The Empirical Economics Letters, 11(5): (May 2012) ISSN 1681 8997

Time Dynamics of the Euro-Induced Inflation Perception Gap: Intervention Analysis

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Abstract: The euro cash changeover on 1 January 2002 has elicited a substantial increase of consumers' inflation perceptions in the euro area, despite actual inflation figures remaining rather stable. Although the inflation perception gap in 2002 has been significantly covered in the literature, only minor efforts have been made in analyzing its persistency after the introduction of euro. Hence this paper adds to the existing literature by examining the nature and magnitude of consumers' inflation perception errors via Box and Tiao's intervention analysis. Employing an extensive dataset from 10 euro area countries (and the euro area as a whole) it was found that the euro has indeed induced large and significant inflation perception errors, but the perception gap has, for the most part, remained only a short-run phenomenon.

Keywords: Euro Area, Euro Cash, Inflation Perception Gap, Box and Tiao's Intervention Analysis

1. Introduction

The introduction of euro at the start of 2002 has been accompanied by a sharp increase in consumers' inflation perceptions in the euro area (EA). However, official HICP inflation figures contradicted it, not revealing any atypical price increases at the aggregate level (Eurostat, 2003). Therefore, various interdisciplinary studies have been undertaken in order to explain relevant driving factors of the newly created perception gap. For example, Brachinger (2008) postulates that the perception gap is heavily dependent on the increased prices of frequently purchased goods (out of pocket expenditure). Traut-Mattausch et al. (2004) prove that the perception gap was mainly driven by the beforehand created expectations (actuated by the media) that euro will be a significant price booster. Dziuda and Mastrobuoni (2009) demonstrate that post-changeover inflation was more intensively perceived by consumers who convert euro prices to former national currency prices. In so doing, often the sole rounding of the conversion rate causes upward-biased inflation perceptions (Ehrmann, 2006).

However, studies of the perception gap persistency have been relatively scarce and mainly of purely descriptive nature. Sturm et al. (2009) use simple graphical analysis to illustrate that the euro inflation perception gap is quite persistent in France, Belgium, Greece and Finland, while convergence is observable in Germany, Italy and Netherlands.

Döhring and Mordonu (2007) estimate a dynamic panel model of perceived inflation for the EA. The authors obtain a large and highly significant autoregressive term of perceived inflation, suggesting its persistency. With that in mind, Döhring and Mordonu (2007) suggest that further research has to be done on the time dimension, i.e. the duration of the perception gap phenomenon. Hence the aim of this paper is to fill that academic niche.
As a side effect of the euro introduction, Lein and Maag (2011) find a significant decrement of the correlation between actual and perceived inflation in the EA. Even more importantly, the authors demonstrate considerable heterogeneity between the EA countries in that sense. For that reason, this paper offers an in depth analysis, relying on an extensive dataset of 10 individual EA member states, and the EA as a whole.

2. Data and Methodology

The dataset comprises year-on-year inflation rates (HICP) and perceived inflation for 10 individual EA member countries[1] (as well as the EA as a whole), spanning from 1997M01-2011M07. HICP data is gathered from Eurostat, while the consumers' inflation perceptions are obtained from the European Commission. The perceived inflation measure is based on the following question from the harmonized EU consumer survey:

How do you think that consumer prices have developed over the last 12 months? They have: a) risen a lot, b)risen moderately, c) risen slightly, d) stayed about the same, e) fallen, f) don't know.

