Santoro (2009) among others.

[3] The REH posits that inflation expectations should have three testable characteristics: long-run unbiasedness, 'efficiency' with respect to available information, and mean reversion with respect to the forecast error's long-run 'rational' value. The latter feature was first noted by Bakhshi and Yates (1998), who start from observing that both inflation and inflation expectations generally display a unit root and hence their interpretation of the REH is that in the long run they should cointegrate, possibly with coefficients of the cointegrating vector equal in absolute value. Clearly, such definition involves the notion of a constant (linear) adjustment process.

[4] A STECM model can be viewed as a generalization of the standard linear ECM model

(Van Dijk and Franses, 2000), real exchange rates (Béreau, López Villavicencio and Mignon, 2010), stock returns (Jawadi and Kouba, 2004) and house prices (Balcilar, Gupta and Shah, 2010). We are convinced that applying STECMs to inflation expectations can shed some new light on the asymmetries inherent to the long-run adjustment process of expectations, thereby providing useful insights both to policy makers and to researchers.

In this work the standard 'probabilistic approach' (Carlson and Parking 1975, Berk 1999) is employed to derive a quantitative measure of expected inflation from the European Commission's (EC) Consumer Survey data[5]. Our sample comprehends 298 monthly observations (1985-2009) for France, Italy and the UK. For sake of comparability with previous studies, we also include the US in the sample by means of the Michigan Survey of Consumers' expectations series. First, we perform the standard tests to assess the 'degree of rationality' of inflation expectations and, like others in this literature, we infer that consumers behave quite differently than what the REH postulates. Afterwards, we test for a nonlinear type of weak rationality that we label *strategic stickiness* by means of a Smooth Transition Error Correction Model (STECM) of the forecast error. We call *strategic stickiness* the type of inertia in the adjustment of expectations that Fehr and Tyran (2001) document in their experimental setting as a by-product of money illusion.[6] It is the inertia that arises from nominal loss aversion in a context of strategic complementarities: people are reluctant to reduce nominal prices after a negative monetary shock because they expect that the others will do the same, actually yielding a higher nominal loss. We have two main results. First, consumers tend to over-estimate inflation both in the short and long-run. Second, strategic stickiness does play an important role in shaping the expectations long-run adjustment dynamics. Furthermore, big and negative shocks have generally a greater influence in speeding up the adjustment process than small and positive ones.

It is important to notice that many factors may be responsible for the non-

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proposed by Engle and Granger (1987), allowing for a nonlinear adjustment mechanism. In this type of models the standard constant feedback parameter is replaced by a continuous function, the so called transition function, which is bounded between $(0, 1)$. Generally the transition function is chosen to be either a logistic function, when one tries to capture sign asymmetries or a second order logistic function, when size asymmetries are thought to be more important. For a detailed description STECMs please refer to Anderson (1995), Van Dijk and Franses (2000), and Kapetanios, Shin and Snell (2003).

[5] Even though this method is quite standard in the literature, there are many authors pointing at its drawbacks mainly due to its assumption of a normal distribution of expectations. Indeed, many methods of correction have been proposed (we chose the one of Berk, 1999) but also many alternative methods are available. Nevertheless, evaluating which of them performs better is beyond the scope of this paper, and for a more detailed treatement of these issues we suggest to refer to Nardo (2003).

[6] The term money illusion seems to have been coined by Irving Fisher as "the failure to perceive that the dollar, or any other unit of money, expands or shrinks in value" (1928, p.4). Fehr and Tyran (2001) give a somewhat more precise definition, by saying that one is prone to money illusion if i) his/her objective function depends on both nominal and real magnitudes and ii) He/she perceives purely nominal changes affecting his/her opportunity sets. For a thorough treatment of money illusion please see Shafir, Diamond and Trevsky (1997), Fehr and Tyran (2001, 2007, 2008).

linear dynamics we find in our data: for example slow information diffusion (Mankiw and Reis 2002, Carrol 2003), Near Rational behavior towards inflation (Akerlof and Yellen 1985, Akerlof, Dickens and Perry 2000, Ball 2000, Maugeri 2010), and in general all the decision heuristics implying less then full adjustment to errors. Among those, this paper stresses the relevance of money Illusion as a parsimonious explanation of the nonlinearity of the adjustment towards the equilibrium. Indeed, our smooth transition model for the adjustment process can be viewed as a reduced form of structural models of expectations formations accounting for nonlinearities due to a number of less than fully rational decision mechanisms, the most parsimonious of those being money illusion.

The rest of this paper is organized as follows. Section 2 is devoted to a general description of our dataset while section 3 develops some formal procedures to assess various theories of expectation formation. First we describe the hypotheses of adaptive expectations and sticky information diffusion, then rational expectations tests both in 'weak' and 'strong' form are discussed, and finally *strategic stickiness* is assessed. Section 5 presents the results of our empirical investigation and section 6 offers some concluding remarks.

2 The Data

Increasing availability of direct survey measures of inflation expectations caused a massive interest of the literature in this topic. The pioneering survey study on consumers expectations is the Survey of Consumers devised in the late 40s by George Katona at the University of Michigan. Parallerly, from 1968 to 1990 the National Bureau of Economic Research, and later the Federal Reserve Bank of Philadelphia, conducted the first survey on the 'professional' views on expectations, i.e. the Survey of Professional Forecasters (SPF). The European Commission has started in 1985 to follow the lead of its foreign rivals, by elaborating surveys on both consumers' and professional forecasters' expectations for the Euro area[7].

Our dataset is composed by monthly CPI inflation rates and inflation expectations series both for consumers and for professionals, from January 1985 to October 2009[8]. The sample comprehends three main European countries, France, Italy, and the United Kingdom, and the United States. The inflation rate series are taken from, respectively, the Centre for European Economic Research (ZEW), the Italian statistical Office (ISTAT), the English Office for National Statistics, and the US Bureau of Labor Statistics. The series are all unadjusted for seasonality. The choice of this subset of European countries is

[7]Both European surveys are basically designed following the US example. One main difference though, is that while the survey of consumers provides data both at a country level of disaggregation and at the Euro-area level of aggregation, the European SPF is available only for the Euro area as an aggregate.That is the main reason why in order to proxy the experts' expecations we decided not to use the EU-SPF data, but the Consensus Economics data, made available to us by the courtesy of Christina Gerberding.

[8]Actually, the French range of available observations is a little bit shorter than the other, since the inflation rate series starts from 1990.

mainly motivated by the fact that these three countries are the ones with greater data availability (about 290 monthly observations on average). The US data are inserted in the dataset mainly to have a reference point with respect to previous studies[9].

The consumers inflation expectations series for France, Italy and the UK are elaborated by applying the so called 'probability approach' (Carlson and Parkin, 1975) to the qualitative data of the European Commission Survey[10]. Following Berk (1999 and 2000), we apply a rescaling of the expectations series by means of 'perceived inflation', as the literature shows that such rescaling dramatically improves the representativeness of the derived expectation measure. Figure 1 displays the series of inflation and consumers expectations over the chosen time sample.

The professionals forecasters' expectations series for Italy, France and the UK are elaborated from the London based firm Consensus Economics. From 1989, this firm asks to renewed experts at the beginning of each month to forecast the development of important macroeconomic variables[11]. The US series is the SPF measure elaborated by the Federal Reserve Bank of Philadelphia.

One of the main criticisms made to the use of consumers based measures of expectations is that survey takers might have little incentives to correctly state their perception of future price developments. On the contrary, business experts' opinions should be driven by market forces to track actual inflation as closely as possible. As a matter of fact, a comparison of figure 1 with figure 2 clearly reveals that on average experts have a lower forecast error than consumers.

What is also clear from figure 1, is that consumers were not able to forecast the 2008 financial crisis and the subsequent trough of inflation[12]. Even though there seems to be a strong relationship between actual and expected inflation, consumers have underpredicted and overpredicted inflation much more than experts, at least in the first part of the sample. Moreover, after the switch to the common currency in 1999, European consumers seem to have believed to the low inflation commitment of the European Central Bank (ECB) and anticipated the consequent downward trend in inflation.

To provide a more quantitative evaluation of the forecast performance of both consumers and experts, Table 1 provides some standard indicators: the Mean Error (ME), showing the average forecast error over the sample period, the Mean Absolute Error (MAE) which measures how close are predictions to the actual inflation rates, and the Root Mean Squared Error (RMSE) which represents the expected value of the squared error loss, hence it is less sensitive to large forecast errors or outliers. Consistent with our graphical evidence, experts have on average a better forecast performance than consumers, since

[9] For studies on the US see Curtin (2005), Bryan Venkatu (2001), Anderson (2008) and Pfajfary and Santoro (2009), among others.

[10] See the Appendix for more details.

[11] We really thank Christina Geberding for making these data available to us.

[12] Actually, since even the reat part of economists were not able to predict the financial crisis, we did not expect consumers to do so. Unfortunately, our series of experts' forecast arrives until 2006 for the majority of countries, hence we cannot give any quantitive judgement of the the experts' forceast performance in 2008.

