MEASURING THE RELATIONSHIP BETWEEN INFLATION AND ECONOMIC GROWTH: EVIDENCE FROM SELECTED EUROPEAN COUNTRIES

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Abstract

The relationship between inflation and economic growth is crucial in any economy; for this reason, it has received wide attention in theoretical and empirical works. The coexistence of high economic growth together with low inflation becomes an essential objective for policymakers. It is particularly interesting to study this relationship in economies converging to the most developed ones, as is the case of Central and Eastern European countries with respect to core economies in the European Union. This paper examines the relationship between inflation and economic growth for six European countries in 1991-2015. This work has a twofold objective. Firstly, to unveil the existence of the relationship in these countries; secondly, to detect a potential different behaviour regarding the impact of inflation on economic growth in these two groups of countries, as they have their idiosyncrasy. The results point to a long-run positive relationship in all countries; regarding the short-run dynamics of economic growth, it is proven to be nonlinear. Following the results, the similarities between the two sets of countries are found out and the policy implications are presented.

Key words: inflation; economic growth; convergence; cointegration; nonlinearities.

JEL Code: C32; E30; C24.

Introduction

The coexistence of high and sustained economic growth together with low inflation becomes an essential objective for policymakers. Due to these macroeconomic policy implications, the nature of the relationship between inflation and economic growth has been widely studied as well as controversial. Despite the fact that the debate is still intense, there is a reasonable agreement on the negative impact of inflation on economic growth in the medium and long run. In any case, a central question relies on the existence and nature of this relationship, as the vast existing literature confirms (Munir and Masur, 2009). Studies on this topic present ambiguous results on the characteristics of this relationship. Some authors suggest a negative association (Fischer, 1993; Barro, 1995); some others consider a positive one (Lucas, 1972). Recent strands of the literature stand for the presence of nonlinearities; the inflation level determines economic growth, so as to promote or deteriorate it (Sarel, 1995). In this sense, empirical literature has mainly focused on threshold effects in the relationship (Burdekin et al., 2004), although several authors have introduced nonlinear models (Espinoza et al., 2010).

This paper aims at determining the nature of the relationship between prices and economic activity, both in the short and the long run. Cointegration techniques will reveal any long-run relationship. Moreover, a key point of this work is the analysis on whether GDP re-adjust to its equilibrium path in a different way depending on the evolution of certain variable(s). It is of particular interest to study this relationship in economies converging to the most developed ones, as in Central and Eastern European countries (CEEs) with respect to core economies in the European Union (EU); in fact, we do not find much empirical evidence regarding CEEs in a nonlinear context. The results of the study may be useful for real convergence. The paper begins with the literature review (section 2). Section 3 describes the methodology applied. Section 4 presents the empirical evidence and analysis. Final section concludes.

1 Inflation and economic growth: literature review

1.1. Theoretical background

Does inflation improves or deteriorates the economic growth? There are different economic theories on this matter, being the Monetarist and the Neoclassical Growth theories the most important ones. Macroeconomic standards usually state that variations in the inflation rate do not affect real activity in the long run. However, a strand of the literature states that the effect in the long run relation exists and occur through different channels. Friedman (1977) poses the problem caused by high inflation rates: reallocation of resources to unproductive activities, economic efficiency distortion and lower employment. Other authors demonstrate that detrimental effects of inflation are not universal but depend on exceeding a threshold value (Sarel, 1996; Bruno and Easterly, 1998).

In relation to the previous comments, in recent times nonlinear behaviour was considered as the one that characterizes the relationship between these two variables. Moreover, nonlinearities may be different for developed and developing countries (Burdekin et al., 2004); in fact, supply and demand behave in a different manner in developed and developing countries, with the subsequent effects on inflation and other macro magnitudes.

A nonlinear perspective is also necessary in terms of policy implications so as to maintain inflation below the level that damages growth; by using threshold models, the level (threshold) at which high inflation becomes very costly for growth can be detected and then policymakers may adopt the necessary measures.

