A Panel Smooth Transition Regression Model for the Determinants of Inflation Expectations and Credibility in the ECB and the Recent Financial Crisis*

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Abstract

This paper studies the determinants of inflation expectations and credibility in the European Central Bank (ECB) during the first decade of European monetary policy. As a measure of credibility we use the gap between the professional economists' inflation forecasts and the ECB's inflation objective. In addition, we investigate whether the main driving factors of inflation expectations and credibility have changed during the recent financial crisis. Within a panel data approach we use Consensus Economics Forecasts in a real-time framework over the period December 2002-May 2010. First, we find that the history of inflation honesty, the forecasts of real GDP growth, M3 growth and the industrial producers' price inflation appear as key determinants of the inflation expectations and the credibility gap in the ECB. Second, within a Panel Smooth Transition Regression (PSTR) modeling we account for a change of regime in the determinants of the inflation forecasts and the credibility in the Central Bank. Finally, we provide new evidence on the impact of the recent non conventional monetary policy operations on the inflation credibility dynamics of the ECB. Using the ratio of Longer-Term Refinancing Operations (LTRO) and the ratio of Securities in the total assets held by the ECB as transition variables, we find that the impact of the key explanatory variables has changed at the onset and at the peak of the financial crisis respectively.

JEL Classification: C23, C24, E52, E58.

Keywords: Central Bank credibility, Panel Smooth Transition Regression, Consensus Economics forecasts, real-time data.

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1 Introduction

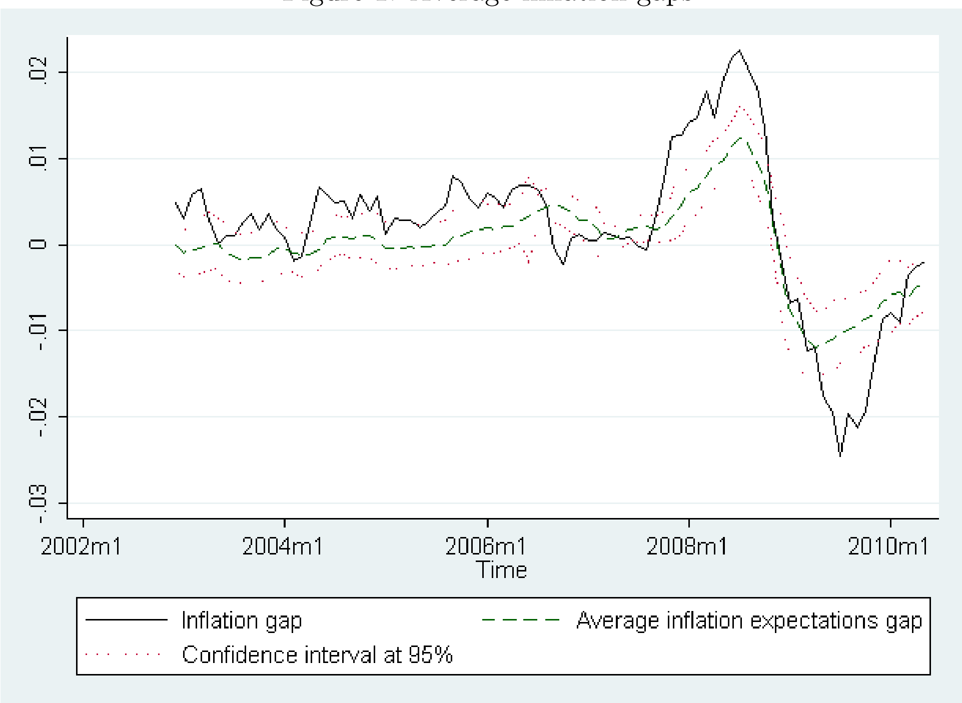
The European Central Bank (ECB), as the Central Bank of the Eurosystem, is responsible for conducting the single European monetary policy since January 1^{st} 1999. Its primary objective is to maintain price stability in the euro area defined as an inflation rate below but close to 2% over the medium term. Without prejudice to that overriding goal, the Central Bank supports the general economic policies in the European Union. These are the objectives that the European Central Bank has been entrusted to achieve and that are embedded in the protocol on the statutes of the European System of Central Banks (ESCB). Hence, any study attempting to assess the policy performance and credibility of the ECB should consider the above mentioned criteria.

Recent academic research has shown evidence that in a forward looking environment monetary policy operates essentially through the agents' expectations, usually assumed to be rational, about the current and future policy actions. This important issue is well emphasized by Woodford (2003): *"For successful monetary policy is not so much a matter of effective control of overnight interest rates as it is of shaping market expectations of the way in which interest rates, inflation, and income are likely to evolve over the coming year and later [...] not only do expectations about policy matter, but, at least under current conditions, very little else matters."* It is of a crucial importance for the effectiveness of monetary policy to have well aligned private agents' expectations with the Central Bank's target. The main benefit from perfectly anchored expectations is that it fosters the long-run predictability of the policy actions of the Central Bank. The more predictable a Central Bank is, the more efficient its monetary policy strategy and the better the overall macroeconomic performance. Moreover, the more transparent an independent Central Bank is the more credible it should be and the more effective its monetary policy would be in achieving price stability. On the one hand, credibility matters mainly for the market participants who are directly involved in real-time economic decision making. However, on the other hand, in a broader perspective, the European citizens' trust in the ECB is also an important factor that should be taken into account in the formulation of the monetary policy strategy. As the ECB's President Jean-Claude Trichet has put it, it is crucial for the effectiveness of the single European monetary policy to be predictable not only to the market participants but also to every European citizen whose support is necessary for the sustainability of the ECB's policy strategy. Hence, in theory and practice, the credibility issue of a Central Bank is a fundamental factor for enhancing the monetary policy effectiveness. Given the 2007-2010 financial and economic turmoil, this issue is a particularly vulnerable one to private agents' shifting beliefs and expectations.

Fischer and Hahn (2008) study the determinants of trust in the ECB at the country level using the European Commission Eurobarometer panel. They find that higher past inflation tends to reduce people's trust, higher national income tends to increase trust in the Central Bank, while unemployment does not seem to exert any significant impact on the dependent variable. In the same spirit, using the Eurobarometer survey Gros and Roth (2010) find that the sharp fall of the citizen's trust in the ECB is due to the broadening of the financial crisis in 2009 at the country level as well. The fall occurred mainly in the three largest euro area countries: Germany, France and Italy. Using the European Commission Survey, Ehrmann, Soudan and Stracca (2010) observe a sharp fall in public trust in the ECB during the global financial crisis at the individual level. The latter is due to the economic slowdown, the fall of citizens' trust in the other European institutions and ultimately to the fact that the ECB has been associated by the public to the large losses of the financial sector and to the governments' bail-out plans. They conclude by asserting that increasing public knowledge of the ECB through communication should lead to a higher level of trust in the Central Bank. At the forefront research field on this topic Wälti (2011) finds that inflation deviation from the Central Bank objective and higher unemployment rates reduce net trust in the ECB. In addition, some financial variables such as higher sovereign bond yields and distress measures of the banking sector seem to exert a negative impact on the public trust in the monetary institution. Geraats (2008) brings out that the financial forecasters expect that the probability of the HICP inflation rate to be located in the range of 0-2% in the medium term is less than 40% in the second quarter of 2008, which is far below the 80% probability reported at the outset of the European Monetary Union. These findings point out that the ECB's credibility could have been particularly threatened during the last decade due to the occurrence of the worst financial and economic crisis since the Great Depression. It is therefore even more challenging and research appealing to further investigate the key driving factors of inflation expectations and of Central Bank credibility in the period before and during the financial crisis.

This paper contributes to the previous literature on the following grounds. First, we investigate the main determinants of the inflation forecasts and of the credibility gap in the ECB using the Consensus Economics panel of professional forecasters over the period December 2002-May 2010. The credibility gap is defined as the absolute value of the difference between the professional forecasters' inflation expectations and the Central Bank's inflation objective. Following the statement made by the ECB's chief economist Otmar Issing in May 2003 the ECB considers inflation expectations located in the range of 1.7-1.9% in line with its price stability goal. Therefore, we use an inflation rate of 1.8% as a measure of the ECB's inflation objective which corresponds to the median of the above range. Figure 1 displays the average inflation expectations gap measure along with the actual inflation rate in deviation from the inflation objective.

Figure 1: Average inflation gaps



Notes: In this figure is plotted the inflation gap series (solid line) from December 2002 to May 2010. The latter is defined as the difference between realized inflation and the Central Bank's inflation objective. We also plot the difference between the (12 months) fixed horizon average CEF's inflation (dashed line) among the 22 professional forecasters used in the estimations and the Central Bank's inflation objective. To have a better view on the accuracy of the average inflation forecasts, a confidence interval (dotted line) at 95% level is also displayed.

As one can see from the above figure the average inflation expectations gap remains quite constant and close to zero from 2002 until 2005. Then, it increases a little at the beginning of 2006 in order to fall again in the same year. Importantly, the gap increases swiftly in 2007 and 2008 following the rising inflationary pressures in the euro area stemming mainly from the commodities' price inflation. At the peak of the financial crisis the gap falls sharply and becomes negative. After the tipping point of the financial turmoil, inflation expectations soar up gradually again as the economy starts recovering from the crisis.

The second core objective of the paper is to investigate the presence of nonlinearity in the determinants of the inflation forecasts and the credibility in the ECB. For that purpose we use a Panel Smooth Transition Regression (PSTR) modeling approach. The latter is a well suited method for exploring nonlinearities between individuals and over time. We estimate a first regime that occurs in normal (non crisis) periods and a second one that takes place in times of deep financial slump. In this model the switch between regimes is driven by an observable transition variable. Finally, the paper sheds new light on understanding the impact of the recent financial downturn on the building-up process of credibility in the ECB. The empirical evidence suggests first that the main determinants of inflation expectations and credibility in the ECB are the history of inflation honesty, the forecasts of the real GDP growth rate, the M3 growth rate and the industrial producers' price inflation. The effect of the core variables is robust to including several control variables: fiscal sustainability measures of the euro area countries, oil price and wage growth forecasts, financial markets expectations, interest rate spreads. More importantly, with the PSTR model we find that the impact of the main driving factors of the inflation and the credibility gaps have changed during the recent financial crisis. Indeed, using the ratio of LTRO (Longer-Term Refinancing Operations) and Securities in the total assets held by the ECB as transition variables we find strong evidence that the credibility building-up process has changed at the onset and at the peak of the financial turmoil respectively.

In a first step, we specify a model for explaining the inflation expectations process where the variables are expressed in level. In a second stage, we set up a model for the inflation credibility gap in the ECB in which the variables are included in absolute value. For the model in level, in the crisis regime past inflation and the GDP growth forecasts play a minor role in shaping inflation expectations compared to the normal regime, while the magnitude of the M3 growth and the producers' price inflation forecasts is amplified. For the specification in absolute value, the results point out that in the crisis regime past inflation plays a minor role in determining the credibility of the ECB, while the impact of the M3 and the GDP growth forecasts is magnified. The estimated regimes and the timing of the transitions are overall robust to using a time trend as a transition variable.

The remaining of the paper is organized as follows. In section 2 we lay down the theoretical framework for investigating the inflation expectations and the credibility gap in the ECB. We also specify the linear and PSTR models and focus on the advantages of the nonlinear specification. In section 3 we briefly describe the real-time data set used and the construction of the relevant variables. The estimation results of the PSTR and the linear panel models are presented in section 4. The last section concludes on the main findings of this paper.

2 Theoretical framework

2.1 The Central Bank credibility framework

2.1.1 Credibility measures

It should be emphasized that credibility is a multidimensional concept that relates the policy actions of the Central Bank to its communication strategy and to the overall macroeconomic performance. At a more intuitive level, Blinder (2000) defines the latter as *matching deeds to words*. The present analysis attempts to bring new insights into understanding the inflation credibility building-up process of the European Central Bank. Intuitively, as a first approach, one could conceive credibility as a correspondence between what the Central Bank promises to do and what it actually does. Moreover, this match could be breached by a noisy communication policy which could give rise to a gap between what the Central Bank does and what the market participants perceive it does. In that case, the implied misalignment of expectations could possibly explain a lack of credibility in the monetary institution.

Therefore, as a simple measure of Central Bank credibility one could conceive the difference between inflation expectations and the Central Bank's inflation target. However, this measure aims at explaining the inflation expectations process in deviation from the inflation objective (Inflation Expectations Gap, IEG) which is defined in the following way:

$$IEG_{i,t} = \pi^e_{i,t} - \pi^{tar}$$

One should also emphasize the potential mismatch that could arise between the announced inflation objective and the quantitative inflation target. In the case of the ECB this should not be an issue at least since 2003 given the fact that the Central Bank has clarified in May 2003 that it aims at bringing inflation close to but below 2% over the medium term. Thus, any potential mismatch could occur in the 1999-2003 period and would be reflected through a higher gap between inflation expectations and the actual inflation rate. With such a measure we test for bias in the inflation forecasts which is defined as the tendency to generate significant positive or negative gaps in the inflation forecasts as explained in Poplawski-Ribeiro and Rülke (2010).

As another approach, Cukierman and Meltzer (1986) consider the absolute value of any deviations between the Central Bank's inflation objective and its forecasts to asses the accuracy of the latter over time. In addition, using the same methodology Poplawski-Ribeiro and Rülke (2010) study the effect of the Stability and Growth Pact (SGP) on the private sector public deficit forecast errors for the euro area. Hence, as a second approach in measuring Central Bank credibility, one could derive the following quantitative measure (Central Bank Credibility Gap, CBCG):

$$CBCG_{i,t} = |\pi^e_{i,t} - \pi^{tar}|$$

We would like to emphasize that this measure for the credibility gap is the most appropriate in light of the data set available to us. Indeed, we are interested in the absolute value of the deviation of inflation expectations with respect to the Central Bank's inflation objective regardless of their sign as reflecting more accurately the inflation credibility of the ECB. In fact, any surge of the inflation forecasts above the Central Bank's target or any decline of the former below the inflation objective would threaten the price stability commitment of the Central Bank and would seriously hamper its inflation credibility.

Alternatively, as a third measure of credibility, Geraats (2008) proposes a probabilistic based approach that is related to a more precise quantitative definition of the price stability goal of the ECB. In the medium term, the ECB's objective is to maintain an HICP inflation close to but below 2%. One could consider as a measure of credibility the probability that inflation expectations are located in the range of 1.7% to 1.9%.

$$CBCG_{i,t} = Pr(\pi^e_{i,t} \in [1.7\% - 1.9\%])$$

Nevertheless, the professional forecasters we consider in our panel do not report the distribution of their inflation forecasts over different inflation values. Hence, we cannot use a probabilistic based measure of credibility within our panel analysis.

2.1.2 Determinants of inflation expectations and credibility in the ECB

At the first and utmost place, credibility depends crucially on the *history of honesty* as denoted in a survey conducted by Blinder (2000). Indeed, a Central Bank is credible when it has not only communicated its goal of maintaining price stability and has provided a quantitative definition as well as a target horizon for it, but mostly when it has successfully reached that objective in the past. Thus, one could use the average of the difference between the past inflation rate and the inflation target as an explanatory variable for the CBCG. The latter is weighted by a memory persistence coefficient ρ following the approach of Geraats (2008). This coefficient reflects the fact that agents put more weight on information that is closer to the present and hence the relevance of current information for policy evaluation is declining over time.

The long-run inflationary pressures could undermine the credibility of the ECB. A possible measure for the former is the expected growth rate of the monetary aggregate M3. Indeed, within its two-pillar strategy, the ECB has defined a reference growth rate of M3 of 4.5% during the early stage of the European Monetary Union. Geraats, Giavazzi and Wyplosz (2008) state that the real GDP growth rate should be in the range of 2% to 2.5% and the velocity growth rate in the range of -1% to -0.5% based on the Quantity Theory of Money. Thus the implied long-term inflation rate falls in the range of 1% to 2%.

The objectives of the ECB are stipulated in the Maastricht Treaty signed on February 7, 1992 by the members of the European Union. Beyond its primary objective of price stability over the medium term, the Treaty specifies that *"Without prejudice to the objective of price stability, the ESCB shall support the general economic policies in the Community with a view to contributing to the achievement of the objectives of the Community as laid down in Article 2."* More specifically, the ECB shall support economic growth in the euro area as long as it is compatible with its overriding goal of price stability. Thus, the real GDP growth rate forecasts and the unemployment rate in the Monetary Union should have an impact on the European citizens' level of confidence in the ECB. Based on the Okun's law we include solely the real GDP growth forecasts in our baseline model.