Figure 1: Consumers forecasts of inflation

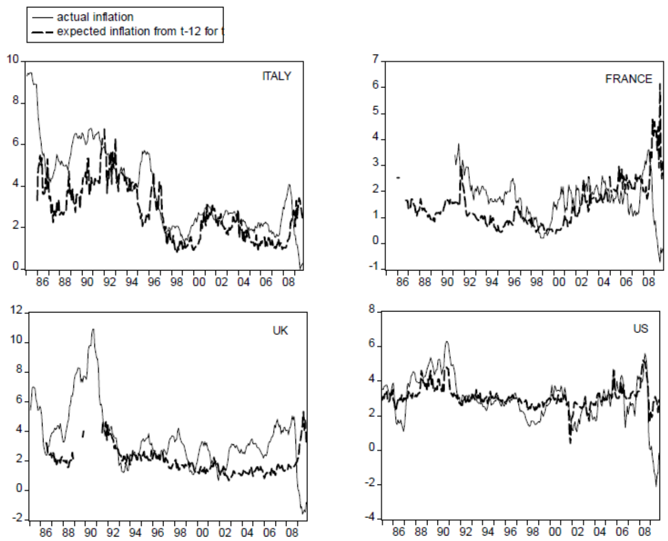


Figure 2: Experts forecasts of inflation

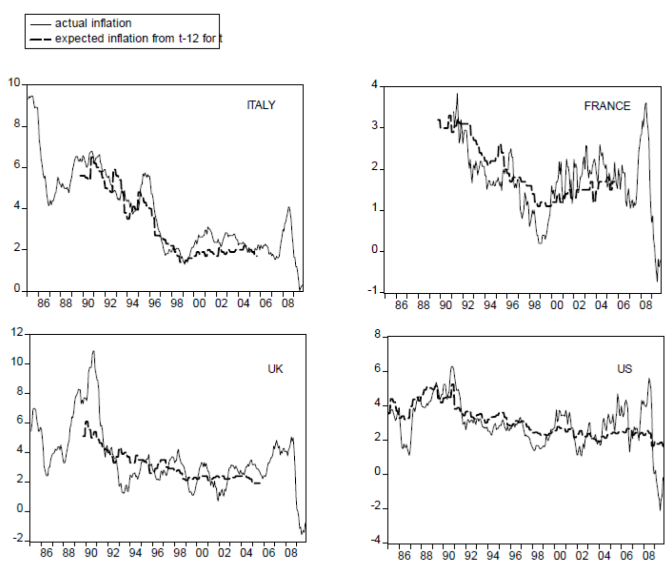


Table 1

Forecast performance statistics: Consumers expectations vs experts expectations

	France	Italy	UK	US	France	Italy	UK	US
	Consumers expectations				Experts expectations			
Full period 1985-2009								
ME	-0.31	-0.99	-1.21	0.11	0.09	-0.37	-0.25	0.12
MAE	0.90	1.13	1.58	0.71	0.48	0.55	1.07	0.76
RMSE	1.11	1.42	2.01	1.00	0.56	0.67	1.52	1.02
Subperiods: 1985-1999								
ME	-0.81	-1.26	-1.25	-0.09	0.41	-0.28	-0.24	0.37
MAE	0.87	1.35	1.45	0.64	0.51	0.54	1.27	0.61
RMSE	1.02	1.66	2.02	0.80	0.59	0.67	1.80	0.77
1985-1999								
ME	0.15	-0.63	-1.16	0.41	-0.41	-0.55	-0.27	-0.25
MAE	0.93	0.83	1.75	0.81	0.43	0.57	0.72	0.99
RMSE	1.19	1.00	2.00	1.24	0.52	0.66	0.81	1.31

Note: ME= Mean Error, MAE= Mean Absolute Error, RMSE= Root Mean Squared Error

their MAEs and RMSEs are systematically lower. However, both consumers and experts seem to frequently commit large but counterbalancing errors, as shown by the fact that the ME is always much lower than the MAE. Another interesting finding that emerges from table 1 is that experts seem to have interiorized the credibility strategy of the ECB much more than the public, as shown from the systematically lower MAE and RMSE in the second subsample. On the other hand, consumers do not seem to have a clear idea of this strategy in every country: only Italian consumers have decreased their MAEs and RMSEs in the Euro-era subsample, while French and US citizens have worsened their forecast performance. For English consumers it is not possible to give a precise judgment, since in the second subsample the MAE increases but the RMSE decreases. On the contrary, our US reference point indicates that during the pre Euro-era American consumers had a much clearer picture in their mind of what was happening to inflation than in the following decades.

A final word on comparability of our expectations measures. Our results are broadly in line with the previous findings of the literature, which report a RMSE for European aggregate inflation expectations between 0.47 and 1.29 (Forsells and Kenny, 2002). Again, one could take the study on the US by Lloyd (1999) as a reference: He finds a RMSE for the period 1983-1997 between 1.09 and 1.57, also very close to our estimates.

3 Assessing Theories of Rationality

This section briefly describes the different theoretical hypotheses we will test throughout the paper, with special attention to their econometric implementation. The section is organized chronologically, it starts by illustrating the adaptive expectations hypothesis and it complements it with the much newer notion of sticky information diffusion (Mankiw and Reis 2002; Carrol, 2003). Subsequently, the Rational Expectations Hypothesis is thoroughly described in its 'weak' and 'strong' form, although the section gives a prominent role to what we call *strategic stickiness*', that is to say 'weak rationality' with asymmetric adjustment process towards the long-run equilibrium. Section 4 then will conclude the analysis, by dealing with estimation issues and presenting our empirical results.

3.1 Adaptive Expectations and Sticky Information Diffusion

The first idea on expectations was that people could revise their predictions according to their past forecast errors. The Adaptive expectations hypothesis was suggested by Irving Fisher in 1930, and then it was formalized by Cagan (1956), Friedman (1957), and Nerlove (1958). The standard way to assess the degree of adaptiveness in consumers expectations is to estimate the following regression

$$\pi^e_t = \theta\pi^e_{t-1} + \xi(\pi_{t-1} - \pi^e_{t-1}) + \epsilon_t \qquad \text{(Adaptiveness)}$$

Here the parameter ξ assumes an important role, since it captures the speed of adjustment of current expectations to the past forecast error. However, as the recent literature on inattentiveness suggests, the speed of this adjustment mechanism depends not only on the subjective 'degree of adaptiveness', but it is also influenced by how fast the information is diffused in the economy and by how costly is obtaining and updating information sets. According to such considerations, equation (Adaptiveness) should be complemented by an equation trying to capture the dynamics of the information diffusion process like the following

$$\pi^e_t = \lambda_1\pi^e_{SPF,t} + (1-\lambda_1)\pi^e_{t-1} + \epsilon_t \qquad \text{(Sticky info)}$$

Equation (Sticky info) summarizes the core of Carrol's (2003a) model of 'epidemiological' diffusion of information about inflation, and it posits that households slowly update their information sets from news reports, which are in turn influenced by professional forecasters. In such a context, $\pi^e_{SPF,t}$ is the mean inflation at time t as predicted by experts (i.e. Consensus Economics' forecasts for France, Italy and the UK, and SPF forecasts for the US), and the coefficient λ_1^{-1} is interpreted as the average updating period for households' information sets. Please notice that equation (Sticky info) considers a type of expectations' stickiness which is only due to the intrinsic difficulty to get updated information about inflation from the news. On the other hand, the strategic stickiness we put our emphasis on is of a different type, in the sense that it has to do with strategic complementarities among agents' forecasts in the presence of money illusion.

3.2 'Strong' Rationality

The Rational Expectations Hypothesis (REH) (Muth, 1961) in its 'strong version', posits that inflation expectations should have two testable characteristics: long-run unbiasedness, and 'efficiency' with respect to available information. As we will see later, a weaker version of the REH assumes the expectations only display mean reversion with respect to their long-run 'rational' value. The idea of rational expectations is that agents can match on average the predictions of the relevant economic models. This translates into an estimated forecast error which should be centered around zero (unbiasedness property) and should not be correlated with variables included in their information sets at the time predictions were made (orthogonality property). Tests for efficiency in the use of information are extensively undertaken by the current literature, hence in this work we will start our analysis by focusing on the a investigation of unbiasedness property.[13]

It is common practice in papers using survey data on expectations to test the strong version of the REH by estimating a series of OLS equations of the following type

$$\pi_t - \pi_t^e = \alpha + \epsilon_t \quad \text{(Rationality 1)}$$

$$\pi_t = \alpha + \beta\pi_t^e + \epsilon_t \quad \text{(Rationality 2)}$$

$$\pi_t - \pi_t^e = \alpha + (\beta - 1)\pi_t^e + \epsilon_t \quad \text{(Rationality 3)}$$

where we indicate with π_t the actual inflation rate for period t, and with π_t^e the expected inflation rate for period t calculated in period $t-12$. By analyzing the properties of the estimated forecast error of these equations and the accurateness of the parameters estimates, gives an idea of whether the REH is verified on average.