1.2. Empirical literature

Nowadays it is commonly accepted that inflation exerts a negative impact on economic growth, but it was not the case in the past. Thus, during the 60s most countries experienced low inflation rates and applied papers did not find evidence of a relevant negative relationship between both variables. In the 70s, however, episodes of hyperinflation took place in many countries; the validity of the positive relationship was questioned and studies on inflation focused on its negative impact on economic growth. Fischer (1993) evidences negative relationship between inflation and growth in a large set of countries by means of pooled cross-section, time series regressions. Using Instrumental Variables, Barro (1995) concludes that an increase in inflation slows per capita GDP growth rate. However, other analysis obtain a weak relationship. Bruno and Easterly (1998) demonstrate that sustained inflation levels do not significantly affect economic performance, but when inflation reaches critical levels, then real activity is severely affected. Other authors do not evidence long-run relationship.

Fischer (1993) suggested the consideration of nonlinear relationships. As Burdekin et al. (2004) point out, failure to account for nonlinearity biases the estimated effects of inflation on growth. Sarel (1996) detects structural breaks in the relationship between the two variables for developed and developing countries. Burdekin et al. (2004) achieve that inflation negatively affects growth from 8% inflation on for industrial economies and from 3% on for developing one. More recently, works on time series and panel data confirm the existence of threshold levels for inflation regarding its impact on growth. By means of TAR models, Munir and Mansur (2009) evidence a nonlinear relationship between the two variables in Malaysia; also using nonlinear threshold models, Espinoza et al. (2010) suggest that inflation above 10% inmediately harms growth in 165 countries except for advanced economies.

2 Methodology

2.1. Cointegration analysis

The potential existence of co-movements between time series can be analysed by means of the cointegration methodology. This technique allows us for investigating empirical evidence of, at least, one long-run relationship between the variables. The components of

$Y_t = (Y_{1t}, Y_{2t}, \ldots, Y_{nt})'$ are said to be cointegrated of order (d, b) if it is verified that all the elements of X_t are integrated of order d and there is a vector $\beta = (\beta_1, \beta_2, \ldots, \beta_n)$ so that the linear combination $\beta Y_t = \beta_1 Y_{1t} + \beta_2 Y_{2t} + \ldots + \beta_n Y_{nt}$ is integrated of order (d - b), with b > 0.

The cointegration study starts with the unit roots analysis. In this sense, we use procedures widely applied in the empirical literature: Augmented Dickey-Fuller (ADF), ADF-GLS and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests. The latter implies stationarity in its null hypothesis. These tests include the constant as deterministic component. In this paper we employ the Johansen (1988) cointegration procedure. Johansen's technique starts with an n-variables vector, $X_t = (X_{1t}, \ldots, X_{nt})'$, generated by a VAR process of order p:

$$Y_t = \mu + A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_p Y_{t-p} + \varepsilon_t \qquad t = 1, ..., T \qquad (1)$$

where Y_t is a vector of stochastic variables and ε_t is a vector with independent and identically distributed variables with zero mean and Σ_ε variance. The error-correction form for (1) is:

$$\Delta Y_t = \mu + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \ldots + \Gamma_{p-1} \Delta Y_{t-p+1} + \Pi Y_{t-p} + \varepsilon_t \qquad t = 1, ..., T \qquad (2)$$

where Γ and Π are coefficient matrices. Both equations may incorporate deterministic terms.

Π matrix contains information on the long-run relationship between the variables and its range provides the number of cointegrating relationships. In case Π rank is zero, there are n stochastic trends (i.e., no long-run relationships). When Π is a full rank matrix, all variables in Y_t are stationary. The intermediate situation occurs when the rank is lower than n: there are r potential cointegrating vectors different from zero. When the rank is larger than zero, Π is decomposed in α and β matrices. Thus, $\Pi = \alpha\beta'$, where β (cointegrating matrix) includes the coefficients for the cointegrating vectors and α (weight matrix) shows the weights for each vector in the n equations of the VAR. Two tests determine the number of cointegrating vectors: the trace and the maximum evigenvalue tests. By means of the λ_{trace} statistic, we test the null hypothesis that the number of cointegrating vectors is lower than r or equals r against the alternative of being larger than r. With the λ_{max} statistic, the null hypothesis that the number of cointegrating vectors is r against the alternative of r+1 is successively tested.