We consider forecasts of industrial producers' price inflation to account for any inflationary pressures stemming from the producers' costs. In fact, any increase in the commodities' prices will affect directly the industrial producers' costs and will exert an impact on consumers' price inflation expectations through second-round effects. This could undermine the Central Bank's low inflation credibility.

The individual characteristics of each professional forecaster and the socio professional category in which they are included might exert a differentiated impact on the credibility gap of the ECB. Our forecasters are mainly from banks and insurance companies and only a few are from research institutes.

As control variables of our baseline specification we include the following set of regressors: wage growth, oil price and unemployment rate forecasts, the annualized growth rate of the Economic Sentiment Indicator (ESI), the ratio of public debt to GDP and the ratio of public deficit forecast to GDP, the European Commission Monetary Conditions Index (MCI), the annualized performance of the Euro Stoxx Dow Jones for the financial sector, the annual VIX growth rate and the spread between the 3-months Euribor and the Eonia rates. The ESI is included to consider the impact of a forward looking measure of the business cycle on the credibility gap. In line with its objective of supporting the general economic policies in the European Union, the credibility in the ECB should crucially depend on the public sector soundness. Indeed, the sustainability of the monetary union relies heavily on the fiscal discipline of the member states' countries, as has been extensively emphasized in the European Stability and Growth Pact. Any deterioration of the fiscal variables could add pressure to the ECB in favor of a more accommodating policy stance. This would not only weaken the credibility and sustainability of the Stability and Growth Pact but would also be harmful to the ECB's inflation credibility. As regards the MCI, an increase in the latter indicates that monetary conditions have tightened in the euro area calling for a rise in interest rates to prevent the build-up of inflationary pressures. The VIX accounts for the impact of perceived market volatility on the ECB credibility gap. Finally, the interest rates spread controls for the effect of a market risk premium on our dependent variable.

2.2 Linear model

We measure the inflation expectations process as the gap between the professional forecasters inflation expectations' and what the Central Bank should do based on its announced inflation objective. The ECB's inflation credibility is measured by the absolute value of the former gap.[1] Thus, we denote by π_{it}^{e} the inflation expectations of financial expert i for period t and π^{tar} the Central Bank's inflation rate target. As previously highlighted, the medium term inflation objective of the ECB is included in the range of 1.7% to 1.9%. We will take the median of this range as the inflation target of the ECB.[2] Thus, one can write the following model:

$$\pi_{it}^{e} - \pi^{tar} = c + \mu_i + \alpha\bar{\pi}_t + \beta m_{it}^{e} + \theta y_{it}^{e} + \phi p_{it}^{e} + \delta d_{crisis} + \varepsilon_{it} \tag{1}$$

where $\bar{\pi}_t$ is a 12-months weighted moving average of the past inflation gap with respect to the target whose construction is explained in section 3 which is devoted to the data description. m_{it}^{e}, y_{it}^{e} and p_{it}^{e} are respectively the 12-months fixed horizon expectations of the growth rate of the monetary aggregate M3, the growth rate of real GDP and the industrial producers' price inflation for forecaster i and period t. To capture the effect of the recent financial turmoil on the inflation expectations and the credibility gaps we specify a dummy variable d_{crisis} taking the value 1 from September 2007, one month after the crisis first erupted, to the end of our sample. In a second specification, to capture the effect of the peak of the financial burst, triggered by the collapse of Lehman Brothers, the dummy variable takes the value 1 for October 2008 and 0 otherwise. Finally, μ_i is the individual fixed effect for each forecaster and ε_{it} is the remaining error term assumed to be $i.i.d(0, \sigma_{\varepsilon}^{2})$. Given that we use variables in a real-time data setting, all regressors are exogenous. As regards the moving average of inflation, it is a predetermined variable since we compute it with twelve monthly lags.

2.3 Panel Smooth Transition Regression model

2.3.1 The model

In this section we briefly present the two-regimes Panel Smooth Transition Regression (PSTR) approach, a non-dynamic panel model with individual fixed effects, developed by González, Teräsvirta and van Dijk (2005). The PSTR model for the credibility gap is defined as follows:

$$\begin{aligned} \pi_{it}^{e} - \pi^{tar} &= \mu_i + [\alpha_0\bar{\pi}_t + \beta_0 m_{it}^{e} + \theta_0 y_{it}^{e} + \phi_0 p_{it}^{e}] + \\ &\quad [\alpha_1\bar{\pi}_t + \beta_1 m_{it}^{e} + \theta_1 y_{it}^{e} + \phi_1 p_{it}^{e}] g(q_t; \gamma, c) + \varepsilon_{it} \end{aligned} \tag{2}$$

[1] Given that the inflation target is constant, modeling the inflation expectations is equivalent to considering the gap. To be consistent with the measure for the credibility gap we, however, consider the inflation expectations gap.

[2] This quantitative measure is consistent with the approach of Smets (2009).

The transition function $g(q_t; \gamma, c)$ is bounded between 0 and 1 and is a continuous function of the observable variable q_t. We follow González, Teräsvirta and van Dijk (2005) (see the references cited therein) and specify the transition function as a logistic distribution. Its cumulative distribution function is given by the following formula.

$$g(q_t; \gamma, c) = \frac{1}{1 + e^{-\gamma(q_t - c)}}, \qquad \gamma > 0 \tag{3}$$

The transition function controls for the switch from one regime to the other. The arguments of this function require further clarification. The coefficient c is a location parameter. When the transition variable q_t is equal to c, the transition function is equal to 1/2 and determines the average point of the parameter switch from regime 1 to regime 2, which is symmetric around c as q_t increases. Thus, c can be considered as the threshold value between the two regimes. The parameter γ is responsible for the smoothness of the transition from one regime to the other. Determined upon its value, two interesting cases can be easily distinguished. When the scale parameter γ tends to zero, the transition function (3) becomes constant leading to the standard linear panel model with individual fixed effects. When γ tends to infinity, the transition function tends to zero if $q_t < c$ and to one if $q_t > c$. In such a case $g(q_t; \gamma, c)$ tends to the indicator function $\mathbb{1}_{(q_t \geq c)}$ and the change from the first to the second regime becomes instantaneous. Consequently, for considerably large values of the smoothing parameter γ the model contains a single structural break. Hence, the PSTR model converges to the Panel Threshold Regression (PTR) model of Hansen (1999) where the observations are split in two regimes depending on whether the observable variable q_t is lower or higher than the threshold. The latter have to be estimated jointly with the other parameters of the model.

The PSTR specification admits two different interpretations. On the one hand, it can be considered as a switching regime model that allows for two extreme regimes[3] associated with the extreme values of the transition function, respectively $g(q_t; \gamma, c) = 0$ and $g(q_t; \gamma, c) = 1$. The transition from one regime to the other is smooth, the degree of smoothness being defined by the slope parameter γ. On the other hand, the PSTR model allows for a "continuum" of regimes (or an infinite number of intermediate regimes), each one being characterized by a different value of the transition function $g(q_t; \gamma, c)$ between 0 and 1. A particular feature of the PSTR approach is that the coefficients associated with the explanatory variables are not directly interpretable. Solely their sign has a direct interpretation. With the PSTR specification we are able to compute the marginal impact of a given variable at each date and for each forecaster.

The PSTR model has several advantages. First, it is a simple parametric approach to introduce nonlinearity in the model specification.

Second, the transition mechanism allows for individual heterogeneity and time variability in the relation of the dependent variable with respect to a given explanatory variable. Fok, van Dijk and Franses (2005) argue that the threshold models are between a fully pooled model and a fully heterogeneous model. In this study, we do not exploit the individual heterogeneity dimension since the transition variables we use are not individual dependent. In a general panel framework, it might be restrictive to allow for a regime change solely in the time dimension. In our model, this should not be the case for three reasons. First, the aim of this paper is to study whether the driving factors of trust in the ECB have a differentiated impact during the recent financial downturn compared to the period before the crisis. Given the global feature of the latter, the switching from the

[3]The smooth transition regression models, whether in a time series or in a panel framework, can be extended to allow for more than two extreme regimes and more than one location parameter for each transition function. The discussion of such models is beyond the scope of this paper. For an extensive treatment of smooth transition models we refer the reader to van Dijk, Teräsvirta and Franses (2002), González, Teräsvirta and van Dijk (2005), Fok, van Dijk and Franses (2005) and references cited therein.

normal to the crisis regime should be driven by changes in the real economy and in the monetary policy strategy. Thereof, the timing of the switch should be the same for all professional forecasters reporting in the data set. Second, if the forecasters are rational, they should correctly incorporate the information publicly available, leading to the convergence of their expectations about economic fundamentals. Third, an individual fixed effect is included to account for any heterogeneity among the forecasters.

Finally, the marginal effect of a given explanatory variable, for instance the moving average of the inflation gap ($\bar{\pi}_t$) on the inflation expectations gap is not constant over time likewise in linear models. Referring to equation (2), such an effect is equal to α_0 if the transition function tends to 0 and it corresponds to $\alpha_0 + \alpha_1$ if the transition function tends to 1, the change being centered around c as previously emphasized. Between these two extreme cases the marginal effect is defined as a weighted average of α_0 and α_1.

$$e_t^{\bar{\pi}} = \frac{\partial(\pi_{it}^e - \pi^{tar})}{\partial \bar{\pi}_t} = \alpha_0 + \alpha_1 g(q_t; \gamma, c) \tag{4}$$

With $0 \leq g(q_t; \gamma, c) \leq 1$ and assuming an increasing transition variable, the marginal effect is decreasing in time if $\alpha_1 < 0$, so that $\alpha_0 + \alpha_1 \leq e_t^{\bar{\pi}} \leq \alpha_0$ and increasing if $\alpha_1 > 0$, so that $\alpha_0 \leq e_t^{\bar{\pi}} \leq \alpha_0 + \alpha_1$.

The major difficulty of the PSTR specification lies in the choice of the transition variable because it is not subject to any restrictions by the model. Among a possible set of candidate transition variables, one should use economic intuition or statistical tools to choose the one that best fits the model. As a statistical criteria one could use the minimization of the residual sum of squares or the rejection of the linearity test which is presented below, as suggested by Teräsvirta (1994), van Dijk, Teräsvirta and Franses (2002) and González, Teräsvirta and van Dijk (2005). Colletaz and Hurlin (2006) choose the transition variable that gives rise to the strongest rejection of linearity. Fok, van Dijk and Franses (2005) circumvent this issue by making use of economic intuition to choose the transition variable. Frequently, the latter variable is exogenous or endogenous lagged to avoid any simultaneity problems (van Dijk, Teräsvirta and Franses (2002)).

2.3.2 Estimation method and hypothesis testing

To estimate the coefficients of the PSTR model as well as the parameters of the logistic function, Hansen (1999), González, Teräsvirta and van Dijk (2005) make use of the Nonlinear Least Squares (NLS) method. We briefly describe the estimation procedure. Let us write equation (2) as follows.

$$\pi_{it}^e - \pi^{tar} = \mu_i + \Psi_0' x_{it} + \Psi_1' x_{it} g(q_t; \gamma, c) + \varepsilon_{it} \tag{5}$$

where $\Psi_j = (\alpha_j \; \beta_j \; \theta_j \; \phi_j)'$ for $j = 0, 1$ and $x_{it} = (\bar{\pi}_t \; m_{it}^e \; y_{it}^e \; p_{it}^e)'$.

As in the standard linear panel model, the fixed effects are eliminated from (5) by subtracting the individual means. Performing this transformation yields the following model.

$$\tilde{\pi}_{it}^e = \Psi' \tilde{x}_{it}(\gamma, c) + \tilde{\varepsilon}_{it} \tag{6}$$

where $\Psi = (\Psi_0' \; \Psi_1')'$, $\tilde{\pi}_{it}^e = (\pi_{it}^e - \pi^{tar}) - (\bar{\pi}_i^e - \pi^{tar})$, $\tilde{x}_{it}(\gamma, c) = (x_{it}' - \bar{x}_i', \; x_{it}' g(q_t; \gamma, c) - \bar{\omega}_i'(\gamma, c))'$ and $\tilde{\varepsilon}_{it} = \varepsilon_{it} - \bar{\varepsilon}_i$ with $\bar{\pi}_i^e$, $\bar{x}_i$ and $\bar{\varepsilon}_i$ the individual means of respectively π_{it}^e, x_{it} and ε_{it}, and $\bar{\omega}_i(\gamma, c) = \frac{1}{T} \sum_{t=1}^{T} x_{it} g(q_t; \gamma, c)$. Notice that equation (6) remains a nonlinear function of γ and c through the level of $x_{it} g(q_t; \gamma, c)$ and through its mean which has to be computed at each iteration. In a first step of the estimation procedure, conditional upon the values of γ and c, the ordinary least squares estimator of the slope coefficients Ψ is obtained as follows:

$$\hat{\Psi}(\gamma, c) = \Big[\sum_{i=1}^{N}\sum_{t=1}^{T}\tilde{x}_{it}(\gamma, c)\tilde{x}_{it}(\gamma, c)'\Big]^{-1}\Big[\sum_{i=1}^{N}\sum_{t=1}^{T}\tilde{x}_{it}(\gamma, c)\tilde{\pi}_{it}^{e}\Big] \tag{7}$$

The residuals sum of squares of equation (6) concentrated with respect to Ψ is given by:

$$S(\gamma, c) = \sum_{i=1}^{N}\sum_{t=1}^{T}\big(\tilde{\pi}_{it}^{e} - \hat{\Psi}(\gamma, c)'\tilde{x}_{it}(\gamma, c)\big)^2 \tag{8}$$

In a second step, conditionally to $\hat{\Psi}(\gamma, c)$, the parameters γ and c are estimated numerically in order to minimize the concentrated residuals sum of squares $S(\gamma, c)$. The estimates of Ψ are given by (7) at each iteration of the nonlinear optimization procedure. Using a grid search method, initial values of γ and c are replaced in equation (7). The vector (γ, c) for which $S(\gamma, c)$ is minimized is then used as starting values for the second step of the algorithm.

In the specification of the model one should test whether the hypothesis of linearity holds against the PSTR alternative. Hansen (1999), González, Teräsvirta and van Dijk (2005) propose such a testing procedure. If the null hypothesis of linearity is not rejected, the conventional linear panel model with fixed affects appears to be appropriate. The PSTR model (2) is reduced to a linear model if $H_0 : \gamma = 0$ as previously mentioned, or $H_0' : \alpha_1 = \beta_1 = \theta_1 = \phi_1 = 0$. In either of the null hypotheses, the location parameter c is not identified. Under H_0 the coefficients $\alpha_1, \beta_1, \theta_1$ and ϕ_1 remain also unidentified, while under H_0' the parameter γ can take any value. In the econometric literature this issue is known as the unidentified nuisance parameter problem. For further details see Davies (1977; 1987) who first considered this issue in the time series context, Andrews and Ploberger (1994) and Hansen (1996). In the presence of unidentifed nuisance parameters the standard asymptotic inference for the linearity tests is invalid. González, Teräsvirta and van Dijk (2005) follow Luukkonen, Saikkonen and Teräsvirta (1988) and sidestep the problem by a first order Taylor series approximation around $\gamma = 0$ and obtain the following auxiliary regression whose derivation is presented in the appendix.

$$\pi_{it}^{e} - \pi^{tar} = \mu_i + \Psi_0^{*\prime}x_{it} + \Psi_1^{*\prime}x_{it}q_t + \varepsilon_{it}^{*} \tag{9}$$

The null hypothesis becomes $H_0 : \gamma = 0$ or equivalently $H_0^* : \Psi_1^* = 0$ (Ψ_1^* is a multiple of γ). To test the homogeneity hypothesis, one can use an LM-type test statistic asymptotically distributed as $\chi^2(K)$ with K the number of regressors (here K=4). The F version of the latter can be carried out with an approximate $F(K, TN - N - 2K)$ distribution. Teräsvirta (1994) argues that such a test may often be more powerful in small samples. In the same way, Lundbergh, Teräsvirta and van Dijk (2003) write that the χ^2-test may be oversized in small samples whereas the size of the F-test is close to the nominal one even in small samples and it has reasonable power. Colletaz and Hurlin (2006) propose an additional test, a pseudo-LRT statistic asymptotically distributed as $\chi^2(K)$. If the null hypothesis of linearity is rejected in favor of the PSTR model, in a second step one should test for no remaining nonlinearity. In other words one should test the null hypothesis of a PSTR model with two extreme regimes (the number of transition functions r is equal to 1) against the alternative of a PSTR model with three extreme regimes ($r = 2$). The testing procedure should be applied until the null hypothesis is not rejected for the first time, as explained in the appendix.