3.3 'Weak Rationality'

Many authors claim that the strong version of the REH, the one involving unbiasedness and efficiency, might be 'too strong', given the informational frictions and transaction costs present in reality. What characterizes rational expectations according to many, is that there is mean reversion of expectations towards the correct mean inflation value, that is to say π_t^e and π_t cointegrate in the long-run. The pioneering work on this issue by Bakhshi and Yates (1998) starts exactly by observing that both inflation and inflation expectations are $I(1)$ variables, hence their dynamic interpretation of the REH is that in the long run they should cointegrate, possibly with coefficients of the cointegrating vector equal

[13] See Gerbering (2007) and Forsells and Kenny (2002) among others.

in absolute value. This interpretation of the REH yields two main implications: i) no matter how long is the adjustment, time movements of expectations and inflation rates should be linked in the long-run ii) The adjustment from the short-run to the long-run always occurs with the same constant intensity, captured by a linear-constant adjustment function.

In order to be more clear let us assume that π_t^e and π_t are given by

$$\begin{aligned} \pi_t &= \pi_t^e + \varepsilon_{1t} \\ \pi_t^e &= \pi_{t-1}^e + \varepsilon_{2t} \end{aligned} \tag{1}$$

Where ε_{it} $i = 1, 2$ has the standard properties. Then the weak version of the REH posits that there is a cointegrating relationship between the two variables of the type

$$\begin{aligned} \pi_t &= \alpha + \beta\pi_t^e + z_t \\ \text{with } z_t &= \rho_1 z_{t-1}, \quad |\rho_1| < 1 \text{ and } \alpha = 0 \ , \ \beta = 1 \end{aligned} \tag{2}$$

In practice, what one does in order to understand whether this is verified by the data is to perform a standard cointegration analysis on the two series including tests for the appropriate coefficients restrictions.

3.4 Strategic Stickiness: 'Weak Rationality' and Asymmetric Adjustment

Sustaining that people are on average correct in their forecasts of inflation is one thing, sustaining that they perform these correction tasks always in the same way is something different. Indeed, the standard notion of 'weak rationality' (equations 1 and 2) implicitly assumes that in the long-run there is a constant linear adjustment process linking expectations to the actual mean value of inflation. However Fehr and Tyran (2001, 2004 and 2008) suggest that expectations of nominal variables often display a sticky and asymmetric adjustment. More specifically, their experiments show that in a context where decisions are confined with nominal magnitudes, people are reluctant to reduce nominal prices after a negative monetary shock because they anticipate that the others will do the same, hence actually magnifying the aggregate nominal inertia. As expected, this type of inertia we call *strategic stickiness*, is much larger after a negative nominal shock than after a positive one and it also depends on the size of the shock.

If one wants to represent this case, and the data generating processes of π_t^e and π_t still follow (1), then *strategic stickiness* implies that there is a cointegrating relationship for the two variables of the type

$$\begin{aligned} \pi_t &= \alpha + \beta\pi_t^e + z_t \\ \text{with } z_t &= F(z_{t-1}) + u_t, \quad z \textit{ stationary}, \text{ and } \ u_t \overset{iid}{\sim} (0, \sigma_u^2) \end{aligned} \tag{3}$$

Where $F(.)$,the *transition function,* is a continuous nonlinear functional form bounded in the $(0,1)$ interval, capturing asymmetries in the adjustment process stemming from *strategic stickiness.* Notice that here we chose the simple case where the deviation from the long-run equilibrium z_t behaves like a first order stochastic process, but clearly a more general case involves a transition function $F(z_{t-d})$ with an higher lag order $d = \{1, 2, ...\}$.[14]

Our aim is to investigate strategic stickiness by specifying a STECM model of consumers' forecast error with the general structure:

$$Dy_t = \boldsymbol{\varphi}_1' \mathbf{w}_t + F(z_{t-d}; \gamma, c) \boldsymbol{\psi}_2' \mathbf{w}_t + \varepsilon_t \tag{4}$$

where y_t is in our case either π_t or π_t^e, depending on the specification, and x_t is respectively either π_t^e or π_t, the cointegration relationship is indicated by $z_t = \pi_t - \alpha - \beta\pi_t^e$, α and β are the ones estimated during the preliminary cointegration analysis, $\mathbf{w}_t = (1, \widetilde{\mathbf{w}}_t)'$, $\widetilde{\mathbf{w}}_t = (z_{t-1}, Dy_{t-1}, ..., Dy_{t-p+1}; Dx_t, ..., Dx_{t-p+1})'$, for $i = 1, 2$, $m = 2p - 1$. Finally $\boldsymbol{\varphi}_1 = (\boldsymbol{\varphi}_{10}, \boldsymbol{\varphi}_{11}, ..., \boldsymbol{\varphi}_{1m})'$ and $\boldsymbol{\psi}_2 = (\boldsymbol{\psi}_{21}, \boldsymbol{\psi}_{22}, ..., \boldsymbol{\psi}_{2m})'$ are vectors of parameters to be estimated.

There are two main reasons why we think this approach is valuable. First, from the econometric point of view it builds on standard cointegration analysis and it amends some of its weaknesses by assessing possible neglected nonlinearities in the ECM adjustment process. Second, from the theoretical point of view, the nonlinear adjustment mechanism is a flexible specification allowing for asymmetric effects of shocks which differ in size and sign: the choice of the transition function can give us precise indications on which type of asymmetry matters more to explain agents' money illusion. Finally, the STECM approach has the further advantage of not having to impose any prior on rationality, and to 'let the data choose' the type of nonlinearity better fitting them by means of the appropriate transition function.

4 Results

Our empirical assessment of theories of rationality starts by performing the standard rationality tests that the literature has proposed so far. As we already pointed out, there are already some studies in the literature analyzing the properties of both the EU and the US consumers expectations series[15]. However, most of them employ data up to 2006, hence it is interesting to see whether the results change with an updated dataset[16]. The section then continues by proposing our strategy to assess 'weak rationality' in the form of *strategic stickiness.*

[14] Notice also that the stationarity condition for z_t in this case is more complicated than the standard one, because it depends on the chosen form of the $F(.)$ function.

[15] For example, Forsells and Kenny (2002) use the EC's consumers data to analyse the properties of expected inflation for the euro area as an aggregate. Arnold and Lemmen (2008) also use the EC's Consumer Survey to assess whether inflation expectations have converged and whether inflation uncertainty has diminished following the introduction of the Euro in Europe. Gerberding (2009) provides an interesting comparison between consumers' and experts' expectations in France, Italy, Germany and UK.

[16] Clearly, we are aware that a longer time span comes at the cost of maybe having a structural break and/or one or more outliers in the sample due to the 2008 financial crisis.

We estimate a STECM model for the countries of interest and we analyze the properties of the estimated transition function so that we can have an indication of what influences the speed of adjustment of expectations in the long-run. The tests for adaptive expectations, sticky information diffusion and rational expectations are all implemented by means of heteroskedasticity corrected OLS, while the STECM estimation for *strategic stickiness* is done by means of nonlinear least squares.

4.1 Adaptive Expectations and Sticky Information Diffusion

To which extent so consumers correct their expectations looking at past errors? and how much does the speed of diffusion of news about inflation influences this process? The results of the estimation of both equations (Adaptiveness) and (Sticky info) in table 2 can provide an answer to these questions.

Table 2

Test for adaptive expectations and sticky information diffusion

type of test	Country					
	France					
	θ	ξ	λ_1	$(1/\lambda_1)$	R^2	N
Adaptiveness	0.99 0.00	0.03 0.08	-	-	0.87	215
Sticky info	-	-	0.04 0.01	25.39 0.00	0.85	186
	Italy					
Adaptiveness	0.94 0.00	0.14 0.00	-	-	0.88	275
Sticky info	-	-	0.21 0.00	4.69 0.00	0.89	182
	UK					
Adaptiveness	0.98 0.00	0.01 0.32	-	-	0.86	248
Sticky info	-	-	0.17 0.00	5.88 0.00	0.89	263
	US					
Adaptiveness	0.99 0.00	0.02 0.26	-	-	0.68	297
Sticky info	-	-	0.10 0.00	9.85 0.00	0.70	297

Notes: small numbers under the estimates are p-values. N is number of observations. Equations are estimated by OLS using covariance matrix corrections suggested by Newey and West (1987).

In the adaptive expectations test, the adjustment coefficient to past errors is quite small for France, UK and the US, averaging at 2%; Parallerly the average updating time for those countries is estimated to be very different, as people update their information sets respectively once every 4,17 and 10 months. Italy

Nevertheless, since our focus is on the effects of the size of shocks on the adjustment of consumers expectations, we decided keep this long time sample, momentarily leaving the model stability issue in the background.

is a special case though, since the adjustment coefficient is very high (14%) but the average updating period is the longest, about 21 months. The estimated θ coefficient in equation (Adaptiveness) is very close to one in all specifications and hence it is of particular interest for two reasons: from the theoretical point of view, there is an high degree of backward looking behavior in expectations formation dynamics; from the econometric point of view, there is an high degree of persistence in inflation expectations, which needs to be handled with the appropriate techniques. As a consequence of that, some of the rationality tests we will apply in the next paragraph handle such persistence with the appropriate techniques.