Let a^p, b^p, c^p, and e^p be the fractions of respondents indicating that prices have risen a lot, risen moderately, risen slightly or fallen in the last 12 months (respectively). The perceived inflation indicator is quantified via Carlson-Parkin's method, its basic assumption being that the shares of respondents providing each particular answer to the survey question can be interpreted as maximum likelihood estimates (probabilities) of areas under the density function of inflation perceptions (Dias *et al*., 2004). The perceived inflation relation can be derived in the following manner:

$$\pi^p = s \quad \frac{A^p + B^p}{A^p - B^p}$$

where π^p is perceived inflation, $A^p = Nz^{-1}(1 - a^p - b^p - c^p)$, $B^p = Nz^{-1}(e^p)$, Nz is the cumulative standardized normal distribution function and s is a scaling factor (derived

1 Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain. Luxembourg and Germany were not included in the analysis due to unavailability of consumers' inflation perceptions. The time span for Ireland is 1997M01-2008M07, due to a break in the inflation perception series.

under the assumption that the average value of the perceived inflation rate equals the average value of the actual inflation rate). The expression for obtaining the scaling factor in period T is given as follows:

$$s_T = \frac{\sum_{t=1}^{T} \pi_t}{\sum_{t=1}^{T} \left(\frac{A_t^p + B_t^p}{A_t^p - B_t^p} \right)}$$

For more details about the CP method see Carlson and Parkin (1975) or Forsells and Kenny (2004).

Econometric analysis is applied on the perception gap variable, calculated as a simple difference between actual and perceived inflation in each specific country.

Primary purpose of intervention analysis is to examine the effect of an exogenous shock to a specific time series (Box and Tiao, 1975).[2] In the context of this paper, it analyzes the impact of euro introduction on the inflation perception gap.

The perception gap (y_t) can be disaggregated into two elements: the noise component N_t and an intervention function, I_t :

$$y_t = I_t + N_t = \omega(B)/\delta(B) \cdot \xi_t + \left(\theta(B)\Theta(B^s)/\phi(B)\Phi(B^s) \right) \cdot \varepsilon_t$$

where B is the backshift operator, $\theta(B) = 1 - \theta_1 B - \theta_2 B^2 - ... - \theta_q B^q$ and $\Theta(B^s) = 1 - \theta_1 B^s - \theta_2 B^s - ... - \theta_Q B^{Qs}$ are the regular and seasonal moving average polynomials, $\phi(B) = 1 - \phi_1 B - \phi_2 B^2 - ... - \phi_p B^p$ and $\Phi(B^s) = 1 - \Phi_1 B^s - \Phi_2 B^{2s} - ... - \Phi_P B^{Ps}$ are the regular and seasonal autoregressive polynomials, and $\varepsilon_t \sim N(0, \sigma^2)$ is a white noise variable.

The intervention parameters are as follows: ω summarizes the instantaneous impact, whereas δ is the long run effect of the intervention on the modelled time series. ξ_t is the exogenous event (intervention). The intervention can take the form of a step function ($S_t^{(T)}$), or a pulse function ($P_t^{(T)}$):

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2 Intervention analysis is preferred to the conventional t-test for mean value comparison because successive time series observations are possibly correlated (Enders, 2004).

$$\xi_t = S_t^{(T)} = \begin{cases} 0, & t < T \\ 1, & t \geq T \end{cases} \quad \text{or} \quad \xi_t = P_t^{(T)} = \begin{cases} 0, & t \neq T \\ 1, & t = T \end{cases}$$

Three different types of intervention function time dynamics are examined here as plausible explanations for the euro inflation perception gap.

$I_t = \omega S_{t-d}^{(T)}$,

where d is the time delay parameter. Equation (6) implies that the perception gap shifted to a certain level abruptly after the euro cash changeover and remained at that level thereafter.

$$I_t = \omega/(1-\delta B) S_{t-d}^{(T)}, \quad \delta < 1$$

Equation (7) involves a gradual adjustment of the perception gap, until finally reaching a long-run level.

$$I_t = \omega/(1-\delta B) P_{t-d}^{(T)}, \quad \delta < 1$$

Equation (8) hypothesizes an abrupt change of the perception gap in the 2002, but shortly after that the gap returns to its initial level.

3. Empirical Results

First step of the analysis was to find an appropriate ARIMA model for each observed perception gap series, namely for the period prior to the euro intervention (1997M01-2001M12). For that purpose the Hyndman and Khandakar (2008) ARIMA model selection approach has been applied, searching for the optimal number of regular and seasonal AR/MA terms in order to minimize the Akaike information criterion (AIC). Seasonal parameters are optimized considering separately $s = 0, 6, 12$. The results are shown in Table 1.[3]

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[3] The estimated coefficients are left out here due to space scarcity, but can be obtained from the authors upon request.