3 Data

We use a disaggregated monthly survey from Consensus Economics Forecasts (CEF) of professionals such as research and financial institutions. They can be divided in two broad categories: banks and insurances on the one hand, and research institutes on the other hand.[4] Table A.2 gives an overview of the professional forecasters who report in our database. The period covered is from December 2002 to May 2010. The data are collected during the first week of each month and are released at the beginning of the second week of the respective month. Professionals are asked to report their expectations for several economic indicators such as inflation, real GDP and money supply growth rates for two horizons: the current year and the year ahead. Given the long and variable lags in the transmission of monetary policy, the year ahead forecasts should be more relevant for actual policy making. Poplawski-Ribeiro and Rülke (2010) use the same survey to analyze the impact of the Stability and Growth Pact on financial market's expectations of government budget deficits. They emphasize a higher accuracy and a smaller bias of these data compared to OECD's and IMF's forecasts. The fact that the identity of each professional forecaster is reported should ensure a high quality of the forecasts given their potential reputational effect.

The forecasts for the end of the current year have a horizon ranging from 12 months to 1 month. For the year ahead forecasts the horizon spans a period from 24 to 13 months. To obtain 12-months fixed horizon forecasts of inflation, money growth, real economic growth and industrial producers' price inflation we compute a weighted average ($\bar{x}_{i,r,h}$) of the current year and the year ahead forecasts using the following formula:

$$\bar{x}_{i,r,h} = \frac{13-h}{12} x_{i,r,h} + \frac{h-1}{12} x_{i,r+1,h}$$

where $x_{i,r,h}$ is any of the current year (r) forecasts of the aforementioned variables reported for month h and $x_{i,r+1,h}$ stands for the year ahead ($r+1$) variable forecasts for the same month. The indices r and h take respectively the values $r = 2002, \ldots, 2010$ and $h = 1, \ldots, 12$. The advantage of this approach is that we obtain a fixed horizon of twelve months in the regressions. However, by applying this formula we cannot assign a specific forecast horizon to the generated variables since they encompass any period between the current year and the year ahead.

As an additional data source we use the ECB's Real Time Database from which we obtain the Harmonized Index of Consumer Prices (HICP). We compute inflation as the annualized percentage change of the HICP. As mentioned earlier, the credibility gap of the ECB should crucially depend on the inflation history. For this purpose, following the approach of Geraats (2008), we construct a 12-months average of the difference between the past inflation rate and the inflation target which is weighted by a memory persistence coefficient ρ we set equal to 11/12. Indeed, the memory persistence coefficient indicates the fact that agents put more weight on information that is closer to the present and hence the relevance of information for policy evaluation is declining over time.[5] We denote the 12-months moving average of the realized inflation gap with respect to the inflation target by $\bar{\pi}_{r,h} \equiv \bar{\pi}_t$ (for t=2002m12,...,2010m5). This measure is calculated with the following formula for the first month of each year r.

$$\bar{\pi}_{r,1} = \frac{1}{12} \sum_{i=0}^{11} \rho^{12-i} (\pi_{r-1,1+i} - \pi^{tar})$$

[4] One of the forecasters, SEB, being an industrial corporation cannot not be classified in either of the above categories.

[5] The value of the memory persistence coefficient accounts for the data frequency in order to obtain a duration of the inflation process of twelve months.

Notice that $\bar{\pi}_{r,1}$ is an average of the inflation gap for the twelve months of the previous year $(r-1)$. For $2 \leq h \leq 12$ the moving average is calculated with observations coming from the years $r-1$ and r.

$$\bar{\pi}_{r,h} = \frac{1}{12}\Big[\sum_{i=0}^{12-h} \rho^{12-i}(\pi_{r-1,h+i} - \pi^{tar}) + \sum_{j=1}^{h-1} \rho^{h-j}(\pi_{r,j} - \pi^{tar})\Big]$$

The first summation term adds up the gaps between the realized inflation $(\pi_{r-1,h+i})$ and the inflation target (π^{tar}) for year $r-1$, for the months ranging from h to December. In the second term the sum of the inflation gaps is calculated for year r and for the months from January to $h-1$. The overall result is divided by 12 in order to get a yearly moving average.

We use successively three threshold variables to capture the transition from the normal to the crisis regime: (i) the ratio of the longer-term refinancing operations of the ECB over the value of total assets (ii) the ratio of the euro area residents' securities with respect to the value of the total assets held by the ECB (iii) a linear time trend. The two former variables are retrieved from the consolidated weekly financial statements of the Eurosystem published, as a general rule on Tuesdays, and relate to the information available on the preceding Friday. Given the monthly frequency of our data we take the values of the last week of each month. Some summary statistics of the inflation forecasts, the main driving factors of the dependent variable, as well as of the threshold variables are presented in the appendix in table A.3.

4 Empirical evidence

4.1 Nonlinear model results for the inflation expectations

The nonlinear estimations are performed within a Panel Smooth Transition Regression (PSTR) model as explained in section 2.3.[6] This methodology permits to account for a differentiated impact of the driving factors of the inflation expectations. Indeed, we expect that during the recent financial crisis the impact of the core variables on the inflation forecasts has changed given the magnitude of the crisis and the unconventional monetary policy measures the ECB has implemented in order to secure the stability of the euro area financial system.

In the PSTR model we have to define a transition variable that drives the change between the policy regimes. In light of the ECB reaction to the crisis we use two main transition variables: the Longer-Term Refinancing Operations (LTRO) and the Securities of euro area residents held by the ECB in the total assets of the Central Bank. Indeed, since the onset of the financial turmoil in August 2007 the ECB has intervened on the interbank lending market implementing longer-term refinancing operations to restore the orderly functioning of the interbank market. Since the tipping point of the crisis that has occurred with the bankruptcy of Lehman Brothers in September 2008, the ECB has broadened the set of unconventional policy measures and has started buying securities as part of the qualitative easing operations aimed at reducing the yield spreads on some market segments. Given the relevance of these measures, we have included the ratio of LTRO to the total assets of the ECB as a driving variable of the transition from a normal (pre-crisis) to a crisis regime in the PSTR model occurring in September 2007.[7]

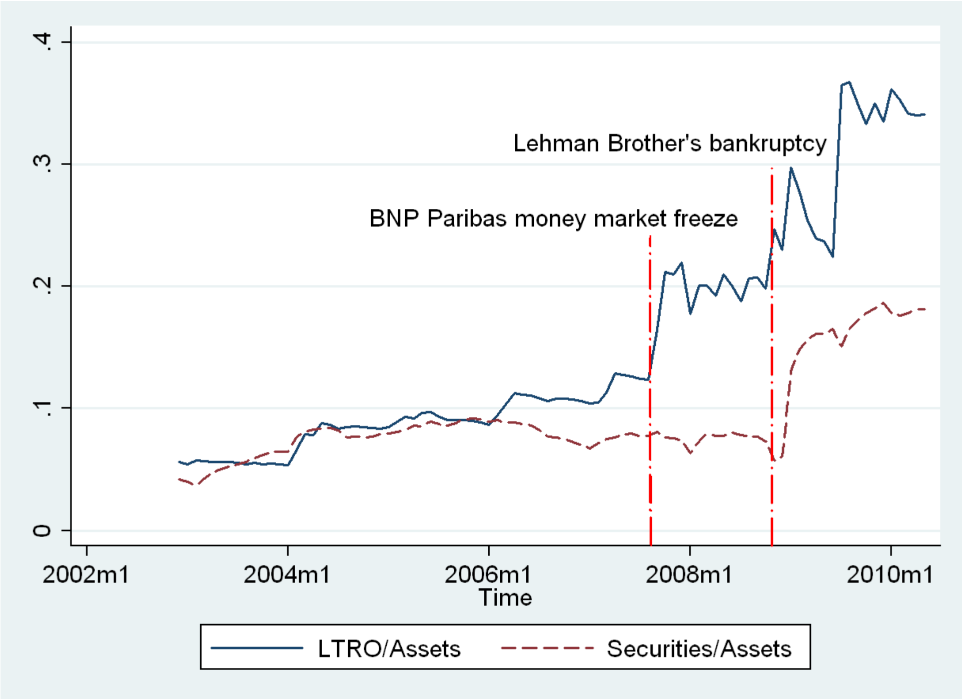
In addition, we use the ratio of the securities in the total assets of the ECB as a second transition variable to account for the peak of the financial turmoil occurring in October

[6] All estimations are performed in Matlab R2009b using the algorithm developed by Christophe Hurlin.

[7] By assumption we are in the normal regime if $g(q_t, \gamma, c) < 0.5$ and in the crisis regime if $g(q_t, \gamma, c) > 0.5$.

2008. The relevance of the two unconventional measures for the determinants of inflation expectations and the ECB's credibility during the crisis can be seen on figure 2. Finally, we have also included a linear time trend ($q_t = t$) as a transition variable in the PSTR model. The latter gives rise to a specification with parameters changing smoothly. Lin and Teräsvirta (1994) argue that when considering a linear time trend as a transition variable we have a suitable way for testing parameter constancy. The estimation results are reported in table 1.

Figure 2: Transition variables



Notes: Time series of the threshold variables, (i) ratio of the longer-term refinancing operations to the total assets (LTRO/Assets) (ii) the value of the securities of euro area residents over the total assets (Securities/Assets) held by the ECB.

Models 1, 2 and 3 of table 1 display the results when using the ratio of LTRO, Securities in the total assets of the ECB and time respectively as threshold variables. The logistic function of each of the three models is displayed in figure 3. In Model 1, the estimated parameter γ is equal to 1930.7 and indicates a sharp structural break occurring at the onset of the crisis in September 2007. The logistic distribution takes the value of 0 until August 2007, it is equal to 0.269 in September 2007 and then immediately jumps to 1 from October 2007 until May 2010. Hence, the transition from the normal to the crisis regime takes roughly 2 months. Figure 4 reports the value of the transition function within the support of LTRO and Securities in the ECB's balance sheet. Concerning LTRO, one can see that the regime switch occurs at the value of 16.47% whereas for the Securities variable the transition takes place at the value of 9.02%. These thresholds correspond to the estimated location parameters c.

The estimated marginal effects are displayed in figure 5. The figure reveals that when switching from the normal to the crisis regime the impact of the moving average of inflation and of the GDP growth rate forecasts on the inflation expectations has been substantially dampened. Furthermore, in the crisis regime the M3 growth rate and the producers' price inflation forecasts have exerted a higher impact on the dependent variable compared to their effect in the normal regime. Indeed, since the Central Bank has started implementing nonstandard operations to increase the interbank market liquidity, the subsequent increase of the monetary aggregates has become a key driving factor of the longer-term inflation expectations in the euro area. Besides, given the substantial increase in the commodities' prices since Fall 2007, the producers' price inflation forecasts also play a crucial role in shaping the agents' inflation perceptions.

Table 1: PSTR model estimation with fixed effects for the inflation expectations

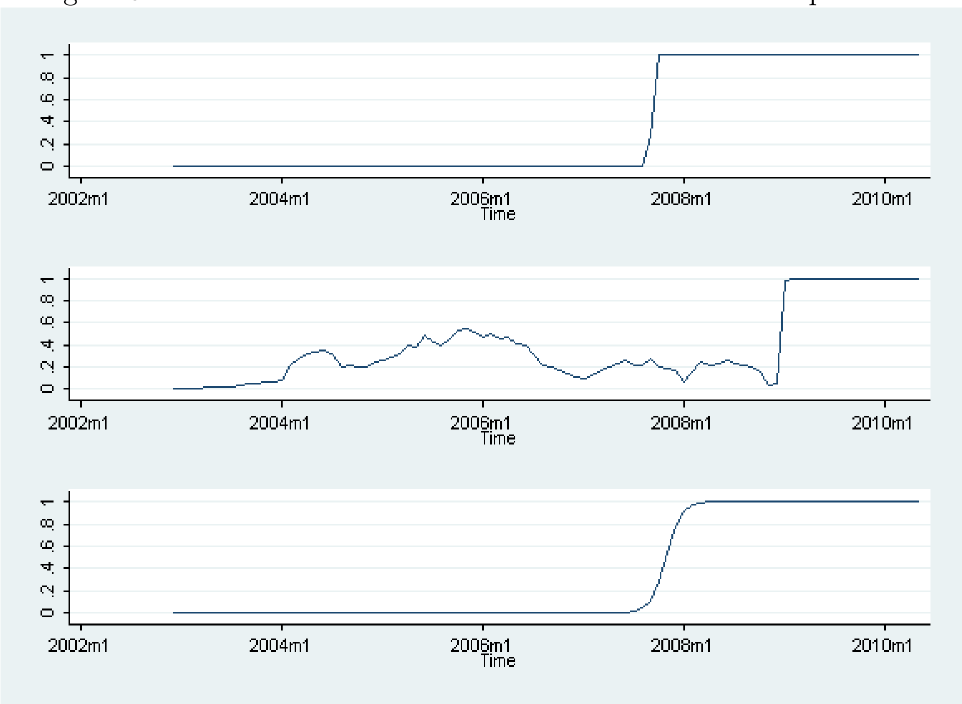
Transition variable		Model 1 LTRO/Assets	Model 2 Securities/Assets	Model 3 Time trend
M.A. inflation	α_0	0.8851***	1.2083***	0.9037***
		(9.3152)	(11.6570)	(10.0369)
	α_1	-0.3655***	-1.0317***	-0.3629***
		(-2.8386)	(-8.4634)	(-2.8433)
M3 growth forecasts	β_0	0.0112	0.0181*	0.0138*
		(1.6140)	(1.9163)	(1.9236)
	β_1	0.0311***	0.0436***	0.0427***
		(4.0280)	(3.7124)	(4.9054)
Real GDP growth forecasts	θ_0	0.2482***	0.3654***	0.2466***
		(12.9165)	(10.4125)	(12.9650)
	θ_1	-0.0123	-0.2729***	0.0373
		(-0.3206)	(-5.0430)	(0.8602)
Producers' price inflation forecasts	ϕ_0	0.0546***	0.1125***	0.0526***
		(5.9922)	(6.0950)	(5.9100)
	ϕ_1	0.0926***	0.0226	0.0616*
		(3.2197)	(0.5554)	(1.8482)
Location parameter	c	0.1647	0.0902	59.8506
Slope parameter	γ	$1'930.7$	100.00	1.1325
Observations		$1'088$	$1'088$	$1'088$
RSS		0.0038	0.0044	0.0036
AIC		-12.4661	-12.3316	-12.5155
BIC		-12.3193	-12.1848	-12.3687

Notes: In this table are reported the estimation results of the PSTR model using Nonlinear Least Squares (NLS). T-statistics with White-corrected errors for heteroskedasticity are reported in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the gap between the inflation expectations of 22 professional forecasters for the period from December 2002 to May 2010 and the ECB's inflation objective. The normal distribution quantiles for two-sided tests at 90%, 95%, 99% are respectively 1.645, 1.960, 2.576. In Model 1 the transition variable is the ratio of longer-term refinancing operations in the total assets of the ECB. In Model 2 the transition variable is the value of the securities of euro area residents over the total assets of the ECB. In Model 3, a linear time trend $t = 1, \ldots 90$ is used as a transition variable. The estimated location parameter corresponds to November 2007.
AIC $= \ln\big(RSS/(NT-n-1)\big) + 2(n/NT)$ and BIC $= \ln\big(RSS/(NT-n-1)\big) + (n/NT)\ln(NT)$ where RSS is the residual sum of squares, $NT = 1'088$ and n the number of estimated parameters ($n = 32$).

In the second model, the estimated parameter γ is equal to 100 and indicates a less pronounced transition between the two regimes occurring at the peak of the financial turmoil around October 2008. Indeed, before the financial downturn the transition function evolves at a value close to 0 and rarely exceeds 0.5. This function becomes greater than 0.5 from October to December 2005 and in February 2006. The model points out that the structural break has occurred by the end of 2008 and at the beginning of 2009. The transition function shown in figure 3 grows rapidly from almost 0 in November-December 2008 to reach nearly unity in January 2009 and remains at that level. The estimated marginal effects, as displayed in figure 6, corroborate the previous findings with the LTRO transition variable. Indeed, in the crisis regime the key driving factors of inflation expectations are the M3 growth rate and the producers' price inflation forecasts, while the inflation history and the GDP growth rate forecasts play a minor role.