Rationality

In what follows we assess the REH in its so called 'strong' and 'weak' version. The general way to test for unbiasedness is estimating equation (Rationality 2) and then testing the null $H_0 : (\alpha, \beta) = (0, 1)$. However, since Holden and Peel (1990) showed that the condition $\alpha = 0$ is both necessary and sufficient for unbiasedness, while $(\alpha, \beta) = (0, 1)$ is not necessary, we can simply use equation (Rationality 1) to see whether expectations error are centered around the right value and then test if such value can be conveniently restricted to zero. Equation (Rationality 3) is simply a way to augment equation (Rationality 2) in order to cross-checks the previous results and to see whether all available information is fully exploited. Please notice that all these three equations are expected to have no predictive power under the null of rationality. Table 3 gives the results of the three estimation for each country in the sample.

Our estimates of equation (Rationality 1) suggest that in our sample the necessary condition for unbiasedness is never met, the only exception being the US. Furthermore, the sufficient condition is also never satisfied for the all four countries, as indicated by the significant Chi-squared statistics of equations (Rationality 2)[17].

Clearly that these first tests of 'strong rationality' give such results, does not exclude that other notions of rationality are still in place. A somewhat weaker notion of rationality might be more appropriate, especially once acknowledged that we are dealing with nonstationary variables. Here we follow the approach first introduced by Bakhshi and Yates (1998) and we try to understand if expectations and inflation move together at least in a long-run perspective, i.e. they cointegrate. After performing the standard unit roots test on both variables (not shown), and having confirmed that they are all integrated of order one, we carried on the standard cointegration tests by Johansen (1981) and estimated the corresponding bivariate vector ECM of the form

$$D\pi_t = c_0 + c_\pi(\alpha\pi_{t-1} - \beta\pi^e_{t-1}) + \sum_{i=0}^{p} a_i D\pi_{t-i} + \sum_{i=0}^{p} b_i D\pi^e_{t-i} + \epsilon_{\pi t} \quad \text{(Inflation)}$$

[17]Notice that the R-squared for the three equations is not always as low as expected, but this has probably to do with our variables being integrated and hence it is probably a spurious result. We will correct for this in the subsequent cointegration analysis.

Table 3

Test for unbiasedness of consumers expectations

type of test	Country					
	France					
	α	β	$(1-\beta)$	R^2	χ^2 for H_{01} and H_{02}	N
Rationality (1)	0.31	-	-	0.00	4.48	220
	0.04				0.03	
Rationality (2)	1.60	0.08	-	0.01	55.67	220
	0.00	0.60			0.00	
Rationality (3)	1.60	-	1.92	0.45	-	220
	0.00		0.00			
	Italy					
Rationality (1)	0.99	-	-	0.00	58.32	281
	0.00				0.00	
Rationality (2)	0.71	1.11	-	0.66	62.62	281
	0.01	0.00			0.00	
Rationality (3)	0.71	-	0.89	0.02	-	281
	0.45		0.00			
	UK					
Rationality (1)	1.21	-	-	0.00	38.45	263
	0.00				0.00	
Rationality (2)	1.02	1.09	-	0.22	51.25	263
	0.04	0.00			0.00	
Rationality (3)	1.02	-	0.91	0.00	-	263
	0.69		0.42			
	US					
Rationality (1)	-0.11	-	-	0.00	0.72	298
	0.40				0.39	
Rationality (2)	-1.73	1.53	-	0.48	7.38	298
	0.01	0.00			0.03	
Rationality (3)	-1.73	-	0.47	0.10	-	298
	0.01		0.02			

Notes: small numbers under the estimates are p-values. N is number of observations. Chi-squared statistics pertain to the null hypothesis H01: $\alpha=0$ in equation (1) and H02: $(\alpha,\beta)=(0,1)$ in equation (2). Equations are estimated by OLS using covariance matrix corrections suggested by Newey and West (1987).

$$D\pi_t^e = g_0 + g_e(\alpha\pi_{t-1} - \beta\pi_{t-1}^e) + \sum_{i=0}^{p} g_i D\pi_{t-i}^e + \sum_{i=0}^{p} h_i D\pi_{t-i} + \epsilon_{et} \quad \text{(Exp. Inflation)}$$

where c_0 and g_0 are constants, c_π and g_e are the ECM adjustment coefficients, and the lag length p is selected in preliminary VAR analysis (not shown).The results of equation (Rationality 3) provide a further confirmation of what we found so far, as the parameters are generally not close to the their theoretical values $(0, 1)$. Our results are in line with the ones of Forsells and Kenny (2002) and Pfajfar and Santoro (2010), and they confirm the poor forecast performance of consumers. Over the full time sample, which probably contains at least one structural break and some outliers due to the current financial crisis, expectations are systematically overestimated (α is always positive, the only exception being the US), as also confirmed by the estimated β which is above 1 in all countries except France. Tables 4 and 5 report the results of this final rationality test.

What we first notice from a general examination of the two tables is that the coefficients of the cointegrating vectors are different in absolute value. This goes against the definition of 'weak rationality', but from a broader perspective it also tells us that the existent long-run relationship between π_t^e and π_t involves also a systematic over/underprediction of inflation[18]. Here we interpret this long-run relationship as the 'ecologically rational' prediction for inflation, because it can be considered the outcome of one of the most parsimonious heuristic that people have given the available information sets: money illusion[19]. Indeed reasoning in nominal terms and ignoring low future inflation is a powerful rule of thumb in a low and stable inflation environment, like the EMU (at least before the financial crisis). On the other hand, the fit of these VECM models is generally satisfactory, with reasonable values for the coefficients but with a problem of non-normality and heteroskedasticity in the residuals (statistics not shown). In particular, the ECM adjustment coefficients are usually significant and with opposite signs. This indicates that there is a potential two-way feedback between inflation and expectations. More specifically, If $g_e > 0$ and $c_\pi < 0$, not only expectations adjust towards their 'ecologically rational value', but also actual inflation adjusts to the level expected by the public, as in the Friedman-Phelps framework.

Strategic Stickiness

Investigating strategic stickiness builds on the cointegration analysis we performed so far. As we saw, there is some evidence for cointegration between inflation and its expectation, but the cointegrating relationship does not look

[18] Depending on the specification, the cointegrating vector also contains a constant and a trend.

[19] A decision rule or an heuristic is defined as 'ecologically rational' if it exploits structures of information that are already in the environment, allowing the decision maker to save on information processing and gathering costs. For a broader perspective on this issue see Smith (2002) and Goldstein and Gigerenzer (2002).

Table 4

Test for cointegration between consumers expectations and actual inflation rates: Italy and France

	Countries					
	Italy		**France**			
-lag lenght:	2		2			
-Trace test: H0: at most 1 CE	1.43	[p= 0.27]	5.76		[p=0.49]	
-Rank test: H0: at most 1 CE	1.43	[p= 0.27]	5.76		[p=0.49]	
	α	β	α	β	trend	constant
Cointegrating vector	1.00	-1.41 (-0.08)	1.00	-1.49 (-0.35)	0.02 (0.00)	-3.19
	VECM		VECM			
	inflation	expected inflation	inflation		expected inflation	
ECM adjustment coefficients:	-0.02 (-0.01)	0.10 (-0.02)	-0.04 (-0.02)		0.09 (-0.02)	
R2	0.20	0.21	0.07		0.25	
N	263		205			

Notes: standard errors in parentheses. N is number of observations. Equations are estimated by OLS.

Table 5

Test for cointegration between consumers expectations and actual inflation rates: UK and US

	Countries					
	UK			**US**		
-lag lenght:	3			2		
-Trace test: H0: at most 1 CE	3.58		[p=0.48]	9.55	[p=0.04]	
-Rank test: H0: at most 1 CE	3.58		[p=0.48]	9.55	[p=0.04]	
	α	β	constant	α	β	constant
Cointegrating vector	1.00	0.59 (-0.48)	-3.77 (-0.91)	1.00	-3.65 (-0.43)	8.31 (-1.34)
	VECM			VECM		
	inflation		expected inflation	inflation	expected inflation	
ECM adjustment coefficients:	-0.05 (-0.017)		-0.04 (-0.013)	-0.01 (-0.01)	0.07 (-0.01)	
R2	0.18		0.22	0.19	0.15	
N	229			295		

Notes: standard errors in parentheses. N is number of observations. Equations are estimated by OLS.

like the one stemming from a rational behavior due to systematic biases. Furthermore, the VECM estimated residuals display some heteroskedasticity that could arise from neglected nonlinearities

In order to shed more light on these issues, we employ the STECM approach suggested by VDF (2000) and we start by estimating a conditional ECM model for the forecast error, as it can be seen from table 6[20].