To center the discourse, we focus our attention on causality running from inflation to economic growth.

2.2 Nonlinear framework

The cointegration study is developed in a linear context, but are our variables related in a linear manner? It implies a severe restriction and nonlinear models may be better for capturing the behaviour of the variables in practice. We apply the Smooth Transition (ST) type of models. STs are state-dependent models with a linear data-generating process that switches between a certain number of regimes according to some rule. We use their widest generalization: the Smooth Transition Regression (STR); it contains an endogenous structure, as well as exogenous variables (see Teräsvirta, 1994; van Dijk et al, 2002, for further details).

Let y_t be a stationary, ergodic process, and, without loss of generality, only one exogenous variable x_t. The STR model is defined as:

$$y_t = w_t^{'}\pi + \left(w_t^{'}\theta\right)F\left(s_t;\gamma,c\right) + u_t \qquad (3)$$

where $w_t = \left(1, y_{t-1}, \ldots, y_{t-p1}; x_t, x_{t-1}, \ldots, x_{t-p2}\right)'$ is a vector of regressors, $\pi = \left(\pi_0, \pi_1, \ldots, \pi_p\right)'$ and $\theta = \left(\theta_0, \theta_1, \ldots, \theta_p\right)'$ are parameter vectors $p=(p_1+p_2+1)$, and u_t is an error process, $u_t \sim$ Niid $(0, \sigma^2)$. The transition variable (s_t) can be a lagged endogenous variable, an exogenous variable or a different variable. F is the transition function and is bounded between 0 and 1. F includes the slope parameter (γ), which reflects the smoothness of the transition from one regime to the other, and the location parameter (c) or threshold between these regimes. The regime at each t is given by s_t and the corresponding value $F(s_t)$. The most usual F forms are logistic and exponential; both models describe different types of behaviour. The logistic function implies extreme regimes associated with s_t values far above or below c, where dynamics may be different; the exponential behaviour involves extreme regimes related to low and high absolute s_t values, with rather similar dynamics, which can differ in the transition period.

The modelling cycle for STR models consists of three steps: specification, estimation and evaluation (Granger and Teräsvirta, 1993). The usual starting point is linearity testing, although many authors claim they are not so relevant for guiding the modelling process (van Dijk et al., 2002). The next step is STR estimation by means of an extensive search; we define several combinations for lags and F, and estimate by nonlinear least squares. Best models are subject to further refinement: non-significant parameters are dropped and cross-parameter and exclusion restrictions are validated. Finally, the estimated model is evaluated using misspecification tests. In this paper we use some specific tests for ST models: no error autocorrelation (AUTO) in the residuals and parameter constancy (PC). We also pay attention to the features of F and to diagnostic measures as the test of no ARCH structure and the variance ratio of the residuals from the nonlinear model and the best linear model (s^2/s^2_L).

It is reasonable to think that the economic growth dynamics could vary according to the characteristics of inflation in each country and time period. Likewise, nonlinearities may arise from the deviations of GDP from its equilibirium or from idiosyncratic components specific to economic activity. So as to consider these facts, we search for evidence of ST behaviour.

3 Empirical results

3.1 The data

Data used for our empirical application consist of two variables: Consumer Price Indexes (CPI) and Gross Domestic Product (GDP). We have selected a group of six European Union members: France, Netherlands, United Kingdom, Czech Republic, Poland and Slovakia. The sample ranges from 1991:Q1 to 2015:Q3 in the GDP case and to 2015:Q4 in the CPI case; all variables are in logarithms. Data have been obtained from Eurostat (GDP) and International Financial Statistics-International Monetary Fund (CPI).

3.2 Long run exam

In relation with unit root testing, numerical results are not shown for space reasons, but are available from authors. Results indicate clear rejection of the null hypothesis of unit root presence in CPI and GDP in all countries. Then, both variables are stationary around a constant. Regarding the long run analysis, table 1 reports the results of the Johansen tests.