In the last model, the estimated parameter γ is equal to 1.1325 and indicates a gradual transition between the two regimes occurring at the onset of the financial crisis around September 2007. The transition from the first regime to the second is smoother and takes several months. The value of the transition function is close to 0 in the period preceding the downturn and increases gradually from September 2007 to reach almost 1 in February-March 2008. The transition function exceeds 0.5 for the first time in November 2007. The estimated marginal effects, as indicated in figure 7, are broadly in line with the previous findings except for the GDP growth forecasts. Indeed, in the transition from the normal to the crisis regime the impact of the latter variable on the inflation expectations has been amplified. Finally, notice that the linear panel model estimations with fixed effects presented in subsection 4.3 can be considered roughly as an average of the estimated parameters in the two regimes.[8] However, in light of the above evidence, any inference made with the linear model could be misleading as one needs to take into account the change of regime in the determinants of the inflation forecasts.

Figure 3: Transition function versus time for the inflation expectations

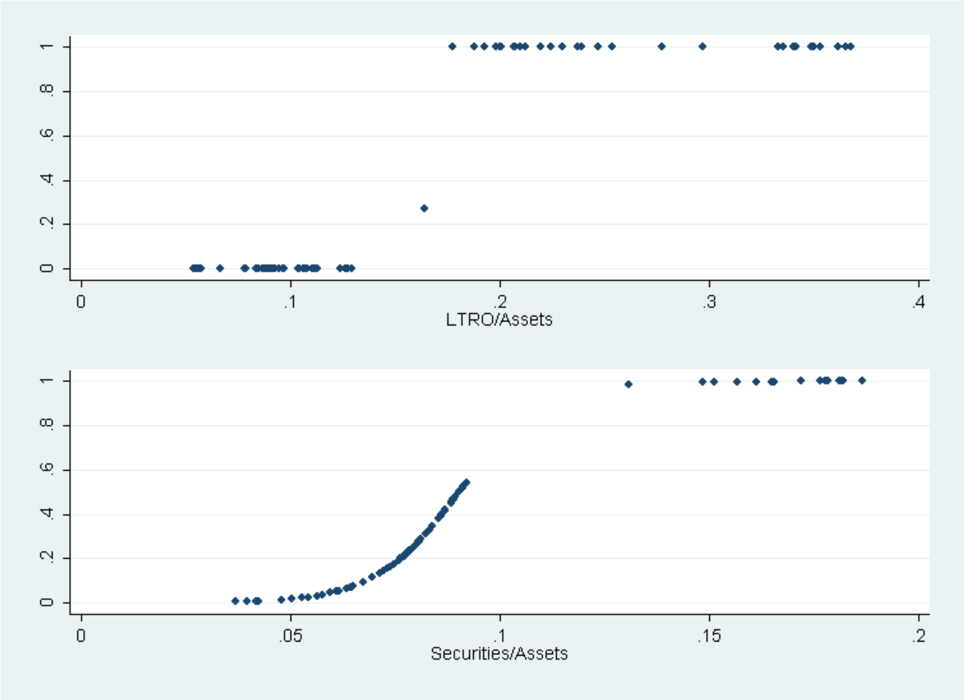


Notes: In this figure are reported, versus time, the value of the transition function evaluated at the transition variable LTRO/Assets (top), Securities/Assets (middle), Time (bottom). The corresponding $\hat{c}$ and $\hat{\gamma}$ are reported in table 1.

Tables A.4 and A.5 in the appendix report the tests of stationarity of the variables and of the residuals of the linear and PSTR models. In general, some of the variables are nonstationary but as all residuals are stationary the estimations remain consistent. However, we should note that the Pesaran's test statistic for panel data yields some strange results. Indeed, according to the value of the test the variables are all stationary but the

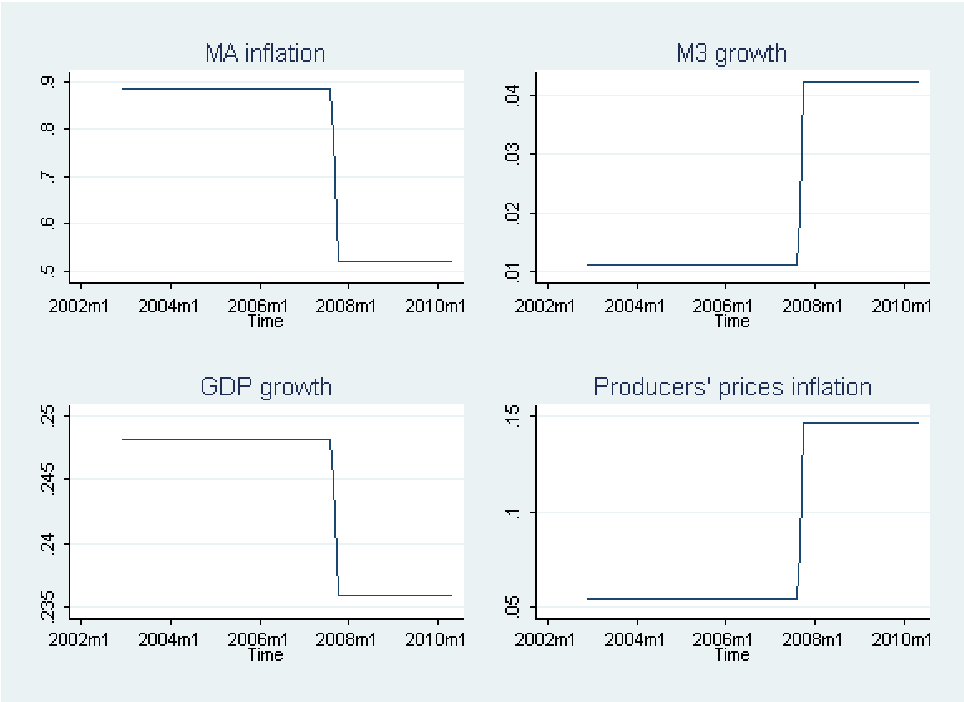
[8] One can compare the estimated parameters in the linear panel model with any value between the first estimated coefficient and the sum of the two estimated coefficients of the PSTR model.

Figure 4: Transition functions versus transition variables for the inflation expectations



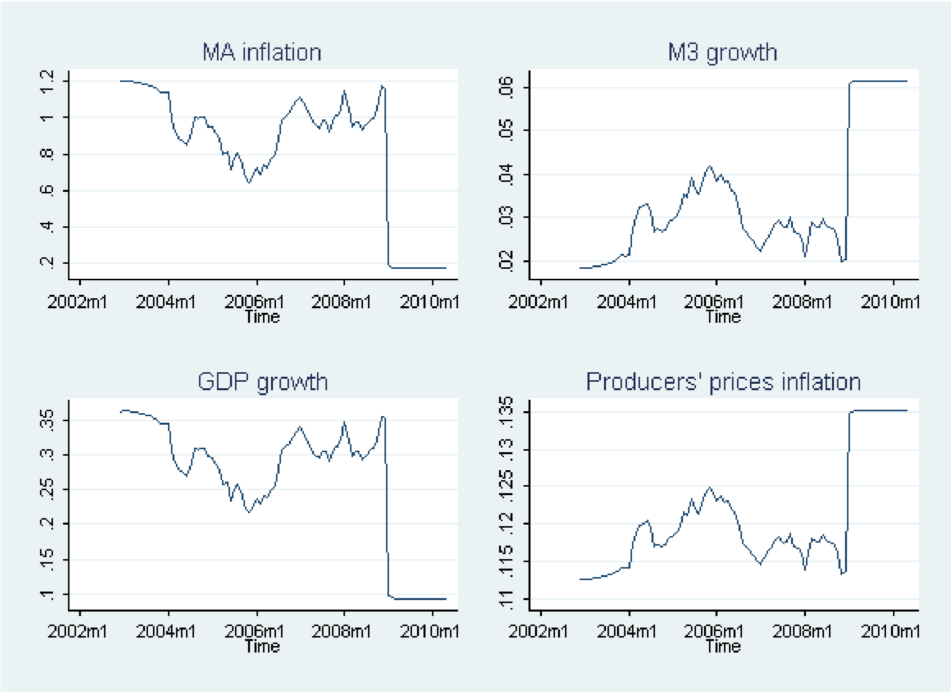
Notes: In this figure are reported the transition functions versus the transition variables: LTRO/Assets on the top and Securities/Assets at the bottom.

Figure 5: Marginal effects for the inflation expectations (LTRO/Assets)



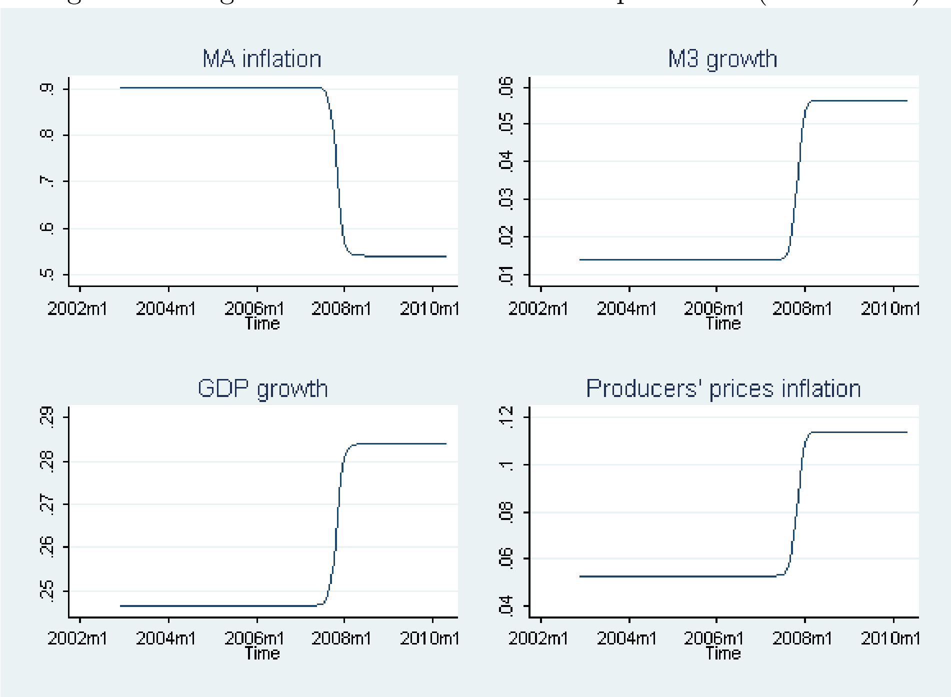
Notes: In this figure are reported the marginal effects of each explanatory variable on the inflation forecasts during the period under study. The transition variable is the ratio of the longer-term refinancing operations in the total assets of the ECB. The marginal effects are computed from the estimated parameters in table 1, Model 1.

Figure 6: Marginal effects for the inflation expectations (Securities/Assets)



Notes: In this figure are reported the marginal effects of each explanatory variable on the inflation forecasts during the period under study. The transition variable is the value of the securities of euro area residents over the total assets of the ECB. The marginal effects are computed from the estimated parameters in table 1, Model 2.

Figure 7: Marginal effects for the inflation expectations (Time trend)



Notes: In this figure are reported the marginal effects of each explanatory variable on the inflation forecasts during the period under study. The transition variable is a linear time trend $t = 1, ..., 90$. The marginal effects are computed from the estimated parameters in table 1, Model 3.

Table 2: Nonlinearity tests for the inflation expectations

PANEL A — Nonlinearity and no remaining nonlinearity tests

Test	Model 1 LM	Model 1 LMF	Model 1 LRT	Model 2 LM	Model 2 LMF	Model 2 LRT	Model 3 LM	Model 3 LMF	Model 3 LRT
$H_0 : r = 0$ vs $H_1 : r = 1$	171.67	49.74	186.83	145.32	40.93	155.98	166.70	48.04	180.95
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$H_0 : r = 1$ vs $H_1 : r = 2$	104.79	28.08	110.18	16.24	3.99	16.36	56.79	14.51	58.33
	(0.000)	(0.000)	(0.000)	(0.003)	(0.003)	(0.003)	(0.000)	(0.000)	(0.000)

PANEL B — Nonlinearity and no remaining nonlinearity tests when the threshold variable is included in the set of the explanatory variables

Test	Model 1 LM	Model 1 LMF	Model 1 LRT	Model 2 LM	Model 2 LMF	Model 2 LRT	Model 3 LM	Model 3 LMF	Model 3 LRT
$H_0 : r = 0$ vs $H_1 : r = 1$	130.28	28.87	138.77	243.97	61.34	276.25	101.72	21.89	106.80
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$H_0 : r = 1$ vs $H_1 : r = 2$	53.30	10.83	54.65	15.02	2.94	15.12	107.62	23.07	113.32
	(0.000)	(0.000)	(0.000)	(0.010)	(0.012)	(0.010)	(0.000)	(0.000)	(0.000)

Notes: In this table are reported the values of the test statistics testing the null hypothesis of linearity ($r = 0$) against the PSTR model ($r = 1$) with r the number of transition functions. If the linearity hypothesis is rejected, one should test the null hypothesis of no remaining nonlinearity ($H_0 : r = 1$) against the alternative of three regimes ($r = 2$). The LM-type test is given by $LM = TN\frac{RSS_0 - RSS_1}{RSS_0}$ and follows a χ^2_K. The F-test statistic is given by $LM_F = \frac{(RSS_0 - RSS_1)/K}{RSS_1/(NT-N-(r+1)K)}$ and follows $(F_{K,TN-N-(r+1)K})$. LRT is a pseudo-likelihood ratio test given by $LRT = NT[\ln(RSS_0) - \ln(RSS_1)]$ and follows also a χ^2_K (see Colletaz and Hurlin (2006)). RSS_0 and RSS_1 represent respectively the residual sum of squares of the linear panel model with fixed effects and the residual sum of squares of the auxiliary regression A.5 when we are testing for linearity. When we test for no remaining nonlinearity RSS_0 and RSS_1 are the residual sum of squares for the PSTR and the auxiliary regression A.7 (see the appendix). The p-values are reported in parentheses.
In panel A the tests are performed for the core model with four explanatory variables ($K = 4$) and with individual fixed effects. If the transition variable has an explanatory power on the dependent variable, the null hypothesis of linearity may be wrongly rejected. To account for such an event the transition variable is involved in the set of regressors ($K = 5$) in the three model specifications. The results of the tests are displayed in panel B.

residuals of both the linear and nonlinear models are nonstationary when using three lags of the differenced variables. This result seems rather implausible and stands in sharp contrast with the findings from the other tests. The LTRO/Assets and the Securities/Assets seem to be nonstationary in light of the standard time series unit root tests. However, table A.6 shows that the series are stationary once we account for a break in the deterministic trend of the variables as pointed out in Perron (1989) and Kim and Perron (2009). The latter have highlighted that the standard unit root tests do not reject the null hypothesis of unit root even in the case when it is false. Moreover, Perron (1989) has emphasized the following: "*Our conclusion is that most macroeconomic time series are not characterized by the presence of a unit root and that fluctuations are indeed transitory.*" Besides, the estimated break dates are in line with the timing of the transitions between the regimes found with the PSTR models.

In order to corroborate the earlier evidence for the two regimes we have performed some tests of nonlinearity as reported in table 2, panel A. The results of the tests clearly reject the null hypothesis of linearity. Therefore, estimating a PSTR model with two regimes seems to be fully appropriate from a statistical point of view and is justified also from an economic perspective as previously explained. Moreover, the null of no remaining nonlinearity seems to be rejected as well which would suggest the presence of at least three distinct regimes. However, from an economic point of view considering such a short time span (around 8 years) does not seem to justify the occurrence of more than two distinct regimes. In addition, from a statistical approach the tests of no remaining nonlinearity use estimates of c and γ, as well as a first order Taylor series approximation to deal with the problem of nuisance parameters. This approach may lead to oversized test statistics and thus to non reliable values.[9] Hence, in view of the previous arguments we can corroborate the presence of two distinct regimes in the inflation expectations building-up process.

We follow Fouquau, Hurlin and Rabaud (2008) approach and include the transition variable in the set of the explanatory variables in order to test the robustness of the linearity test. The results of the tests are reported in table 2, panel B. If the transition variable has a direct impact on the inflation expectations, the null hypothesis of linearity could be wrongly rejected. The results of the tests show that the null hypothesis of linearity is strongly rejected for the three model specifications. For Models 1 and 3, the values of the tests are higher when the transition variable is not included in the regressors, while for Model 2 the evidence points to the opposite finding. Nevertheless, in the three models the values of the tests are considerably above their critical values at any significance level, thus yielding a strong evidence against linearity. In the following subsection we have estimated the model for the determinants of the ECB's credibility gap.