As noted earlier, the linear models do not seem to perform badly. Parameters significance is quite satisfactory and the residuals seem to be well behaved, a part from a problem of heteroskedasticity indicated by the high $ARCH(1)$ statistic. However, with the models in CECM form we are able to investigate the issue of neglected nonlinearity by applying the LM test by Lukkonen et al (1988)-VDF (2000) to past forecast errors z_{t-d}[21]. Indeed the results of the test, displayed in table 7, show that the null hypothesis of linearity is rejected for several values of the lag length d of the past forecast error.

Beyond giving evidence of nonlinearities in the adjustment process stemming from *strategic stickiness,* the test also gives us an indication of which of the past forecast errors is responsible for such nonlinearities, as indicated by the lag order d^* with lowest p-value (underlined in table 7). An other important indication on the type of *strategic stickiness* characterizing expectations is given from what the data choose to be the appropriate transition function. In the literature, three types of transition function are generally used.

When one suspects that it is *sign asymmetry* that matters more for the adjustment process of the endogenous variable, one should use the logistic transition function. For example, there is evidence that many macroeconomic and financial variables seem to be affected in an asymmetric way by positive and negative shocks[22]. In this case the transition function takes the form

$$F(z_{t-d}) \equiv F(z_{t-d}; \gamma, c) = (1 + \exp\{-\gamma(z_{t-d} - c)\})^{-1} \quad \gamma > 0 \tag{5}$$

By substituting (5) in (4) one obtains the logistic STECM, where positive and negative deviations from the equilibrium relative to the threshold c will give rise to different effects, with z_t being attracted towards 0 with a speed indicated by γ. The higher γ, the faster the transition from ρ_1 to $\rho_1 + \rho_2$, while as γ approaches infinity, the $F(.)$ approaches an indicator function $I[z_{t-d} > c]$, with $I[A] = 1$ if $A = true$ and $I[A] = 0$ if $A = false$. On the other hand, when γ approaches zero we transition becomes linear as in the standard case.

In some other cases, *size asymmetry* may be more appropriate to describe the dynamics of the endogenous. For example, large or small misalignments of real effective exchange rates from their 'behavioral equilibrium' values have been shown to have different effects on the adjustment process of the exchange

[20] The ECM model is conditiona in the sense that it isolates either equation (**??**) or (**??**) from the VECM, and it conditions it to an appropriate number of lagsof the other endogenous variable.

[21] For technical details about the test, please refer to the appendix where we replicated an entire an example of estimatation of a STECM from the paper of VDF (2000).

[22] A popular example is aggregate demand, reacting much more quickly to a negative change in money supply than to a positive one.

Table 6 : *Estimation of the conditional ECM*

	France		***Italy***		***UK***		***US***	
dependent variable	Ye		Y		Y		Y	
	coefficients							
	constant	0.00	constant	0.03	constant	0.00	constant	-0.01
		0.89		0.05		0.99		0.72
	Z-1	0.08	Z-1	-0.04	Z-1	-0.03	Z-1	-0.04
		0.00		0.00		0.09		0.01
	Y-2	-0.18	Y-1	0.22	Y-1	0.36	Y-1	0.41
		0.01		0.00		0.00		0.00
	Y-1	-0.35	Y-2	0.22	Y-2	0.11	Y-2	-0.20
		0.03		0.00		0.11		0.00
	Y	-0.10	Y-3	0.18	Y-3	0.14	Ye-1	-0.06
		0.14		0.00		0.03		0.53
			Ye-2	-0.05	Ye-1	-0.04	Ye	0.41
				0.04		0.64		0.00
diagnostics								
	R2	0.25	R2	0.24	R2	0.19	R2	0.30
	DW	2.05	DW	2.01	DW	2.02	DW	1.97
	ARCH(1)	18.68	ARCH(1)	5.63	ARCH(1)	7.12	ARCH(1)	12.85
		0.00		0.02		0.01		0.00

Note: Equations are estimated by Nonlinear Least Squares using covariance matrix suggested by Newey and West (1981). Small numbers below the coefficients are p-values.

Note: For notational simplicity in the tables we renamed $D\pi_t^e$=Ye and $D\pi_t$=Y.

Table 7

LM-type test for smooth transition error correction in consumers forecast error

Test	Null	d=1	d=2	d=3	d=4	d=5	d=6
Country: **France**							
F Test	H_0'	0.63	0.80	0.03	0.04	0.20	0.00
χ Test	H_0'	0.63	0.79	0.03	0.04	0.20	0.00
Country: **Italy**							
F Test	H_0'	1.00	0.92	1.00	0.83	0.05	0.64
χ Test	H_0'	1.00	0.91	1.00	0.82	0.05	0.63
Country: **UK**							
F Test	H_0'	1.00	1.00	0.01	0.00	0.00	0.20
χ Test	H_0'	1.00	1.00	0.01	0.00	0.00	0.19
Country: **US**							
F Test	H_0'	0.56	0.69	0.63	0.05	0.00	0.00
χ Test	H_0'	0.55	0.68	0.62	0.05	0.00	0.00

Note: p-values for LM-type tests for smooth transition error correction in the forecast error of consumers expectations. The test refers to the Conditional ECM specfication. The null hypothesis is given in the text. Underlined values indicate the lag lenght chosen by the test at the 1% or 5% significance levels.

rates itself (Béreau, Villavicencio,and Mignon, 2009). The exponential function could be used to model this type of asymmetry

$$F(z_{t-d}) \equiv F(z_{t-d}; \gamma, c) = \left(1 - \exp\left\{-\gamma (z_{t-d} - c)^2\right\}\right) \quad \gamma > 0 \tag{6}$$

Here large (both positive and negative) deviations from the equilibrium gradually change the strength of the adjustment, implying that when $z_{t-d} = c$ the $F(.)$ is zero, while when z_{t-d} either decreases or increases to (minus) infinity, then $F(.)$ approaches one. The problem with the exponential function is that it shrinks to a linear function when γ either approaches zero or infinity. If this is not consistent with the dynamic behavior of the variable of interest, one might use instead the quadratic logistic function

$$F(z_{t-d}) \equiv F(z_{t-d}; \gamma, c) = \left(1 + \exp\left\{-\gamma (z_{t-d} - c_1)(z_{t-d} - c_2)\right\}\right)^{-1} \quad \text{(7a)}$$

$$\gamma > 0 \text{ and } c_1 \leq c_2 \quad \text{(7b)}$$

For finite γ, this particular function has a minimum value which is not equal to zero, while for γ going to infinity $F(.)$ is equal to one, both for $z_{t-d} < c_1$ and for $z_{t-d} > c_2$, but it is equal to zero in between. As in the previous case, the transition becomes linear when the speed parameter γ approaches zero.

From the practical point of view, in order to select the appropriate transition variable and transition function for each of our countries, we started from the indications of the nonlinearity test in table 7 but we also used a 'data specific approach' consisting in fitting various specifications and choosing the best one according to model evaluation criteria. Indeed, this is also Terasvirta's (1994) suggestion when dealing with nonlinear models, since the available tests might have low power in the presence of possible mispecification errors. For what regards the choice of the transition function we also took into considerations the insights from Fehr and Tyran's (2001) experimental evidence, indicating that both the size and signs of the shocks should matter in influencing the degree of strategic stickiness of expectations. As a consequence, we restricted the possible transition functions to (5) and (7a) we chose among the two based on model evaluation criteria. The result we obtained is that the quadratic logistic function seems to better fit our data in three cases out of four, suggesting that it should be more the size of the past forecast error than the sign determining *strategic stickiness* in the adjustment of consumers' expectations. Once chosen both the transition variable and the transition function, we are finally able to estimate our STECM models, as shown in table 8.[23].

At a first glance the STECM models seem to perform very well, and certainly better than their linear rivals at least in terms of parameters significance. The estimation of these models clearly involves losing twice as much degrees of freedom compared to the ECMs, but parallerly it results in generally higher R^2 (ranging between 0.27 and 0.56) and not lower Durbin-Watson statistics, a comforting sign. A little bit less comforting is the fact that these models solve the problem of heteroskedasticity of residuals only in two cases out of four, namely in Italy and in the US. Probably, this is due to the large number of outliers that are still present in the sample and that at this stage we did not attempt to correct. The transition function that the data generally seem to prefer is the quadratic logistic one, with the only exception of the UK which seems to favor the simple logistic. That is an indication that size more than sign asymmetry might be very important in determining the stickiness of expectations, and it is indeed consistent with one particular feature of money illusion: once the size of a nominal shock exceeds a certain (subjective) loss threshold, individuals start to take into considerations the (high) costs of reasoning in nominal terms rather than in real ones[24]. Also notice that the smoothness parameter γ is generally estimated quite imprecisely, while the other threshold parameters have always high significance. These two regularities in our estimation should both to be taken as positive. Normally in nonlinear models the standard deviation of the smoothness parameter tends to grow with the size of the parameter itself, and a precise estimate is always difficult to obtain[25]. To have a clearer idea of

[23] Notice that in our estimation of STECMs we standardize the exponent of the $F(.)$ function by divinding it to the variance of the chosen transition variable. This is an adviced choice to render the parameters γ, c_1 and c_2 scale free and it does not influence the other parameters' estimates. See Terasvirta (1994) for more details.