Tab. 1: Johansen tests for the cointegration rank

	Rank	Eig. Value	Trace test	p-value (adj.)	λ-max test	p-value
Czech Republic	0	0.2438	35.051	0.0002	26.271	0.0005
	1	0.0892	8.7798	0.0593	8.7798	0.0590
France	0	0.3022	37.053	0.0001	34.179	0.0000
	1	0.0298	2.8737	0.6115	2.8737	0.6109
Netherlands	0	0.4103	53.045	0.0000	50.179	0.0000
	1	0.0297	2.8662	0.6129	2.8662	0.6123
Poland	0	0.1677	25.301	0.0090	17.255	0.0279
	1	0.0820	8.045	0.0824	8.0457	0.0821
Slovakia	0	0.1828	25.695	0.0077	18.974	0.0136
	1	0.0690	6.7206	0.1465	6.7206	0.1460
United Kingdom	0	0.3418	42.204	0.0000	39.735	0.0000
	1	0.0256	2.4689	0.6863	2.4689	0.6858

Source: Own elaboration.

Given that we have two variables, there can be at most one cointegrating vector. According to table 1, trace and largest eigenvalue tests indicate a rejection of the null hypothesis that the cointegration rank is zero; later, when the rank is one, we do not reject the null of a unique cointegrating relationship. Then, prices and GDP show a stochastic common trend.

From table 2 we observe a positive relationship running from prices to GDP in all countries, which meets some strands of the literature; the impact of prices on GDP is remarkable in Czech Republic, while Slovakia reveals a pretty insignificant effect. The magnitude of the impact does not appear to be related to the group of economies they belong to.

Tab. 2: Identified cointegrated vectors

Czech Rep.	$lGDP_t = -10.157 + 3.0999\, lCPI_t$	Poland	$lGDP_t = -5.0978 + 2.1114\, lCPI_t$
France	$lGDP_t = -2.4751 + 1.4923\, lCPI_t$	Slovakia	$lGDP_t = 4.6421 + 0.0407\, lCPI_t$
Netherlands	$lGDP_t = -4.2507 + 1.8229\, lCPI_t$	United Kingdom	$lGDP_t = 2.2262 + 0.6633\, lCPI_t$

Source: Own elaboration.

3.3 Nonlinearities: detection and model estimation

For those those countries with cointegration relationships we estimate linear models. These models initially include regular differences of both variables and their lags (up to 5), as well as the error correction term at t-1 obtained from the cointegration vector; parameters with the lowest t-values are successively excluded. Final linear specifications are the starting point for the next stages. Then, we test the linearity hypothesis against STR; we account for the previously mentioned variables as transition variables and we allow for the main F forms. Table 3 displays the p-values of the F tests (for space reasons, only lowest p-values shown).

Tab. 3: Linearity tests against Smooth Transition Regressions (p-values)

	s_t: Δp_t		s_t: Δq_t		s_t: ec_{t-1}	
	LSTR	**ESTR**	**LSTR**	**ESTR**	**LSTR**	**ESTR**
Czech Rep.	0.0000	0.0000	0.0000	0.0000	0.0008	0.0015
France	0.0030	0.0009	0.0107	0.0063	0.3411	0.1508
Netherlands	0.0034	0.0018	0.0077	0.0041	0.0009	0.0036
Poland	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Slovakia	0.0005	0.0032	0.0481	0.0000	0.0643	0.0001
United Kingdom	0.0112	0.0225	0.0006	0.0003	0.0255	0.1611

Source: Own elaboration. Notes: q_t stands for lGDP; p_t is lCPI; ec_t is the error correction term.

We obtain strong rejection of linearity for economic growth in all countries. These results serve as a guide for the subsequent estimation, but we also follow those authors in favour of an extensive search of STR models. We consider logistic (LSTR) and a generalization of the exponential case, the second-order logistic, functional forms (LSTR2). We explicitly include the error correction term, which captures the deviation from equilibrium. The proposed STR-ECM models are reported in table 4, along with several evaluation tests (based on six lags).