4.2 Nonlinear model results for the credibility gap

Table 3 presents the estimation results for the model in which all variables are included in absolute value. As pointed out previously, this specification is used to study the determinants of the credibility gap in the ECB. The coefficient estimates of Model 1 suggest that in the transition from the first to the second regime past inflation has exerted a smaller impact on the dependent variable, while the effects of the M3 growth, real GDP growth and the producers' price inflation forecasts have been magnified. However, notice that the latter effect is not significant. Therefore, it turns out that in the crisis regime the credibility of the Central Bank is less affected by the inflation history and depends more importantly on the forecasts of the economic outlook and on the expected increase in the money supply. The estimated location parameter ($\hat{c}$) identifies the transition from the normal to the crisis regime since the onset of the financial turmoil in August 2007. The LTRO/Assets of the Central Bank takes the value of 17.43% at the threshold. A comparison of the estimated slope parameters ($\hat{\gamma}$) with the model for the inflation expectations process (table 1, Model 1) shows that the switch between regimes is much smoother than previously found.

The results of the second model corroborate the evidence for Model 1 except for the producers' price inflation forecasts whose effect on the credibility gap has been reduced in the transition from the first to the second regime. Also, the coefficient estimates of past inflation are not significant. The estimated location parameter indicates that the switch from the normal to the crisis regime occurs after the peak of the financial downturn in October 2008, at the threshold level of 8.90% for the Securities/Assets of the ECB. Interestingly, the slope parameter estimate points out that the transition between regimes is particularly gradual.

Model 3 contains the time trend as a transition variable and is performed mainly as a sensitivity analysis for the previous findings. It shows that the results are qualitatively identical to those obtained for the first and second models. In addition, the transition to the crisis regime starts in October 2007, reaches the threshold value of 0.5 of the

[9] González, Teräsvrita and van Dijk (2005), pages 14-15, write that the no remaining nonlinearity test "[...] may quite likely indicate the presence of (additional) heterogeneity because of the presence of heteroskedasticity. This suggests caution when applying the test for determining the number of transitions in the multiple PSTR model."

logistic distribution in January 2008 and is completed in October 2008. This very gradual switch between the regimes is reflected in the small value of the smoothness parameter. These results are overall consistent with the timing of the switch for the model where the LTRO/Assets is a transition variable. In general, figure 8 for the logistic distribution shows that the estimated regimes and the timing of the transitions are robust to considering the variables in absolute value in comparison to figure 3. Figure 9 reports the value of the transition function with respect to the transition variable. The graphs corroborate the previous results that the transition from the first to the second regime occurs at the threshold levels of 17.43% and 8.90% for the LTRO/Assets and the Securities/Assets respectively.

Table 3: PSTR model estimation with fixed effects for the credibility gap

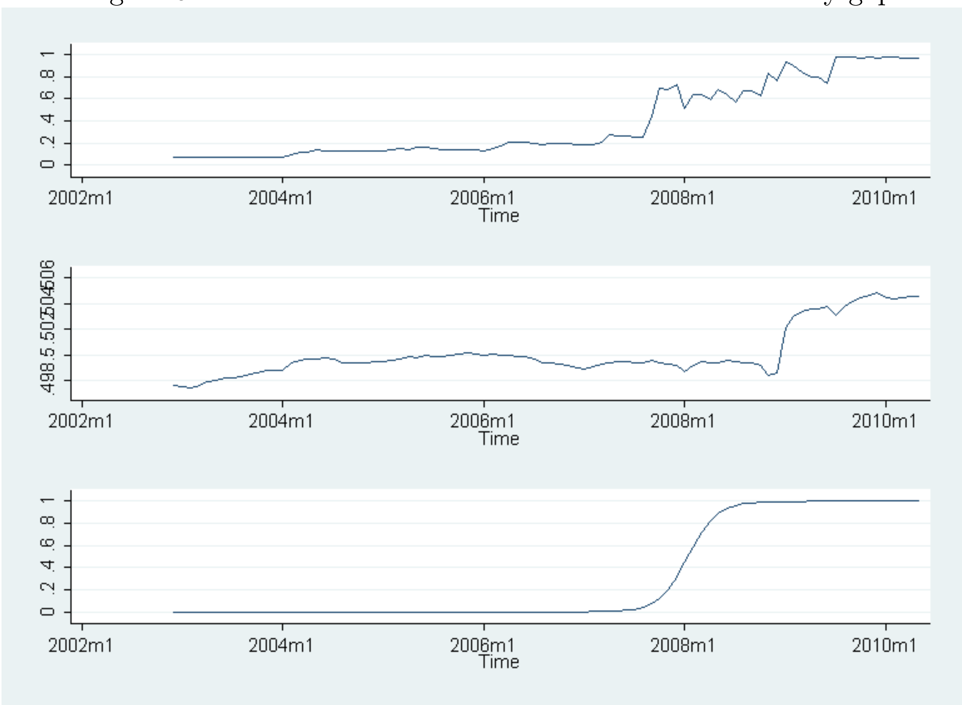
Transition variable		Model 1 LTRO/Assets	Model 2 Securities/Assets	Model 3 Time trend
M.A. inflation	α_0	1.4058***	14.2297	0.5092***
		(10.8380)	(1.2727)	(5.5125)
	α_1	-1.2189***	-27.0849	-0.4997***
		(-8.4852)	(-1.2140)	(-5.5762)
M3 growth forecasts	β_0	-0.0410***	-3.4741**	-0.0166***
		(-4.5107)	(-2.1295)	(-2.6763)
	β_1	0.0741***	7.0287**	0.0884***
		(3.9847)	(2.1535)	(7.0811)
Real GDP growth forecasts	θ_0	-0.0322	-33.0221***	0.0315*
		(-1.4638)	(-7.1113)	(1.6812)
	θ_1	0.3378***	66.1436***	0.2305***
		(7.3108)	(7.1289)	(8.4297)
Producers' price inflation forecasts	ϕ_0	-0.0066	14.9868***	0.0278***
		(-0.5780)	(3.2634)	(3.1320)
	ϕ_1	0.0168	-29.9468***	-0.0072
		(0.5544)	(-3.2616)	(-0.3767)
Location parameter	c	0.1743	0.0890	62.3766
Slope parameter	γ	21.4937	0.2000	0.5823
Observations		$1'088$	$1'088$	$1'088$
RSS		0.0040	0.0051	0.0030
AIC		-12.4258	-12.1829	-10.4109
BIC		-12.2790	-12.0361	-12.5667

Notes: In this table are reported the estimation results of the PSTR model using Nonlinear Least Squares (NLS). T-statistics with White-corrected errors for heteroskedasticity are reported in parentheses, *** p<0.01, ** p<0.05, * p<0.1. All variables are in absolute values. The dependent variable is the absolute value of the gap between the inflation expectations of 22 professional forecasters for the period from December 2002 to May 2010 and the ECB's inflation objective. The normal distribution quantiles for two-sided tests at 90%, 95%, 99% are respectively 1.645, 1.960, 2.576. In Model 1 the transition variable is the ratio of longer-term refinancing operations in the total assets of the ECB. In Model 2 the transition variable is the value of the securities of euro area residents over the total assets of the ECB. In Model 3, a linear time trend $t = 1, \ldots 90$ is used as a transition variable. The estimated location parameter corresponds to January 2008.

AIC $= \ln\big(RSS/(NT-n-1)\big) + 2(n/NT)$ and BIC $= \ln\big(RSS/(NT-n-1)\big) + (n/NT)\ln(NT)$ where RSS is the residual sum of squares, $NT = 1'088$ and n the number of estimated parameters ($n = 32$).

The marginal effects of Model 1 are displayed in figure 10. The graphs show that the marginal effects of the explanatory variables on the credibility gap are qualitatively similar to the model in which the variables are included in level except for the GDP growth forecasts whose effect is now increasing possibly due to the magnitude of the economic slump. Figure 11 for Model 2 indicates that the marginal effects of past inflation and the M3 growth forecasts are in line with the earlier findings displayed in figure 6 for the model in level. However, the GDP growth forecasts exert a higher impact in the crisis regime while the effect of the producers' prices inflation forecasts is dampened in the transition from the first to the second regime. The marginal effects of the model with a time trend as a transition variable are shown in figure 12. In general, the results are robust to Model 3 presented in figure 7 except for the producers' price inflation forecasts whose effect has been weakened in the crisis regime.

Figure 8: Transition function versus time for the credibility gap

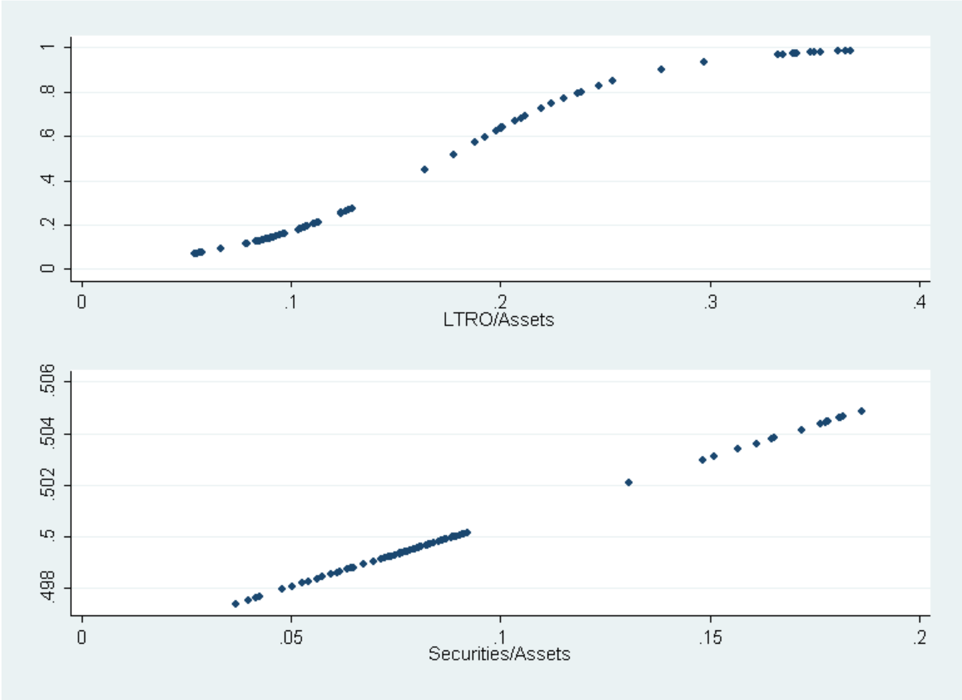


Notes: In this figure are reported, versus time, the value of the transition function evaluated at the transition variable LTRO/Assets (top), Securities/Assets (middle), Time (bottom). The corresponding $\hat{c}$ and $\hat{\gamma}$ are reported in table 3.

Overall, the nonlinear estimation results have shown that the determinants of the credibility gap in the ECB have been altered since the onset and after the broadening of the financial turmoil. In particular, it seems that past inflation has played a minor role in shaping the credibility of the European monetary institution in the period of financial turbulence. Besides, in light of the quantitative easing operations implemented by the Central Bank since the start of the crisis the effect of the M3 growth forecasts has been amplified in the transition to the second regime. The impact of the GDP growth forecasts on the credibility gap has increased during the financial slump while the effect of the producers' price inflation forecast on the dependent variable changes along with the transition variable used in the PSTR model estimations. Therefore, the M3 and GDP growth forecasts have become main driving factors of the ECB's inflation credibility in the crisis period relative to the pre-crisis regime.

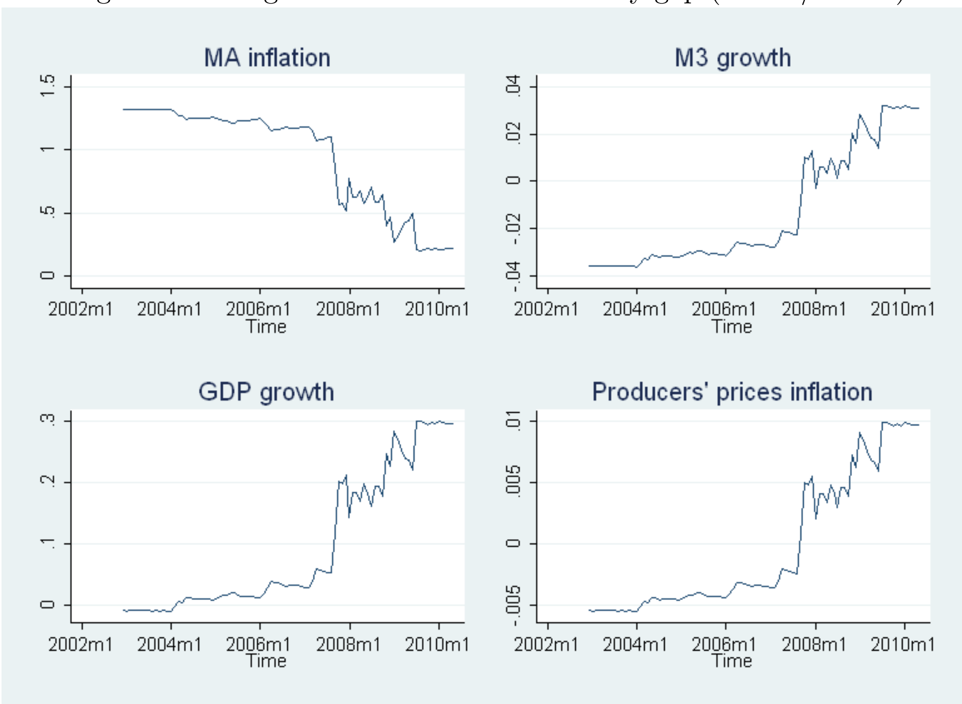
Panel A of table 4 presents the nonlinearity tests for the models with the variables in absolute value. The LM, LMF and LRT test statistics show strong evidence against the null hypothesis of linearity which is in line with the results from table 2. Unfortunately, we do not reject the null hypothesis of two regimes against the alternative of a three-regime

Figure 9: Transition function versus transition variables for the credibility gap



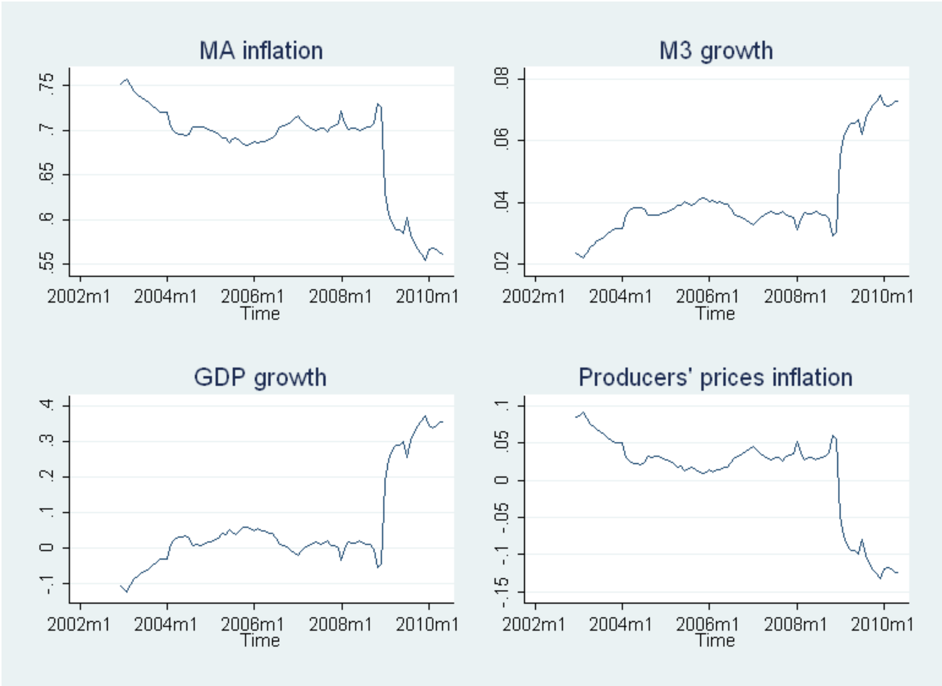
Notes: In this figure are reported the transition function versus the transition variables: LTRO/Assets on the top and Securities/Assets at the bottom.