[24] Akerlof, Dickens and Perry (1985, 2000) name this kind of behavior 'near rational', in the sense that it implies only second order losses. Indeed, money illusion can only be operational in contexts of slow and small nominal price increases: in situations of hyperinflation (e.g. the Nazi Germany during the 30s) people are perfectly aware of their loss or purchasing power, hence money illusion is totally absent.

[25] As noted by Terasvirta (1994), when γ is large and at the same time the c parameters are sufficiently close to zero, a negative definite Hessian matrix is difficult to obtain for mere numerical reasons, even when convergence is achieved. That is the reason why joint estimation of the threshold parameters and the other model parameters is generally not adviced.

Table 8 : *Estimation of the STECM*

	France		Italy		UK		US	
dependent variable		Ye		Y		Y		Y
		coefficients						
	φ_1	-0.01	φ_1	0.02	φ_1	0.01	φ_1	-0.01
		0.74		0.38		0.66		0.38
	$\varphi_2 * Z_{-1}$	0.08	$\varphi_2 * Z_{-1}$	-0.03	$\varphi_2 * Z_{-1}$	-0.05	$\varphi_2 * Z_{-1}$	-0.06
		0.00		0.19		0.00		0.00
	$\varphi_3 * Y_{-2}$	-0.19	$\varphi_3 * Y_{-1}$	0.15	$\varphi_3 * Y_{-1}$	0.12	$\varphi_3 * Y_{-1}$	0.33
		0.00		0.07		0.04		0.00
	$\varphi_4 * Ye_{-1}$	-0.02	$\varphi_4 * Y_{-2}$	0.29	$\varphi_4 * Y_{-2}$	0.10	$\varphi_4 * Y_{-2}$	-0.29
		0.79		0.00		0.11		0.00
	$\varphi_5 * Y$	-0.02	$\varphi_5 * Y_{-3}$	0.33	$\varphi_5 * Y_{-3}$	0.23	$\varphi_5 * Ye_{-1}$	-0.06
		0.75		0.00		0.00		0.42
	ψ_1	10.95	$\varphi_6 * Ye_{-2}$	-0.07	$\varphi_6 * Ye_{-1}$	-0.09	$\varphi_6 * Ye$	0.37
		0.00		0.06		0.22		0.00
	$\psi_2 * Z_{-1}$	7.55	ψ_1	0.05	ψ_1	-0.35	ψ_1	0.03
		0.00		0.35		0.51		0.55
	$\psi_3 * Y_{-2}$	-1.69	$\psi_2 * Z_{-1}$	-0.03	$\psi_2 * Z_{-1}$	-0.04	$\psi_2 * Z_{-1}$	0.02
		0.00		0.34		0.71		0.64
	$\psi_4 * Ye_{-1}$	2.53	$\psi_3 * Y_{-1}$	0.28	$\psi_3 * Y_{-1}$	0.87	$\psi_3 * Y_{-1}$	0.30
		0.00		0.08		0.00		0.05
	$\psi_5 * Y$	4.75	$\psi_4 * Y_{-2}$	-0.25	$\psi_4 * Y_{-2}$	0.62	$\psi_4 * Y_{-2}$	0.44
		0.00		0.10		0.06		0.02
			$\psi_5 * Y_{-3}$	-0.29	$\psi_5 * Y_{-3}$	1.00	$\psi_5 * Ye_{-1}$	0.17
				0.15		0.01		0.64
			$\psi_6 * Ye_{-2}$	0.02	$\psi_6 * Ye_{-1}$	-0.51	$\psi_6 * Ye$	0.40
				0.67		0.11		0.26
Transition function		quadratic logistic		quadratic logistic		logistic		quadratic logistic
Transition variable		Z_{-4}		Z_{-5}		Z_{-3}		Z_{-6}
	γ	-2.71	γ	-11.74	γ	-25.07	γ	-369.42
		0.08		0.01		0.01		0.93
	c_1	-2.31	c_1	0.42	c_1	-2.97	c_1	-1.60
		0.00		0.00		0.00		0.00
	c_2	2.34	c_2	-1.85			c_2	0.78
		0.00		0.00				0.00
R2		0.56	R2	0.27	R2	0.38	R2	0.39
DW		1.97	DW	2.03	DW	1.98	DW	1.94
ARCH(1)		33.16	ARCH(1)	1.69	ARCH(1)	80.03	ARCH(1)	3.52
		0.00		0.19		0.00		0.06

Note: Equations are estimated by Nonlinear Least Squares using covariance matrix suggested by Newey and West (1981). Small numbers below the coefficients are p-values.

how the adjustment of expectations is behaved and to understand how strategic stickiness affects it, let us examine more closely figure 3.

For each country, on the left side we find two panels regarding model performance, both in terms of actual versus fitted values and of residuals' behavior. On the right side instead, we can see how the estimated transition function evolves in time and how it is influenced by the transition variable itself.

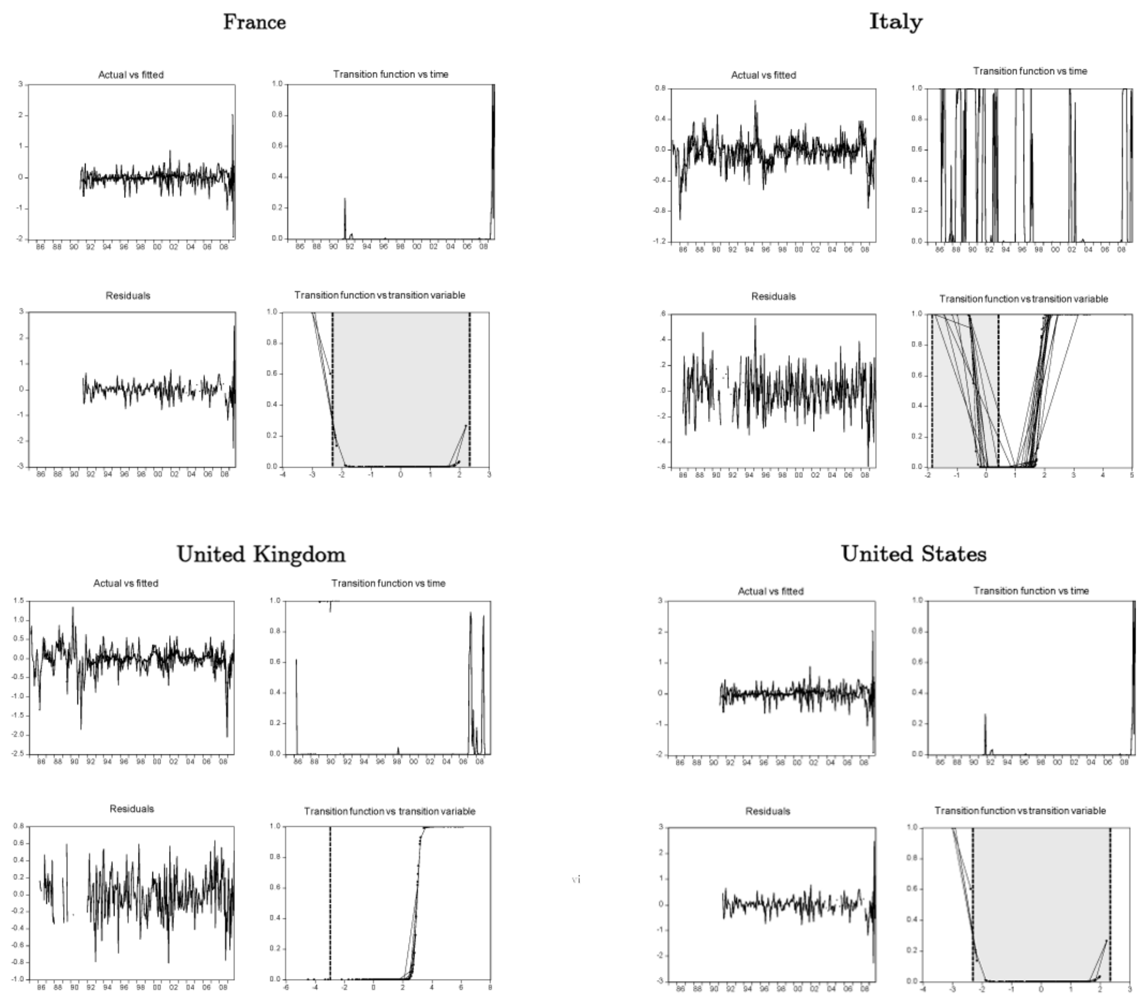
For all the four countries it seems that there is still a lot to be done from the model specification point of view. Although the actual and the fitted series correlate very much, the models still fail to capture some of the largest movements in the forecast error, especially at the end of the sample with the recent financial crisis. The properties of the estimated transition functions in the upper and lower right panels deserve some particular attention.