Table 1: Estimated ARIMA Models For the Pre-intervention Period

Country	ARIMA model	Ljung-Box statistic
Austria[4]	$ARIMA(0,1,1)(0,0,1)_{12}$	$Q_{24} = 24.673\,(0.172)$
Belgium	$ARIMA(2,1,1)(1,0,2)_{6}$	$Q_{24} = 13.558\,(0.559)$
Finland	$ARIMA(0,1,3)(0,0,1)_{12}$	$Q_{24} = 18.559\,(0.551)$
France	$ARIMA(1,0,2)(1,0,2)_{6}$	$Q_{24} = 13.329\,(0.821)$
Greece	$ARIMA(3,0,3)$	$Q_{24} = 17.384\,(0.497)$
Ireland	$ARIMA(0,0,4)(0,0,1)_{12}$	$Q_{24} = 15.544\,(0.687)$
Italy	$ARIMA(1,0,1)(0,0,1)_{12}$	$Q_{24} = 14.680\,(0.839)$
Netherlands	$ARIMA(0,1,1)(0,0,1)_{12}$	$Q_{24} = 29.073\,(0.143)$
Portugal	$ARIMA(3,0,3)(1,0,1)_{12}$	$Q_{24} = 13.909\,(0.605)$
Spain	$ARIMA(3,0,2)(1,0,2)_{6}$	$Q_{24} = 12.887\,(0.744)$
Euro area	$ARIMA(3,1,4)(1,0,2)_{6}$	$Q_{24} = 11.620\,(0.393)$

Equation (3) is estimated for each country, modelling the intervention separately by relations (6-8) for different delay periods ($d = 1, 6, 12, 24$). The results were found to be highly sensitive to the delay period, so table 2 presents the optimal intervention model for each country in terms of the AIC criterion.

It is clearly visible that the inflation perception gap exhibits an abrupt, but only temporary, increment following the 2002 changeover in the best part of the observed countries. The values of ω indicate an immediate rise of the perception gap by between -1.60 in Spain and 4.71 percentage points in the Netherlands. The "immediate" character of the perception gap shift should not be taken literally, considering it takes place with the time delay of 1, 12 or 24 months (depending on the country). δ parameters capture the rate of decay of the observed increase (between -0.955 in Italy and 0.989 in Austria and Finland).[5] There are only minor exceptions to these conclusions. The Greek inflation perception gap manifests a highly persistent immediate growth (in line with the conclusions of Sturm *et al*., 2009), while Belgium exhibits a more gradual adjustment of the instantaneous gap increase. All observed intervention models are proven to be adequate in terms of the Ljung-Box test.

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[4] Using the Hyndman and Khandakar (2008) selection approach, the optimal ARIMA model for Austria was found to be $ARIMA(0,1,1)(0,0,1)_{12}$, but the Ljung-Box autocorrelation test demonstrated its inadequacy. Hence it was reestimated as shown in the table in order to satisfy all model assumptions.

[5] Negative values of δ suggest a sinusoidal decline of the perception gap.