Figure 10: Marginal effects for the credibility gap (LTRO/Assets)



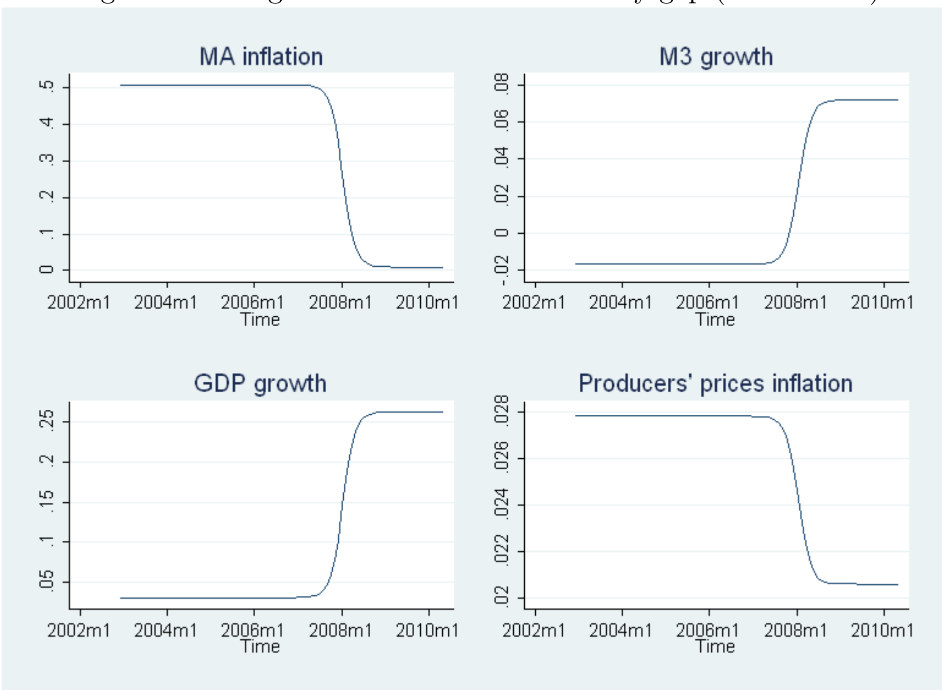
Notes: In this figure are reported the marginal effects of each explanatory variable on the absolute value of the inflation gap forecasts during the period under study. The transition variable is the ratio of the longer-term refinancing operations in the total assets of the ECB. The marginal effects are computed from the estimated parameters in table 3, Model 1.

Figure 11: Marginal effects for the credibility gap (Securities/Assets)



Notes: In this figure are reported the marginal effects of each explanatory variable on the absolute value of the inflation gap forecasts during the period under study. The transition variable is the value of the securities of euro area residents over the total assets of the ECB. The marginal effects are computed from the estimated parameters in table 3, Model 2.

Figure 12: Marginal effects for the credibility gap (Time trend)



Notes: In this figure are reported the marginal effects of each explanatory variable on the absolute value of the inflation gap forecasts during the period under study. The transition variable is a linear time trend $t = 1, ..., 90$. The marginal effects are computed from the estimated parameters in table 3, Model 3.

model as found for the models in level. The null hypothesis of linearity is also strongly rejected when the transition variable is included in the set of the explanatory variables used in the three models as shown in panel B of table 4.

Tables A.10 and A.11 in the appendix display the unit root tests of the variables in absolute value and for the residuals of the linear and the PSTR models. The results point out that most of the variables are stationary except for the LTRO/Assets and the Securities/Assets. The latter series take only positive values and thereby as shown in table A.6 they are in fact stationary once we account for a break in the deterministic trend function. The residuals are also all stationary with all test statistics except with the Pesaran test when including three lags for the differenced residuals.

Table 4: Nonlinearity tests for the credibility gap

PANEL A	Nonlinearity and no remaining nonlinearity tests								
		Model 1			Model 2			Model 3	
Test	LM	LMF	LRT	LM	LMF	LRT	LM	LMF	LRT
$H_0 : r = 0$ vs $H_1 : r = 1$	399.29	153.93	497.52	231.24	71.66	259.96	399.78	154.2	498.30
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$H_0 : r = 1$ vs $H_1 : r = 2$	90.96	24.04	94.99	115.75	31.37	122.38	73.58	19.11	76.18
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

PANEL B	Nonlinearity and no remaining nonlinearity tests when the threshold variable is included in the set of the explanatory variables								
		Model 1			Model 2			Model 3	
Test	LM	LMF	LRT	LM	LMF	LRT	LM	LMF	LRT
$H_0 : r = 0$ vs $H_1 : r = 1$	245.75	61.92	278.55	199.77	47.73	220.72	299.51	80.60	350.31
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$H_0 : r = 1$ vs $H_1 : r = 2$	101.68	21.67	106.75	128.49	28.15	136.73	9.59	1.87	9.63
	(0.000)	(0.000)	(0.000)	(0.010)	(0.012)	(0.010)	(0.088)	(0.097)	(0.088)

Notes: In this table are reported the values of the test statistics testing the null hypothesis of linearity ($r = 0$) against the PSTR model ($r = 1$) with r the number of transition functions. If the linearity hypothesis is rejected, one should test the null hypothesis of no remaining nonlinearity ($H_0 : r = 1$) against the alternative of three regimes ($r = 2$). The LM-type test is given by $LM = TN\frac{RSS_0 - RSS_1}{RSS_0}$ and follows a χ^2_K. The F-test statistic is given by $LM_F = \frac{(RSS_0 - RSS_1)/K}{RSS_1/(NT - N - (r+1)K)}$ and follows ($F_{K,TN-N-(r+1)K}$). LRT is a pseudo-likelihood ratio test given by $LRT = NT[\ln(RSS_0) - \ln(RSS_1)]$ and follows also a χ^2_K (see Colletaz and Hurlin (2006)). RSS_0 and RSS_1 represent respectively the residual sum of squares of the linear panel model with fixed effects and the residual sum of squares of the auxiliary regression A.5 when we are testing for linearity. When we test for no remaining nonlinearity RSS_0 and RSS_1 are the residual sum of squares for the PSTR and the auxiliary regression A.7 in absolute value (see the appendix). The p-values are reported in parentheses.
In panel A the tests are performed for the core model with four explanatory variables ($K = 4$) in absolute value and with individual fixed effects. If the transition variable has an explanatory power on the dependent variable, the null hypothesis of linearity may be wrongly rejected. To account for such an event the transition variable is involved in the set of regressors ($K = 5$) in the three model specifications. The results of the tests are displayed in panel B.

4.3 Linear model results for the inflation expectations

The empirical evidence suggests that there are four main determinants of inflation expectations in the ECB. First, the key factor is the history of past inflation as measured by the 12-months moving average of the difference between the rate of inflation and the inflation objective of the Central Bank. As one can see from the first column of table A.7 in the appendix, there is a strong and highly significant impact of this variable on the inflation expectations. A 1% increase in the moving average of inflation induces a 0.51% increase in the dependent variable. Second, as money growth is a main determinant of inflation in the longer term it also exerts a significant positive impact on the inflation forecasts. Hence, a 1% increase in the growth rate of the M3 forecasts involves a 0.04% increase in the inflation expectations of the professional forecasters. Third, as the ECB has to take due account of economic activity when setting the policy rate, the GDP growth forecasts may have exerted an important effect on the inflation expectations. Indeed, a 1% increase in the former induces a 0.165% increase in inflation expectations. Finally, as the commodities' price inflation is an important component of headline inflation, we also check for the impact of the former on our dependent variable. As an increase in the commodities' prices impacts directly the producers' prices we use the forecasts of the latter variable as a measure of inflationary pressures. Hence, a 1% increase in the producers' price inflation forecasts leads to a 0.145% increase in the professional inflation expectations. One can notice that the explanatory power of our model is particularly high featuring an R^2 of 77%.

The second column of table A.7 controls for the effect of the recent financial crisis on the dependent variable using a time dummy for the period starting from September 2007 until May 2010. The impact of the crisis period is positive and highly significant even though quantitatively small. The crisis dummy strengthens the effect of the moving average of inflation and the real GDP growth forecasts on the inflation expectations. Conversely, it weakens the impact of the M3 growth forecasts and the producers' prices inflation on the dependent variable. In addition, it renders the effect of M3 insignificant. As regards the R^2, the explanatory power increases to 82% as one could have expected when incuding an additional regressor.

The last column of table A.7 includes a time dummy that accounts for the peak of the financial crisis that occurred in October 2008 after the bankruptcy of Lehman Brothers. Even though the impact is positive as expected, it is quantitatively very small and insignificant. Moreover, accounting for the peak of the crisis does not alter the impact of our core variables on the inflation expectations as reported in the first column of table A.7. As reflected in the R^2, the explanatory power of our model remains unchanged.

Furthermore, we have controlled for the effect of other relevant variables on the core model results. Table A.9 in the appendix reports the estimation results of the control variables. At a first glance, the effect of the main variables remains broadly unaltered when accounting for the additional regressors. There are only two main exceptions where the impact of the M3 growth forecasts on the dependent variable is altered when adding the oil price forecasts and the lagged MCI in the regressions. Indeed, the estimated coefficient on the M3 growth forecasts becomes negative in columns (2) and (7) of table A.9 but is insignificant. The impact of the oil price forecasts on the dependent variable is positive as expected and highly significant but quantitatively close to zero. An increase in the MCI composite index indicates that monetary conditions have tightened in the euro area and therefore call for an increase in the policy rate. As a rise in the latter would prevent the build-up of inflationary pressures, the inflation expectations should be reduced. Since in our estimations the MCI coefficient has a positive sign we discard it from the baseline specification.

As regards the wage growth forecasts, the impact on the inflation expectations is positive and highly significant. Nevertheless, we have decided not to include it in our baseline specification because we consider that this variable is already reflected in the producers' price inflation through the production costs dynamics. Besides, this variable does not yield meaningful results in the nonlinear panel estimations. On the one hand, an increase in the unemployment rate may reduce inflation expectations as it reflects a sluggish economic activity. On the other hand, a rise in the unemployment rate forecasts could exert a positive impact on the inflation expectations because the professional forecasters would expect the ECB to intervene in order to support the general economic policies in the Union. As table A.9 points out, this variable has a negative sign and since the effect is not robust across specifications we discard it from the baseline model.

The Economic Sentiment Indicator (ESI) is a forward looking composite index of the euro area business cycle. An increase in the latter should reflect the agents' perceptions of an economic expansion and therefore exerts a positive effect on inflation expectations. Nevertheless, our results point out that this effect is negative and not significant and thereby this variable is removed from the model as well.

Besides, it is important to emphasize that we have controlled for the impact of the fiscal sustainability in the euro area on the inflation expectations. The fiscal sustainability is measured mainly by the public deficit to GDP ratio and the public debt to GDP ratio as defined in the Maastricht Treaty. As highlighted earlier, our paper focuses on the use of forecasts within a real-time data framework. However, we do not have forecasts of the debt to GDP variable but we use the realized debt to GDP at a quarterly frequency only. In addition, even though we have forecasts for the level of public deficit there are many missing observations of this variable in the panel. The fiscal sustainability variables are not included in the baseline model since they do not exhibit the expected sign and add noise to the estimations. Indeed, any deterioration in the debt to GDP and deficit to GDP ratios could lead the ECB to implement interest rate cuts or additional monetary easing through unconventional policy measures. In this case, one would expect a positive impact of the debt to GDP ratio on the inflation expectations. However, if the deficit to GDP ratio rises we should expect a negative impact on the dependent variable.[10] This result is consistent with a positive effect of the deficit to GDP ratio on the inflation forecasts.

Regarding the impact of the financial market and the VIX index on the inflation expectations the effect is negative and significant for the former and positive but insignificant for the latter. Furthermore, both effects are close to zero and thus not included in the core model. Finally, the interest rate spread exerts a positive and significant effect on the dependent variable.[11] Indeed, an increase in the latter reflects an increasing risk premium and points to a deterioration in the interbank lending market. In such an event the ECB should restore the smooth functioning of the market by reducing the policy rate for instance. In turn, this measure could exert a positive effect on the dependent variable. However, we do not include the interest rate spread in the model because it yields unsatisfactory results in the nonlinear panel estimations.

To test whether the impact of the driving factors of the inflation expectations is different during the financial downturn compared to the period before the crisis, we divide the overall sample in two sub-samples. We define the crisis period in two ways. The first starts with the onset of the financial burst in September 2007 and lasts until May 2010 and the second corresponds to the aftermath of the Lehman Brothers' bankruptcy, from October 2008 to the end of the sample. The estimation results of table A.8 reveal that the effect of the moving average of the inflation gap and the expected output growth rate have been highly reduced during the crisis. Conversely, the impact of the producers' price inflation has markedly increased. The impact of the M3 growth rate on the inflation forecasts at the inception of the financial burst has increased, but the estimated coefficient for the period before the crisis is not significant. On the contrary, for the second sub-sample which corresponds to the peak of the financial turmoil, the producers' price inflation has exerted a substantially higher effect on the dependent variable whereas the impact of M3 has been dampened.

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[10] Since the deficit is defined as revenues minus expenditures in the database, an increase in the deficit yields a smaller measure of this variable.

[11] The interest rate spread is computed as the difference between the 3-months Euribor rate and the Eonia rate.

To make sure that the differentiated impact of the determinants of the inflation expectations is statistically significant we compute a Chow test. The null hypothesis of a non differentiated effect is strongly rejected in favor of the alternative of a differentiated impact. This result provides further evidence in favor of a nonlinear effect of the core variables on the credibility gap rendering the linear panel model with fixed effects inappropriate.

4.4 Linear model results for the credibility gap

Table A.12 in the appendix displays the estimation results for the model that includes the variables in absolute value in order to explain the ECB's credibility gap. The table shows that most of the results previously obtained are qualitatively very similar. In particular, the moving average of past inflation and the real GDP growth forecasts are the main determinants of the inflation credibility gap in the Central Bank. The M3 growth and the producers' price inflation forecasts exert a weaker effect on the dependent variable and are not statistically significant.

Besides, the time dummy for the crisis period has produced a positive effect on the credibility gap while the peak of the financial turmoil has lead to a reduction in the dependent variable, as pointed out in columns 2 and 3 of table A.12 respectively.

Table A.13 in the appendix presents the estimation results with the additional control variables. In general, the evidence indicates that the baseline results remain qualitatively similar when including additional relevant regressors in the estimations. However, it is important to emphasize that an increase in either the debt to GDP ratio or in the deficit to GDP forecast ratio will worsen the credibility gap in the ECB. While the latter effect is highly significant, the former is not statistically relevant. This finding is particularly important in light of the recent sovereign debt crisis in the euro area. In fact, the results show that a worsening of the state public finances of the euro area member countries is harmful not only for the credibility in the Stability and Growth Pact but also for the people's trust in the European monetary institution.

5 Conclusion

This paper has shed new light on understanding the determinants of the professional forecasters' inflation expectations and of the credibility in the European Central Bank. Using a Panel Smooth Transition Regression (PSTR) approach we contribute to the empirical literature in the following aspects. First, within the panel regressions we have found that the key driving factors of inflation expectations and the credibility gap in the ECB are the history of inflation honesty, the forecasts of the M3 and GDP growth rates and producers' price inflation. The effects of these variables are robust to the presence of several control variables.

Second, within the PSTR model the empirical evidence suggests the presence of two extreme regimes leading to a differentiated impact of the explanatory variables on the credibility gap measure and on inflation expectations. The first regime corresponds to the normal (pre-crisis) period, while the second occurs since the beginning of the financial turmoil. Moreover, the econometric tests firmly reject the null hypothesis of linearity in favor of the PSTR specifications.

Third, we find that in the transition from the normal to the crisis regime the M3 growth rate and the producers' price inflation forecasts have exerted a stronger impact on inflation expectations compared to their effect in the pre-crisis period, while past inflation and the GDP growth rate forecasts have produced a much weaker effect on the dependent variable. Indeed, at the onset of the financial crisis the ECB has implemented nonstandard monetary policy operations in order to increase liquidity provision on the interbank lending market. The sharp increase of the funds provided through the quantitative easing channel might challenge the long-run price stability objective of the ECB. Therefore, the money growth forecasts have become an important determinant of inflation expectations within the crisis regime along with the producers' price inflation forecasts. In addition, since the peak of the crisis occurring in October 2008, the ECB has extended the set of unconventional policy measures and has started buying securities on the interbank market to reduce the risk premia on specific market segments through its qualitative easing channel. Hence, we have found that the ratio of securities in the total assets of the ECB is a transition variable to the crisis regime at the tipping point of the financial turmoil. Ultimately, the results remain mostly qualitatively unaltered when considering a linear time trend as a transition variable in the PSTR model.