The quadratic logistic function for both Italy and the US show a very similar pattern, oscillating between zero and one as the observed forecast error exceeds or stays in the threshold range (c_1, c_2). However, for the Italian case, nonlinearity seems to explain mainly the behavior of data in the first part of the sample, while the opposite is true for the US. Parallerly, the bottom right panels of both the Italian and the US estimations show that the transmission function becomes close to zero and linear for low values of the past forecast errors, respectively between $(0, 2)$ and $(-1, 1)$. This supports the hypothesis of strategic stickiness since there is almost no adjustment of expectations to the long-run equilibrium when past errors are very small (whatever their sign is): Money illusion is operational at its highest potential since the costs of those errors are almost irrelevant. Notice instead that when past forecast errors are in the threshold range (c_1, c_2), indicated by the shaded area in the graphs, nonlinearity kicks in and the transition function takes positive values, approaching one for larger values of past errors. This is a sign that expectations gradually loose their strategic stickiness due to money illusion, as forecast errors become larger and larger, yielding high costs. Clearly a linear cointegration analysis could not have given us so much information about these factors affecting the speed of adjustment of expectations.

The case of France is a little bit different. Even though the quadratic logistic function is still the one which better fits the data, the overall performance of the estimated STECM model seems to beat the one of all the other countries in terms of fit ($R^2 = 0.56$). To confirm that, the left panels of figure 5 show that only the financial crisis of 2008 is not entirely captured by the model, and consequently also the residuals look better behaved than the others. However, from the bottom left panel we can see that the transition function remains for the majority of the time at its minimum value, with just few observations exceeding the threshold range. This is consistent with a quite precise estimate of the smoothness parameter $\gamma = -2.71$ (p-value=0.08), the lowest γ we obtain. We interpret these results in terms of a high persistence of money illusion on behalf of French consumers: for past forecast errors falling in the range $(-2, 2)$ the adjustment towards the long-run equilibrium is almost irrelevant, and indeed for the great part of the time sample expectations display strategic stickiness.

The case of UK is also peculiar, since it is the logistic function that the data

Figure 3: Estimated STECMs



seem to choose. According to Fehr and Tyran's (2001) results, expectations errors should be very sensitive to sign asymmetry, hence the logistic function is the one we were expecting the data to choose more often, while this is only the case for English data[26]. From the right side panels we can clearly see that the logistic STECM model fails to capture many movements of the forecast error both in the first half of the sample and after 2008. The UK adjustment coefficient remains at its minimum value until the forecast error exceeds approximately the value of 3, indicating high strategic stickiness of expectations for shocks smaller than that threshold. After that, cointegration becomes almost linear, and also English consumer adjust their errors to the long-run equilibrium.

Our general conclusion is that in our data there is evidence of money illusion resulting in strategically sticky inflation expectations. Furthermore, our data seem to suggest that it is the size more than the sign of past forecast errors that matters more in explaining strategic stickiness. Nevertheless, given the early stage of our analysis, we want to make it clear that the good fit of the STECM specification for our data does not exclude the relevance of other types of theoretical models we did not consider to explain a nonlinear adjustment of expectations.

5 Concluding Remarks

A model of 'ecological rationality' posits that when agents are confined with complex tasks such as forecasting inflation, they should use the best heuristics methods they have, given the available information sets. Indeed reasoning in nominal terms and ignoring low future inflation might be a powerful rule of thumb in a low and stable inflation environment. This paper has shown that traces of such heuristic behavior can also be found in the aggregate expected inflation time series.

By using standard rationality tests and novel econometric techniques like STECMs, we obtain two main results. On the one hand, European consumers seem to systematically overpredict the level of future inflation, being also very much influenced by the speed of diffusion of the available information (stickiness *à la Carrol, 2003*). On the other hand, there seems to be a strong evidence also for strategic stickiness, implied by the fact that small past forecast errors have a much lower influence on the speed of adjustment of expectations than large ones. In such a context, we obtain that size asymmetry seems to play a greater role than sign asymmetry in determining such stickiness. We interpret this findings as a manifestation of the presence of money illusion, since it is the effect of a

[26] Nevertheless, we should notice there is one big difference between Fehr and Tyran's experimental setting and our context. Fehr and Tyran were able to implement a fully anticipated monetary shock on experimental subjects and study its effects, while here we can only study the effects of past forecast errors on the aggregated adjustment mechanism of expectations. Indeed, it is possible to think of past forecast errors as incorporating exogenous monetary shocks, and clearly we based our notion of strategic stikiness on such a proxying. However, due to these considerations it is not possible to interpet the sign/size asymmetry favored by our models exactly in the same way as Fehr and Tyran.

strategic way of thinking in a context where inflation adjustments are strategic complements.

Of course one can always question the informative content of expectations series derived from qualitative survey data. Moreover, the use of nonlinear time series techniques implies particular caution because it is sensitive to the choice of the starting parameters and of the algorithm used. In particular, STECMs are admittedly vulnerable to mispecification errors either in small samples, or in samples with multiple outliers. VDF (2000) also show that the availability of high frequency data (i.e. weekly or daily time series) increases the power of the nonlinearity tests and it could be helpful to distinguish 'disguised' nonlinearity from true nonlinearity.

Clearly, all the above considerations can provide fruitful insights for future research in this topic. A particularly promising new line for future research regards the application of panel smooth transition autoregression techniques, like the ones used in Béreau, Lopez, Villavicencio and Mignon (2010) to inflation expectations data. We are aware that our analysis of each expectation series separated one from the other implies a certain loss of potential variability/heterogeneity in the data, hence we hope to amend for this weakness in future work. Finally, it would be very interesting to conduct our investigation of strategic stickiness also with disaggregated expectations data, along the lines of what Pfajfar and Santoro (2010) do for the Michigan Consumer Survey data. Nevertheless, this kind of analysis is subject to a data availability constraint for European countries, since the European Commission does not publish the disaggregated data for the survey of consumers' expectations. At any rate, and bearing in mind all these potential improvements of our work, we want to stress our main finding: consumers' inflation expectations do exhibit a relevant degree of strategic stickiness which can be reconducted to behavioral biases like money illusion.

Appendix

A. The European Commission Consumers Survey and the Carlson-Parking's (1975) Method

In the European Commission consumers survey, consumers are asked the following question on future price developments (Question 6): "By comparison with the past 12 months, how do you expect consumer prices will develop in the next 12 months? They will . . .

1. increase more rapidly
2. increase at the same rate
3. increase at a slower rate
4. stay about the same
5. fall
6. don't know

The 'Probability approach' (Carlson-Parking,1975) is based on the idea to interpret the share of responses to each category as estimates of areas under the density function of aggregate inflation expectations, that is to say as probabilities. By specifying a distribution function for these probabilities (generally the logistic or the normal distributions are employed) it is then possible to compute a measure of the mean expected inflation and its standard deviation, together with the two response thresholds δ_t and ε_t. In particular Denoting S_i (for $i = 1, 2, 3, 4, 5$) as the sample proportions opting for each of the five response categories in the survey undertaken in month t, equations (8) to (11) below give the relevant measures for the derived expectations series.

$$\pi_t^e = -\pi_{t-12}^p \left(\frac{Z_{t-12}^3 + Z_{t-12}^4}{Z_{t-12}^1 + Z_{t-12}^2 - Z_{t-12}^3 - Z_{t-12}^4} \right) \tag{8}$$

$$\sigma_t^e = -\pi_{t-12}^p \left(\frac{2}{Z_{t-12}^1 + Z_{t-12}^2 - Z_{t-12}^3 - Z_{t-12}^4} \right) \tag{9}$$

$$\delta_t = -\pi_{t-12}^p \left(\frac{Z_{t-12}^1 + Z_{t-12}^2}{Z_{t-12}^1 + Z_{t-12}^2 - Z_{t-12}^3 - Z_{t-12}^4} \right) \tag{10}$$

$$\varepsilon_t = -\pi_{t-12}^p \left(\frac{Z_{t-12}^3 - Z_{t-12}^4}{Z_{t-12}^1 + Z_{t-12}^2 + Z_{t-12}^3 + Z_{t-12}^4} \right) \tag{11}$$

Where π_t^e indicates expected inflation and σ_t^e denotes the standard deviation of the aggregate distribution for inflation expectations, and π_{t-12}^p is the perceived rate of inflation at time $t - 12$ used as a scaling factor following Berk (1999). Finally, $N^{-1}[.]$ is the inverse of the assumed probability distribution function which has the following arguments: $Z^1_{t-12} = N^{-1}[1 - S^1_{t-12}]$, $Z^2_{t-12} = N^{-1}[1 - S^1_{t-12} - S^2_{t-12}]$, $Z^3_{t-12} = N^{-1}[1 - S^1_{t-12} - S^2_{t-12} - S^3_{t-12}]$, $Z^4_{t-12} = N^{-1}[S^5_{t-12}]$.