Table 2: Estimated Intervention Models

Country	Intervention model		Ljung-Box statistic
Austria	$I_t = \omega/(1-\delta B)P_{t-1}^{(T)}$	$\omega = 0.841\,(0.054)$ $\delta = 0.989\,(0.000)$	$Q_{24} = 31.180\,(0.149)$
Belgium	$I_t = \omega/(1-\delta B)S_{t-1}^{(T)}$	$\omega = 0.436\,(0.506)$ $\delta = -0.935\,(0.000)$	$Q_{24} = 32.737\,(0.110)$
Finland	$I_t = \omega/(1-\delta B)P_{t-1}^{(T)}$	$\omega = 1.501\,(0.000)$ $\delta = 0.989\,(0.000)$	$Q_{24} = 21.664\,(0.599)$
France	$I_t = \omega/(1-\delta B)P_{t-24}^{(T)}$	$\omega = 1.735\,(0.000)$ $\delta = 0.967\,(0.000)$	$Q_{24} = 23.825\,(0.472)$
Greece	$I_t = \omega S_{t-12}^{(T)}$	$\omega = 1.123\,(0.012)$	$Q_{24} = 27.569\,(0.279)$
Ireland	$I_t = \omega/(1-\delta B)P_{t-24}^{(T)}$	$\omega = 4.189\,(0.000)$ $\delta = 0.928\,(0.000)$	$Q_{24} = 20.882\,(0.646)$
Italy	$I_t = \omega/(1-\delta B)P_{t-12}^{(T)}$	$\omega = 0.270\,(0.002)$ $\delta = -0.955\,(0.000)$	$Q_{24} = 23.582\,(0.486)$
Netherlands	$I_t = \omega/(1-\delta B)P_{t-12}^{(T)}$	$\omega = 4.712\,(0.000)$ $\delta = 0.910\,(0.000)$	$Q_{24} = 26.117\,(0.347)$
Portugal	$I_t = \omega/(1-\delta B)P_{t-12}^{(T)}$	$\omega = 2.311\,(0.000)$ $\delta = -0.853\,(0.000)$	$Q_{24} = 15.273\,(0.913)$
Spain	$I_t = \omega/(1-\delta B)P_{t-12}^{(T)}$	$\omega = -1.603\,(0.024)$ $\delta = -0.710\,(0.000)$	$Q_{24} = 19.944\,(0.670)$
Euro area	$I_t = \omega/(1-\delta B)P_{t-24}^{(T)}$	$\omega = 0.851\,(0.001)$ $\delta = 0.794\,(0.001)$	$Q_{24} = 25.708\,(0.368)$

Note: p-values are shown in the parentheses

4. Conclusion and Policy Implications

The intervention analysis results in a quite uniform conclusion: the euro induced inflation perception gap has been, at the EA level and in most of the member countries, only a short-run phenomenon. After an abrupt gap increase due to the euro cash changeover, no significant permanent effect was found. These results connote some important policy implications, relevant for future EA member states. Specific communication strategies are needed as a crucial element of the euro adoption strategy, in order to properly inform the consumers about the time dynamics of the perception gap in current member countries and about the relevant factors influencing inflation perceptions. Such communication campaign is vital for two reasons. Firstly, from the perspective of economic policy holders, media reports are the only endogenously given inflation perception driving force. Even more importantly, having in mind the recent euro crisis, additional inflation perception pressures in future EA member countries might represent a definitive downfall of the public support of euro as a common currency.