Regarding the models for the credibility gap, the previous results are qualitatively similar. In fact, in the transition from the normal to the crisis regime past inflation has exerted a weaker effect on the credibility gap whereas the M3 and GDP growth forecasts have produced a stronger impact on the inflation credibility gap of the Central Bank in the period of financial turbulence.

As a future line of research, it would be valuable to investigate more in-depth the effects of the current nonstandard monetary policy operations on the inflation credibility dynamics of the ECB and of other major Central Banks. Given that these measures are expected to be implemented for a rather protracted period they might undermine the long-run price stability commitment of the Central Bank. This in turn could lead to a further structural change in the determinants of credibility in the ECB.

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Appendix

Let us write model (2) as follows:

$$\pi_{it}^e - \pi^{tar} = \mu_i + \Psi_0' x_{it} + \Psi_1' x_{it} g(q_t; \gamma, c) + \varepsilon_{it} \tag{A.1}$$

where $\Psi_j = (\alpha_j \ \beta_j \ \theta_j \ \phi_j)'$ for $j = 0, 1$ and $x_{it} = (\bar{\pi}_t \ m_{it}^e \ y_{it}^e \ p_{it}^e)'$. The value of the transition function $g(q_t; \gamma, c)$ at $\gamma = 0$ is 0.5. Its derivative with respect to γ is given by:

$$\frac{\partial g(q_t; \gamma, c)}{\partial \gamma} = \frac{e^{-\gamma(q_t - c)}}{\left(1 + e^{-\gamma(q_t - c)}\right)^2}(q_t - c) \tag{A.2}$$

Evaluated at $\gamma = 0$ the above derivative becomes:

$$\frac{\partial g(q_t; 0, c)}{\partial \gamma} = \frac{1}{4}(q_t - c) \tag{A.3}$$

The first order Taylor series expansion around $\gamma = 0$ is written as follows:

$$g(q_t; \gamma, c) = \frac{1}{2} + \frac{1}{4}(q_t - c)\gamma + R_1(q_t; \gamma, c) \tag{A.4}$$

where $R_1(q_t; \gamma, c)$ is the remainder of the Taylor expansion. By replacing equation (A.4) in equation (A.1) and rearranging the terms we get the following model.

$$\pi_{it}^e - \pi^{tar} = \mu_i + \Psi_0^{*\prime} x_{it} + \Psi_1^{*\prime} x_{it} q_t + \varepsilon_{it}^* \tag{A.5}$$

where $\Psi_0^* = \Psi_0 + (\frac{1}{2} - \frac{1}{4}\gamma c)\Psi_1$, $\Psi_1^* = \frac{1}{4}\gamma\Psi_1$ and $\varepsilon_{it}^* = \varepsilon_{it} + \Psi_1' x_{it} R_1(q_t; \gamma, c)$. The remainder $R_1(q_t; \gamma, c)$ is equal to zero under the null hypothesis of linearity, yielding $\varepsilon_{it}^* = \varepsilon_{it}$. Consequently, the asymptotic theory is not affected by the Taylor series approximation.

If the null hypothesis of linearity is rejected in favor of a PSTR model with two extreme regimes (one transition function, $r = 1$), one should test the latter hypothesis against the alternative of three extreme regimes (two transition functions, $r = 2$). The model becomes:

$$\pi_{it}^e - \pi^{tar} = \mu_i + \Psi_0' x_{it} + \Psi_1' x_{it} g_1(q_t^{(1)}; \gamma_1, c_1) + \Psi_2' x_{it} g_2(q_t^{(2)}; \gamma_2, c_2) + \varepsilon_{it} \tag{A.6}$$

The transition variables $q_t^{(1)}$, $q_t^{(2)}$ can be either different or the same. As in the two regime PSTR model the nuisance parameter issue is circumvented by a first order Taylor series expansion around $\gamma_2 = 0$.

$$\pi_{it}^e - \pi^{tar} = \mu_i + \Psi_0' x_{it} + \Psi_1' x_{it} g_1(q_t^{(1)}; \hat{\gamma}_1, \hat{c}_1) + \Psi_2^{*\prime} x_{it} q_t^{(2)} + \varepsilon_{it}^* \tag{A.7}$$

where $\hat{\gamma}_1$ and $\hat{c}_1$ are estimates under the assumption of a two regime PSTR model. The null hypothesis of no remaining nonlinearity is simply defined as $H_0 : \Psi_2^{*\prime} = 0$ where $\Psi_2^{*\prime}$ is a K-vector of coefficients which are multiples of γ_2. This testing procedure should be applied until the null hypothesis is not rejected for the first time.

Table A.1: List of variables

Variable	Description
π^e_{it}	12-months fixed horizon inflation forecasts by professional forecaster i and time t.
π^{tar}	Inflation target of the ECB fixed at 1.8%.
$\bar{\pi}_t$	12-months moving average of the realized (annual) inflation gap with respect to the inflation target for time t.
m^e_{it}	12-months fixed horizon growth rate of the monetary aggregate M3 expected by expert i and time t.
y^e_{it}	12-months fixed horizon forecasts of annual growth rate of real GDP by expert i and time t.
p^e_{it}	12-months fixed horizon forecasts of producers' price annual inflation, by professional forecaster i and time t.
d_{crisis}	Crisis dummy defined in two ways: (i) it takes the value 1 from the onset of the financial crisis in September 2007 to the end of the sample in May 2010 and 0 otherwise (ii) it takes the value 1 for the peak of the downturn in October 2008 and 0 otherwise.
q_t	Transition variables: (i) the value of the longer-term refinancing operations of the ECB over the value of total assets (ii) the ratio of the value of the euro area residents' securities denominated in euro with respect to the value of the total assets held by the ECB and (iii) a linear time trend.
$z_{i,t}$	Several control variables used in tables A.9 and A.13.

Table A.2: Forecasters and their socio professional category

Forecaster	ID number	Category	Country of origin
ABN Amro	1	Bank & Insurance	The Netherlands
Banca IMI	2	Bank & Insurance	Italy
Bank Julius Baer	3	Bank & Insurance	Switzerland
Bank of America	4	Bank & Insurance	Unites States
BNP-Paribas	5	Bank & Insurance	France
Commerzbank	6	Bank & Insurance	Germany
Credit Lyonnais/Agricole	7	Bank & Insurance	France
Deutsche Bank	8	Bank & Insurance	Germany
F.A.Z. Institut	9	Research Institute	Germany
Fortis	10	Bank & Insurance	Belgium
Goldman Sachs	11	Bank & Insurance	United States
HSBC	12	Bank & Insurance	United Kingdom
IHS Global Insight	13	Research Institute	United States
Intesa Sanpaolo	14	Bank & Insurance	Italy
Lehman Brothers	15	Bank & Insurance	United States
Lloyds TSB	16	Bank & Insurance	United Kingdom
Merrill Lynch	17	Bank & Insurance	United States
Morgan Stanley	18	Bank & Insurance	United States
SEB	19	Industrial Corporation	France
UBS	20	Bank & Insurance	Switzerland
UniCredit MIB	21	Bank & Insurance	Italy
WestLB	22	Bank & Insurance	Germany

Notes: In the Consensus Economics forecasts for the euro area there are 38 professional forecasters. Unfortunately we had to remove from the data set the experts who report their expectations for one of the variables of interest for less than 5 months within the period under study.

Table A.3: Summary statistics

	Dec. 2002 - Aug. 2007					Sep. 2007 - May. 2010				
	Obs.	Mean	Std.	Min	Max	Obs.	Mean	Std.	Min	Max
DEPENDENT AND EXPLANATORY VARIABLES										
Inflation forecasts (%)	1′093	1.88	0.21	1.27	2.64	550	1.72	0.82	0.125	3.33
Inflation (%)	57	2.11	0.25	1.56	2.59	33	1.82	1.47	-0.65	4.05
M.A. inflation (%)	57	0.20	0.07	0.04	0.35	33	0.09	0.68	-0.94	1.03
M3 growth forecasts (%)	874	5.82	1.05	2.00	10.10	365	6.12	1.96	0.20	10.33
Producers' price inflation forecasts (%)	870	1.94	0.93	-3.40	4.75	401	1.60	2.09	-4.35	6.44
Real GDP growth forecasts (%)	1′098	1.78	0.38	0.80	2.68	551	0.42	1.58	-3.38	2.5
TRANSITION VARIABLES										
LTRO/Assets (%)	57	8.75	2.25	5.39	12.90	33	26.14	6.79	16.41	36.72
Securities/Assets (%)	57	7.43	1.44	3.69	9.20	33	12.23	4.90	5.76	18.64

Data sources: The monthly forecasts of the variables are obtained from the CEF data set. The monthly inflation series is obtained from the ECB's real-time database.

Notes: All forecasts are for a 12-months fixed horizon. "M.A. inflation" stands for the 12-months moving (weighted) average inflation gap with respect to the target of 1.8%. "LTRO/Assets" and "Securities/Assets" denote respectively the value of the longer-term refinancing operations of the ECB over the value of total assets and the ratio of the value of the securities of euro area residents denominated in euro with respect to the value of the total assets of the ECB. To bring to light the effect of the crisis we split the sample in two subperiods: before the onset of the crisis, until August 2007 and during the financial downturn, from September 2007 to the end of the data set.

Table A.4: Unit root tests for the variables in level

	1 lag			3 lags		
	Fisher (DF)	Fisher (PP)	Pesaran	Fisher (DF)	Fisher (PP)	Pesaran
Time and individual varying variables						
Inflation gap forecasts	44.04	50.60	-8.87***	60.93**	59.96*	-4.33**
	(0.470)	(0.229)	(0.000)	(0.046)	(0.05)	(0.000)
M3 growth forecasts	40.27	44.18	-4.47***	34.26	47.47	[c]-3.19***
	(0.632)	(0.464)	(0.000)	(0.80)	(0.333)	(0.001)
Real GDP growth forecasts	62.10**	22.80	-8.42***	65.84**	31.55	-2.67***
	(0.037)	(0.997)	(0.000)	(0.018)	(0.920)	(0.004)
Producers' price inflation forecasts	41.09	41.60	[a]-5.00***	187.10***	47.37	[b]-2.74***
	(0.511)	(0.575)	(0.000)	(0.000)	(0.337)	(0.003)
Time varying variables	AD-Fuller	P-Perron		AD-Fuller	P-Perron	
M.A. inflation	-5.778***	-0.115		-3.710***	-0.786	
	(0.000)	(0.948)		(0.004)	(0.823)	
LRTO/Assets	-0.048	-0.150		0.432	0.054	
	(0.954)	(0.944)		(0.983)	(0.963)	
Securities/Assets	-0.717	-0.388		-0.455	-0.401	
	(0.842)	(0.912)		(0.901)	(0.910)	

Notes: The values in parentheses are the corresponding p-values., *** p<0.01, ** p<0.05, * p<0.1. The null hypothesis of the panel unit root tests is that all the series composing the panel are not stationary against the alternative that at least one of them is stationary. "Fisher (DF)" and "Fisher (PP)" are Fisher-type unit root test statistics for panels using respectively the augmented Dickey-Fuller test and the Phillips-Perron test. The number of lags specifies the number of lagged difference terms to include in the covariate list. Both tests follow a chi-squared distribution. "Pesaran" stands for the unit root test developed in Pesaran (2003) and allows for cross sectional dependence. For the variables varying only in time we perform time series tests, namely the augmented Dickey-Fuller and Phillips-Perron tests with 1 and 3 lags (respectively lagged differences for the ADF and Newey-West lags for PP). The null hypothesis for both tests is that the series has a unit root.

[a] To compute the Pesaran test in column (3) on the producers' price inflation forecasts, professional forecaster number 12 is removed since it does not report this variable 84 times within our sample. [b] Forecasters number 1 (81 missing values) and 12 are removed as well. [c] Forecasters number 1 and 12 are also dropped.

Table A.5: Panel unit root tests on the residuals for the models in level

	1 lag			3 lags		
Variable	Fisher (ADF)	Fisher (PP)	[a]Pesaran	Fisher (ADF)	Fisher (PP)	[b]Pesaran
LINEAR MODEL						
Column (1)	75.75***	75.79***	-2.771***	78.14***	82.40***	1.788
	(0.003)	(0.002)	(0.003)	(0.000)	(0.000)	(0.963)
Column (2)	103.70***	106.41***	-2.946***	112.62***	112.18***	1.044
	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.852)
Column (3)	71.55***	75.65***	-2.763***	78.13***	82.33***	1.799
	(0.003)	(0.002)	(0.003)	(0.000)	(0.000)	(0.964)
PSTR MODEL						
Model 1	111.40***	109.11***	-2.050**	123.86***	113.13***	1.077
	(0.000)	(0.000)	(0.020)	(0.000)	(0.000)	(0.859)
Model 2	93.24***	88.06***	-3.645***	92.33***	94.59***	0.749
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.773)
Model 3	117.58***	117.91***	-2.211**	125.84***	123.35***	1.081
	(0.000)	(0.000)	(0.014)	(0.000)	(0.000)	(0.860)

Notes: See notes in table (A.4) for the panel unit root tests.

[a] To compute Pesaran's test in column (3), forecaster number 12 is dropped since there are 84 missing values.

[b] Forecaster number 1 (81 missing values) is dropped as well.

Table A.6: Unit root tests with a break in the trend of the transition variables

	Additive outlier model					Innovational outlier model				
Variables	T	T_B	λ	k	$t_{\hat{\alpha}}^{AO}$	T	T_B	λ	k	$t_{\hat{\alpha}}^{IO}$
LTRO/Assets	90	57	0.63	0	-5.367***	90	58	0.64	0	-5.330***
Securities/Assets	90	69	0.77	1	-3.600*	90	72	0.80	1	-6.744***

Additive outlier model: the change in the trend function occurs instantaneously. We use model A3 which accounts for a break in the intercept and slope of the trend function for the LTRO/Assets. For the Securities/Assets we consider model A2 in which a break is present only in the slope of the deterministic time trend. T is the total number of observations over time and T_B is the break date. 57 and 69 correspond to August 2007 and August 2008 respectively. λ is defined as $\frac{T_B}{T}$, k is the number of extra lags of the first differences of the variables which is selected using the BIC criterion. The critical value at 1% for the LTRO/Assets is -4.88 based on table VI.B in Perron (1989) and for the Securities/Assets it is -3.50 at 10% based on table V.B. *** p<0.01, ** p<0.05, * p<0.1.

Innovational outlier model: the change in the trend function occurs gradually. We use model I3 which accounts for a break in the intercept and slope of the trend function for the LTRO/Assets and for the Securities/Assets. 58 and 72 correspond to September 2007 and November 2008 respectively. The critical value at 1% for the LTRO/Assets is -4.88 based on table VI.B in Perron (1989) and for the Securities/Assets it is -4.70 at 1% based on table VI.B.

Table A.7: OLS estimation of the linear model with fixed effects for the inflation expectations

Variables	(1)	(2)	(3)
M.A. inflation	0.512***	0.673***	0.511***
	(0.0773)	(0.0751)	(0.0779)
M3 growth forecasts	0.0387***	0.00463	0.0388***
	(0.00980)	(0.0118)	(0.00983)
Real GDP growth forecasts	0.165***	0.289***	0.165***
	(0.0238)	(0.0272)	(0.0236)
Producers' price inflation forecasts	0.145***	0.0944***	0.145***
	(0.0223)	(0.0159)	(0.0224)
Crisis		0.00330***	
		(0.000512)	
$\text{Crisis}_{\text{Oct.2008}}$			0.000189
			(0.000656)
Observations	$1'088$	$1'088$	$1'088$
Groups	22	22	22
R^2 within	0.772	0.822	0.772
R^2 between	0.483	0.617	0.483
R^2 overall	0.760	0.810	0.760
RSS	0.0052	0.0041	0.0052
AIC	-12.1792	-12.4266	-12.1792
BIC	-12.0599	-12.3073	-12.0599

Notes: In this table are reported the estimation results obtained by the OLS method of the linear panel model with fixed effects. The dependent variable is the gap between the inflation expectations of 22 professional forecasters for the period from December 2002 to May 2010 and the ECB's inflation objective. Robust standard errors are in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The variable "Crisis" is a dummy taking the value 1 over the period September 2007-May 2010 and 0 otherwise. The variable "$\text{Crisis}_{\text{Oct.2008}}$" is a dummy taking the value 1 for the peak of the financial burst, that is in October 2008 and 0 otherwise.