The above expressions for the mean and standard error of expected future inflation express the mean and the uncertainty of expected inflation as a function of the actual and the perceived rate of inflation, which is used as a scaling function. It has been shown by Berk (1999) that using a notion of perceived inflation as a scaling function for the above system significantly improves the accuracy of the derived expectations series. The perceived rate of inflation can be computed by slightly modifying the Carlson Parkin method and applying it to Question 5 of the EC Consumer Survey, related past price developments.

For a more detailed description of this approach and of the rescaling based on perceived inflation, we suggest to refer to Berk (1999) and Gerberding (2007). For a critical survey of alternative methods to transform qualitative data into quantitative ones see Nardo (2003).

B. Replicating VDF (2000)[27]

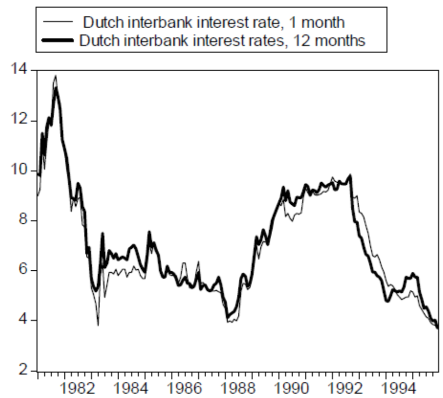
The case for nonlinear adjustment towards the long-run equilibrium is particularly evident for equivalent assets in the context of efficient financial markets (Yadav et al 1994, and Anderson 1995). Indeed, prices of equivalent assets should be such that investors are almost indifferent between holding for example stocks or futures with similar characteristics, or bonds of different maturity from the same issuing company. Nevertheless, market frictions (transaction costs, short selling restrictions etc.) which are different for each trader, give rise to asymmetric adjustment of prices deviations from the no arbitrage equilibrium. Coherently with such a framework, VDF (2000) illustrate the properties of STECM models by taking as an example a monthly bivariate interest rate series for the Netherlands composed by one- and twelve-month interbank interest rates (indicated respectively as $R1_t$ and $R12_t$) from January 1981 to December 1985. In this section we are able to replicate their results by using the same STECM estimation strategy we applied in our paper.

From simple graphical inspection of Figure 9, one can already see that the two time series display a tendency to move together. Indeed, unit roots tests on the individual series confirm that the two interest rates are individually $I(1)$ (ADF t-statistics are respectively -1.26 and -1.25), while the spread between the two, $S_t = R_{12,t} - R_{1,t}$, can be considered stationary (ADF t-statistic -2.90).

The first step of VDF's procedure to specify a STECM model for S_t consists in fitting a standard linear ECM model. Having had evidence for cointegration through the Johansen trace test, a $VECM(1)$ for the first differences of the two

[27] The programs we used in this paragraph and all the other ones we used for model estimation are available upon request.

Figure 4: Dutch interbank interest rates [Source: Prebon Yamane Inc.]



interest rates is fitted with the following result[28]:

$$
\begin{aligned}
D(R12)_t &= \underset{(0.068)}{0.11} * (R12_{t-1} - \underset{(0.018)}{1.029} * R1_{t-1}) - \underset{(0.148)}{0.206} * D(R12_{t-1}) + \\
&\quad + \underset{(0.135)}{0.275} * D(R1_{t-1}) \\
D(R1)_t &= \underset{(0.073)}{0.23} * (R12_{t-1} - \underset{(0.018)}{1.029} * R1_{t-1}) - \underset{(0.159)}{0.096} * D(R12_{t-1}) + \\
&\quad + \underset{(0.145)}{0.095} * D(R1_{t-1})
\end{aligned}
$$

The authors then choose to restrict the cointegrating vector to $(1, -1)$, being the standard error of $R1_{t-1}$ equal to 0.018. Moreover, since the error correction coefficient not significant in the equation for the twelve-months interest rate, they estimate a conditional ECM model for $R1_t$ by conditioning it on $R12_t$. The resulting ECM specification is then taken as a basis for the subsequent analysis for nonlinearities in the adjustment process (Here for notational simplicity we renamed $D(R1)_t = X_t$ and $D(R12)_t = Y_t$[29]).

$$X_t = -\underset{(0.02)}{0.02} + \underset{(0.04)}{0.13} * S_{t-1} + \underset{(0.04)}{0.92} * Y_t - \underset{(0.07)}{0.16} * X_{t-1} + \underset{(0.08)}{0.09} * Y_{t-1} \qquad (12)$$

Equation (12) has a problem of residuals non-normality (JB statistic=135.51 and Kurtosis=7.27), which might be caused both by aberrant observations at the beginning of the sample and by neglected nonlinearity. As a consequence of that, the second step of VDF's procedure is testing for possible nonlinearity in the error correction mechanism by means of the Lukkonen et al.'(1988) test,

[28] Standard errors are given in parentheses.

[29] As a check of correctness of our procedure, notice that the estimated parameters in equation (12) closely replicate the ones of equation (13) in VDF's (1997) paper.

generalized by Terasvirta (1994), Swanson (1996) and VDF(2000) in the context of smooth transition autoregressive models.

As we already explained, the test is based on a reparametrization of the STECM model by approximating the $F(.)$ function with its third order Taylor approximation, and on computing a LM test for the null hypothesis $H_0' : \varphi_1 = \varphi_2 = \varphi_3 = 0$. Through a similar procedure it is also possible to obtain an estimate of the appropriate lag d^* for the transition variable S_{t-d},and of the most convenient form of the transition function.

Table 13 shows that for the choice of the transition variable, lag $d^* = 1$ yields the lowest p-value. Therefore we agree with the choice of VDF to select S_{t-1} as transition variable.

Table 9

LM-type test for smooth transition error correction in the CECM from VDF (1997)(*)

Test	Null	d=1	d=2	d=3	d=4	d=5	d=6
F Test	H_0'	0.01	0.56	0.56	0.12	0.05	0.02
χ Test	H_0'	0.01	0.54	0.154	0.12	0.05	0.01

(*): Author s calculation on data from VDF (1997).

The choice of the transition function should be conducted by means of a similar procedure where a sequence of alternative tests is carried out sequentially. However, since there is no guarantee that this sequence will give rise to the right answer, we will use a more practical strategy, as VDF: we estimate the STECM with the three types of transition function and chose the one that best fits the data. After alternative specifications are estimated, and based on different information criteria, we reach the same conclusion of VDF choosing the quadratic logistic transition function.

As suggested by Terasvirta (1994), we estimate the final STECM model by nonlinear least squares in two steps. First, we use the estimated parameters in equation (12) as starting values to estimate the $\boldsymbol{\pi}_2'$ vector of parameters, imposing sensible starting values for the γ, c_1 and c_2 parameters[30]. Then, we estimate the final STECM model by giving as initial values $\widehat{\boldsymbol{\pi}}_1'$ and $\widehat{\boldsymbol{\pi}}_2'$ obtained in the previous step. Our procedure yields parameters estimates and standard errors which are really close to the ones of VDF:

$$\begin{aligned} X_t = & \underset{(0.03)}{-0.03} + \underset{(0.07)}{0.12} * S_{t-1} + \underset{(0.04)}{0.90} * Y_t - \underset{(0.09)}{0.24} * X_{t-1} + \underset{(0.1)}{0.23} * Y_{t-1} + \\ & +(\underset{(0.12)}{0.32} + \underset{(0.19)}{0.42} * S_{t-1} + \underset{(0.19)}{0.15} * Y_t - \underset{(0.17)}{0.17} * X_{t-1} - \underset{(0.25)}{0.31} * Y_{t-1}) * \\ & *[1 + \exp(\underset{(5.69)}{3.74} / \sigma^2_{S_{t-1}} * (S_{t-1} - \underset{(0.12)}{1.25}) * (S_{t-1} + \underset{(0.08)}{0.40}))^{-1}] \end{aligned} \qquad (13)$$

The large standard error of the estimated γ is a very common problem

[30] Terasvirta (1994) suggests to inizialize the $F(.)$ parameters with $\gamma = 1$ and $c_1 = c_2 = mean(transition\ variable)$.

in the estimation of smooth transition functions, which makes it generally very difficult the joint estimation of the $F(.)$ parameters. Furthermore, the estimates of γ, c_1 and c_2 and their standard errors are sensitive to rescaling, and to the type of algorithm used. Fortunately, these uncertainties do not affect the other parameters estimates.[31]

[31] Nonlinear estimation is always cumbersome because one risks that algorithm used finds only one of the local maxima, and possibly not the best one. In order to be sure that what we found with our iterative procedure was at least 'the best' local maximum of the likelihood function, we run a tridimensional grid search for the threshold parameters of the $F(.)$ function, γ, c_1 and c_2. This further check confirms the robustness of VDF's findings and the correctness of our procedure, since it indicates that the maximum found is actually the 'best' among the other local maxima. The Eviews programs we wrote to perform this robustness check is also given at the end of this technical appendix.

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