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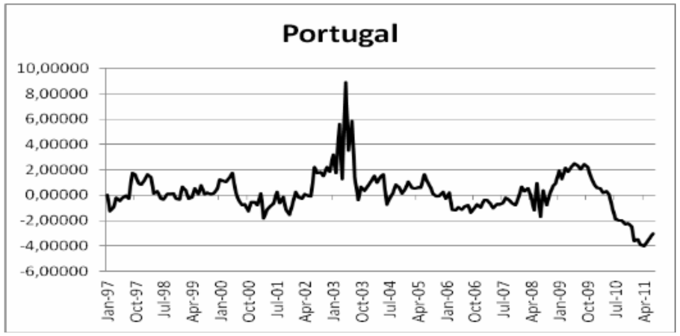
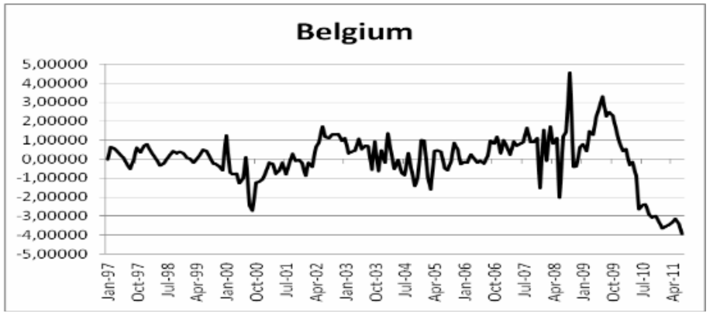
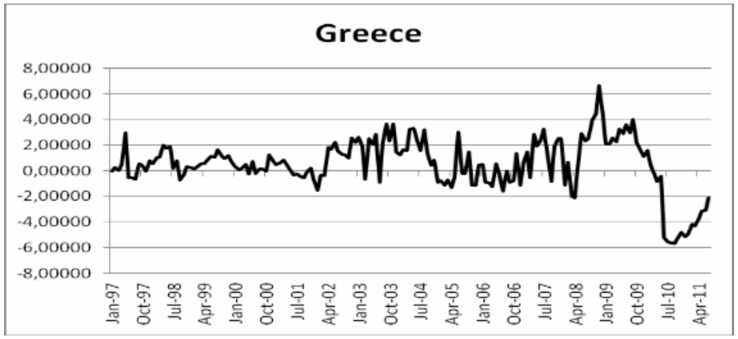
Appendix: Graphical Presentations of the Inflation Perception Gap Series







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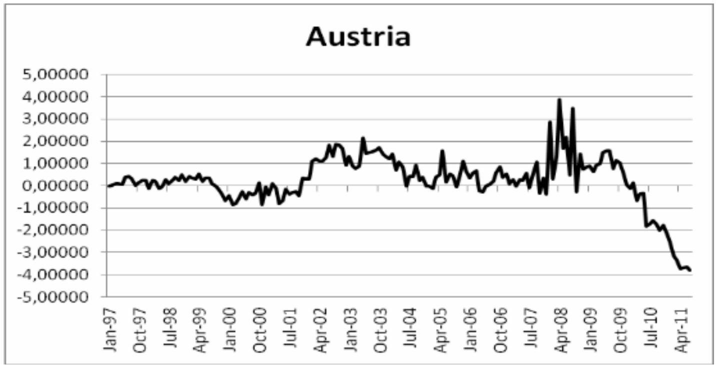

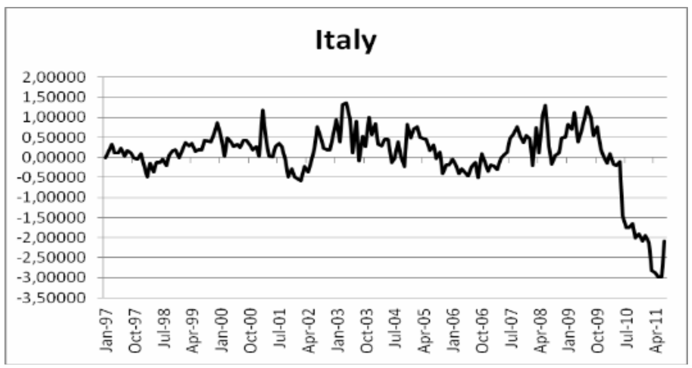

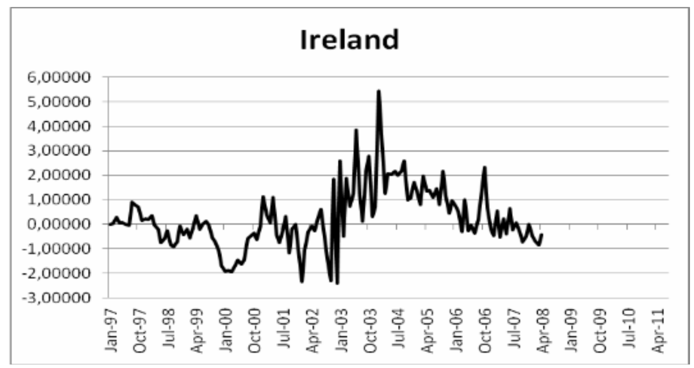

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