$\text{AIC} = \ln\big(RSS/(NT-n-1)\big) + 2(n/NT)$ and $\text{BIC} = \ln\big(RSS/(NT-n-1)\big) + (n/NT)\ln(NT)$ where RSS is the residual sum of squares, $NT = 1'088$ and n the number of estimated parameters ($n = 26$).

Table A.8: Linear model with fixed effects for the inflation expectations: Chow test

	Whole sample	Onset of the crisis		Peak of the crisis	
Variables		Until Sep.2007	From Sep.2007	Until Oct.2008	From Oct.2008
M.A. inflation	0.512***	1.081***	0.448***	1.475***	0.212**
	(0.0773)	(0.113)	(0.100)	(0.0682)	(0.0886)
M3 growth forecasts	0.0387***	0.0136	0.0441*	0.0640***	0.0405**
	(0.00980)	(0.00936)	(0.0209)	(0.0119)	(0.0143)
Real GDP growth forecasts	0.165***	0.297***	0.195***	0.236***	0.0852*
	(0.0238)	(0.0251)	(0.0515)	(0.0349)	(0.0463)
Producers' price infl. forecasts	0.145***	0.0437***	0.174***	0.0494***	0.178***
	(0.0223)	(0.0104)	(0.0331)	(0.00811)	(0.0277)
Observations	1′088	793	295	942	146
Groups	22	22	18	22	11
R^2 within	0.772	0.572	0.875	0.732	0.810
R^2 between	0.483	0.651	0.704	0.613	0.672
R^2 overall	0.760	0.553	0.860	0.720	0.704
RSS	0.0052	0.0013	0.0022	0.0027	0.0007
F(4, 1′088-8)		127.99 (0.000)		149.73 (0.000)	
F(26,1′088-52)		18.89 (0.000)		22.10 (0.000)	

Notes: In this table are reported the estimation results obtained by the OLS method of the linear panel model with fixed effects for the whole sample, for the period before and during the financial turmoil. Robust standard errors are in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the gap between the inflation expectations of 22 professional forecasters for the period from December 2002 to May 2010 and the ECB's inflation objective. The crisis period is defined in two ways: (i) from September 2007 (column (3)) and (ii) from October 2008 (column (5)). If the impact of the driving factors of the inflation expectations remains the same during the pre-crisis and the crisis periods, the slope coefficients should not be statistically different. To test this hypothesis we compute the Chow statistic given by $F = \frac{(S_c-(S_1+S_2))/K}{(S_1+S_2)/(N-2K)} \sim F(K, NT-2K)$ where S_c, S_1 and S_2 are respectively the residual sum of squares of the constrained model, of the model for the period before the crisis and during the financial downturn. The p-values of the test are in parentheses.
The first statistic (K=4) tests the null hypothesis of equality of the slope coefficients associated to the driving factors of the inflation forecasts. The critical values of the test at 90%, 95% and 99% are respectively 1.95, 2.38 and 3.34, leading to a very strong rejection of the null hypothesis in favor of the alternative of a differenciated impact. The second statistic (K=26) tests the equality of the slope coefficients and of the fixed effects between the two periods. The null hypothesis is again highly rejected with zero p-values. The critical values of the test at 90%, 95% and 99% are respectively 1.38, 1.51 and 1.77. Notice that in columns (3) and (5), because of missing observations, there are respectively 18 and 11 forecasters. This may have an impact on the results of the second test.

Table A.9: Linear model for the inflation expectations: controlling for additional explanatory variables

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
M.A. inflation	0.391***	0.720***	0.415***	0.466***	0.276***	0.323***	0.513***	0.421***	0.505***	0.526***
	(0.0907)	(0.0668)	(0.0778)	(0.0733)	(0.0900)	(0.0964)	(0.0709)	(0.0740)	(0.0730)	(0.0737)
M3 growth forecasts	0.0305***	-0.00883	0.00728	0.0333**	0.0166	0.0148	-0.0148	0.0311***	0.0373***	0.0155
	(0.00721)	(0.0133)	(0.0140)	(0.0118)	(0.0110)	(0.0133)	(0.0134)	(0.00932)	(0.0104)	(0.0124)
Real GDP growth forecasts	0.138***	0.272***	0.134***	0.184***	0.101***	0.108***	0.195***	0.209***	0.168***	0.229***
	(0.0277)	(0.0207)	(0.0217)	(0.0263)	(0.0263)	(0.0310)	(0.0188)	(0.0236)	(0.0258)	(0.0286)
Producers' price inflation forecasts	0.169***	0.0383**	0.143***	0.148***	0.167***	0.162***	0.108***	0.154***	0.144***	0.113***
	(0.0259)	(0.0174)	(0.0229)	(0.0235)	(0.0251)	(0.0278)	(0.0183)	(0.0209)	(0.0227)	(0.0216)
Wage growth forecasts	0.177***									
	(0.0319)									
Oil price forecasts		7.57e-05**								
		(9.77e-06)								
Unemployment rate forecasts			-0.0940***							
			(0.0194)							
L.ESI growth				-0.00276						
				(0.00182)						
Debt to GDP					-0.0359***					
					(0.00723)					
Deficit to GDP forecasts						0.0725***				
						(0.0244)				
L.MCI							0.165***			
							(0.0196)			
L. Dow Jones finance								-0.00270***		
								(0.000616)		
L.VIX growth									0.000144	
									(0.000209)	
L.spread										0.317***
										(0.0727)
Observations	809	1´088	1´087	1´088	1´088	977	1´088	1´088	1´088	1´088
R^2 within	0.796	0.830	0.782	0.773	0.783	0.789	0.813	0.783	0.772	0.792
R^2 between	0.499	0.476	0.513	0.493	0.572	0.582	0.534	0.566	0.492	0.510
R^2 overall	0.784	0.814	0.770	0.761	0.773	0.777	0.801	0.772	0.760	0.780
Groups	21	22	22	22	22	22	22	22	22	22

Notes: In this table we control for the effect of relevant economic, fiscal and financial variables. For the oil price we have an average of 12-months forecasts. For the deficit we have forecasts for its level. In order to compute the ratio of the deficit to GDP we follow Heppke-Falk and Hüfner (2004) and Poplawski-Ribeiro and Rülke (2010) to obtain monthly forecasts of the nominal GDP ($Y^e_{i,r,h}$) calculated by the following formula: $Y^e_{i,r,h} = Y^{nom}_{r-1} \times (1 + y^e_{i,r,h} + \pi^e_{i,r,h})$ where Y^{nom}_{r-1} is the realized nominal GDP for year $r-1$ and $y^e_{i,r,h}$, $\pi^e_{i,r,h}$ are respectively the forecasts for real output growth and inflation for month h of year r. "L.MCI" corresponds to the first lag of the Monetary Conditions Index, "L.ESI growth" stands for the first lag of the growth rate of the Economic Sentiment Indicator. "L.Dow Jones finance", "L.VIX growth" and "L.spread" correspond to the first lags of respectively the Dow Jones index, the VIX growth rate and the spread computed as the difference between the 3-months Euribor and the Eonia rate. The coefficients are estimated by OLS. Robust standard errors are in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table A.10: Unit root tests for the variables in absolute value

	1 lag			3 lags		
	Fisher (DF)	Fisher (PP)	Pesaran	Fisher (DF)	Fisher (PP)	Pesaran
Time and individual varying variables						
Inflation gap forecasts	49.75	64.94**	-8.039***	42.82	68.50**	-4.38***
	(0.255)	(0.022)	(0.000)	(0.522)	(0.011)	(0.000)
M3 growth forecasts	40.27	44.18	-4.47***	34.26	47.47	[c] -1.77**
	(0.632)	(0.464)	(0.000)	(0.797)	(0.333)	(0.039)
Real GDP growth forecasts	156.72***	115.01***	8.47***	159.39***	130.38***	-2.49
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.006)
Producers' price inflation forecasts	66.73***	75.56***	[a]-4.49***	192.72***	80.70***	[b]-2.53***
	(0.009)	(0.002)	(0.000)	(0.000)	(0.001)	(0.006)
Time varying variables	AD-Fuller	P-Perron		AD-Fuller	P-Perron	
M.A. inflation	-3.96***	-1.33		-2.41	-1.79	
	(0.002)	(0.614)		(0.139)	(0.386)	
LRTO/Assets	-0.048	-0.150		0.432	0.054	
	(0.954)	(0.944)		(0.983)	(0.963)	
Securities/Assets	-0.717	-0.388		-0.455	-0.401	
	(0.842)	(0.912)		(0.901)	(0.910)	

Notes: The values in parentheses are the corresponding p-values., *** p<0.01, ** p<0.05, * p<0.1. The null hypothesis of the panel unit root tests is that all the series composing the panel are not stationary against the alternative that at least one of them is stationary. "Fisher (DF)" and "Fisher (PP)" are Fisher-type unit root test statistics for panels using respectively the augmented Dickey-Fuller test and the Phillips-Perron test. The number of lags specifies the number of lagged difference terms to include in the covariate list. Both tests follow a chi-squared distribution. "Pesaran" stands for the unit root test developed in Pesaran (2003) and allows for cross sectional dependence. For the variables varying only in time we perform time series tests, namely the augmented Dickey-Fuller and Phillips-Perron tests with 1 and 3 lags (respectively lagged differences for the ADF and Newey-West lags for PP). The null hypothesis for both tests is that the series has a unit root.

[a] To compute the Pesaran test in column (3) on the producers' price inflation forecasts, professional forecaster number 12 is removed since it does not report this variable 84 times within our sample. [b] Forecasters number 1 (81 missing values) and 12 are removed as well. [c] Forecasters number 1 and 12 are also dropped.

Table A.11: Panel unit root tests on the residuals for the models in absolute value

	1 lag			3 lags		
Variable	Fisher (ADF)	Fisher (PP)	[a]Pesaran	Fisher (ADF)	Fisher (PP)	[b]Pesaran
LINEAR MODEL						
Column (1)	121.10***	109.59***	-7.02***	103.46***	114.22***	0.086
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.534)
Column (2)	142.23***	140.18***	-5.36***	127.99***	141.34***	1.33
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.908)
Column (3)	118.16***	111.61***	-6.94***	108.92***	115.43***	0.285
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.612)
PSTR MODEL						
Model 1	170.36***	159.50***	-4.20***	166.15***	158.20***	-0.093
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.463)
Model 2	100.49***	116.66***	-5.59***	59.90**	120.30***	-0.279
	(0.000)	(0.000)	(0.000)	(0.022)	(0.000)	(0.390)
Model 3	152.27***	166.46***	-4.769***	180.45***	166.43***	0.743
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.771)

Notes: See notes in table (A.10) for the panel unit root tests.

[a] To compute Pesaran's test in column (3), forecaster number 12 is dropped since there are 84 missing values.
[b] Forecaster number 1 (81 missing values) is dropped as well.

Table A.12: OLS estimation of the linear model with fixed effects for the credibility gap

Variables	(1)	(2)	(3)
M.A. inflation	1.098***	0.489***	1.107***
	(0.0824)	(0.0745)	(0.0819)
M3 growth forecasts	0.0130	-0.0134	0.0136
	(0.0119)	(0.00810)	(0.0116)
Real GDP growth forecasts	0.219***	0.160***	0.214***
	(0.0449)	(0.0293)	(0.0465)
Producers' price inflation forecasts	-0.00497	0.0245	-0.00286
	(0.0177)	(0.0177)	(0.0174)
Crisis		0.00436***	
		(0.000318)	
$\text{Crisis}_{\text{Oct.2008}}$			-0.00166***
			(0.000574)
Observations	$1'088$	$1'088$	$1'088$
Groups	22	22	22
R^2 within	0.416	0.6063	0.4175
R^2 between	0.579	0.7884	0.5875
R^2 overall	0.438	0.6196	0.4406
RSS	0.0065	0.0044	0.0065
AIC	-11.9570	-12.3472	-11.9570
BIC	-11.8377	-12.2279	-11.8377

Notes: In this table are reported the estimation results obtained by the OLS method of the linear panel model with fixed effects. All variables are in absolute values. The dependent variable is the absolute value of the gap between the inflation expectations of 22 professional forecasters for the period from December 2002 to May 2010 and the ECB's inflation objective. Robust standard errors are in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The variable "Crisis" is a dummy taking the value 1 over the period September 2007-May 2010 and 0 otherwise. The variable "$\text{Crisis}_{\text{Oct.2008}}$" is a dummy taking the value 1 for the peak of the financial burst, that is in October 2008 and 0 otherwise.

AIC = $\ln\big(RSS/(NT-n-1)\big)+2(n/NT)$ and BIC = $\ln\big(RSS/(NT-n-1)\big)+(n/NT)\ln(NT)$ where RSS is the residual sum of squares, $NT = 1'088$ and n the number of estimated parameters ($n = 26$).

Table A.13: Linear model for the credibility gap: controlling for additional explanatory variables

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
M.A. inflation	1.170***	1.098***	1.080***	0.692***	1.015***	0.965***	1.104***	1.022***	1.128***	0.684***
	(0.102)	(0.0833)	(0.0759)	(0.0987)	(0.0746)	(0.0861)	(0.0904)	(0.0773)	(0.0758)	(0.0903)
M3 growth forecasts	0.000509	0.0256	0.0251	0.0320**	0.0277*	0.0409**	0.0144	0.0172	0.0150	-0.0178
	(0.0124)	(0.0171)	(0.0201)	(0.0123)	(0.0143)	(0.0161)	(0.0161)	(0.0124)	(0.0120)	(0.0130)
Real GDP growth forecasts	0.285***	0.255***	0.228***	0.105**	0.202***	0.207***	0.223***	0.203***	0.212***	0.171***
	(0.0435)	(0.0500)	(0.0498)	(0.0386)	(0.0408)	(0.0396)	(0.0524)	(0.0396)	(0.0474)	(0.0379)
Producers' price inflation forecasts	-0.00326	-0.0322	0.00407	0.0162	0.00638	0.0194	-0.00470	-0.00160	-0.0104	-0.00336
	(0.0199)	(0.0213)	(0.0170)	(0.0183)	(0.0167)	(0.0213)	(0.0173)	(0.0175)	(0.0172)	(0.0190)
Wage growth forecasts	0.0776**									
	(0.0307)									
Oil price forecasts		0.00363***								
		(0.000858)								
Unemployment rate forecasts			0.0310							
			(0.0333)							
L.ESI growth				0.0131***						
				(0.00304)						
Debt to GDP					0.0125					
					(0.00744)					
Deficit to GDP forecasts						0.0568***				
						(0.0183)				
L.MCI							0.00859			
							(0.0341)			
L. Dow Jones finance								0.00212**		
								(0.000869)		
L.VIX growth									-0.000676**	
									(0.000302)	
L.spread										0.509***
										(0.0481)
Observations	809	919	1´087	1´088	1´088	977	1´088	1´088	1´088	1´088
R^2 within	0.429	0.425	0.418	0.455	0.422	0.421	0.416	0.422	0.419	0.501
R^2 between	0.502	0.474	0.573	0.622	0.558	0.512	0.578	0.591	0.554	0.684
R^2 overall	0.454	0.445	0.441	0.479	0.445	0.457	0.438	0.444	0.442	0.519
Groups	21	22	22	22	22	22	22	22	22	22

Notes: In this table we control for the effect of relevant economic, fiscal and financial variables. For the oil price we have an average of 12-months forecasts. For the deficit we have forecasts for its level. In order to compute the ratio of the deficit to GDP we follow Heppke-Falk and Hüfner (2004) and Poplawski-Ribeiro and Rülke (2010) to obtain monthly forecasts of the nominal GDP ($Y^e_{i,r,h}$) calculated by the following formula: $Y^e_{i,r,h} = Y^{nom}_{r-1} \times (1 + y^e_{i,r,h} + \pi^e_{i,r,h})$ where Y^{nom}_{r-1} is the realized nominal GDP for year $r-1$ and $y^e_{i,r,h}$, $\pi^e_{i,r,h}$ are respectively the forecasts for real output growth and inflation for month h of year r. "L.MCI" corresponds to the first lag of the Monetary Conditions Index, "L.ESI growth" stands for the first lag of the growth rate of the Economic Sentiment Indicator. "L.Dow Jones finance", "L.VIX growth" and "L.spread" correspond to the first lags of respectively the Dow Jones index, the VIX growth rate and the spread computed as the difference between the 3-months Euribor and the Eonia rate. All variables are in absolute values. The coefficients are estimated by OLS. Robust standard errors are in parentheses, *** p<0.01, ** p<0.05, * p<0.1.