We achieve valid STR-ECMs for the economic growth in all countries. In most of them, economic growth depends on variations in general prices, as well as on GDP deviations from the long-run path; the recent history of GDP variations is only present as nonlinear driver in Czech Republic. Outstandingly, United Kingdom and Poland show abrupt regime changes, so that economic activity is especially sensitive to shocks in these countries. The role played by the error correction term should be stressed; movements in GDP appear to react to deviations from equilibrium in five out of six countries. The transition between extreme regimes is logistic in most cases, remarkably in the core ones. In United Kingdom and Netherlands GDP growth presents different dynamics depending on how the deviations behave; these thresholds are close to the corresponding ec_t means. In France, GDP growth dynamics is different for variations of prices below (lower regime) and above (upper regime) 0.7%.

Tab. 4: Estimated STR models

	Czech Rep.	France	Netherlands	Poland	Slovakia	United K.
Linear part						
Constant	0.02 (0.02)	0.03 (0.01)	-0.25 (0.13)	0.01 (0.001)	0.15 (0.06)	0.009 (0.000)
Δq_{t-1}	-0.26 (0.07)	0.39 (0.09)	-0.46 (0.21)			
Δq_{t-2}	-0.88 (0.19)	0.38 (0.13)				
Δq_{t-3}						-0.19 (0.11)
Δq_{t-4}					0.88 (0.12)	
Δp_{t-2}		-0.44 (0.13)				
Δp_{t-3}				-0.35 (0.12)		
Δp_{t-4}	-1.68 (0.40)					
Δp_{t-5}				-0.19 (0.11)		
ec_{t-1}	-0.004 (0.002)	-0.003 (0.001)	0.03 (0.02)		-0.02 (0.007)	
Nonlin. part	LSTR s_t: Δq_{t-2}	LSTR s_t: Δp_{t-5}	LSTR s_t: ec_{t-1}	LSTR2 s_t: ec_{t-1}	LSTR2 s_t: Δp_{t-5}	LSTR s_t: ec_{t-1}
Constant	0.04 (0.03)	-0.001 (0.002)	0.30 (0.13)	-0.02 (0.003)	0.02 (0.005)	-0.25 (0.14)
Δq_{t-1}			0.84 (0.24)			0.60 (0.16)
Δq_{t-2}		-0.38 (0.13)				0.53 (0.19)
Δq_{t-4}		-1.63 (1.11)		1.00 (0.05)	-1.03 (0.17)	
Δq_{t-5}						-0.27 (0.13)
Δp_{t-1}						-0.20 (0.17)
Δp_{t-2}		1.29 (0.74)				
Δp_{t-3}			-0.46 (0.14)	0.39 (0.12)		
Δp_{t-4}	5.16 (0.82)					
Δp_{t-5}				0.24 (0.11)		0.30 (0.16)
ec_{t-1}	0.004 (0.002)		-0.04 (0.02)			0.02 (0.01)
γ	1.66 (0.36)	2.21 (1.10)	5.29 (5.47)	19.91 (11.02)	20.23 (28.84)	21.91 (11.36)
c_1 (or c)	0.02 (0.002)	0.007 (0.002)	8.08 (0.15)	8.27 (0.04)	0.01 (0.001)	9.84 (0.008)
c_2				9.54 (0.05)	0.11 (0.03)	
s^2/s^2_L	0.38	0.82	0.77	0.59	0.78	0.76
ARCH	18.02 (0.006)	2.47 (0.87)	1.08 (0.98)	5.30 (0.50)	13.83 (0.09)	5.14 (0.53)
AUTO	2.21 (0.05)	1.27 (0.28)	1.03 (0.41)	1.79 (0.11)	0.66 (0.68)	0.88 (0.51)
PC	2.46 (0.003)	1.24 (0.25)	1.14 (0.34)	1.74 (0.05)	2.62 (0.04)	1.70 (0.05)

Source: Own elaboration. Notes: Values after regression coefficients are SEs of the estimates. Numbers in parentheses evaluation statistics are p-values.

In CEEs, we observe second-order logistic cases in Slovakia and Poland. Slovakia presents an inner regime for prices variations lower than 0.9% or higher than 10.8%, and an outer regime covering the remaining values; thus, when prices suffer from extreme variations, Slovak economy behaves in a different manner that when prices grow at normal pace. In Poland, extreme regimes are related to the values of the ec_t; as the mean for this variable is 8.03, the right outer regime is non-existent in practice. Finally, the economic growth in Czech Republic shows different dynamics depending on its own recent history (threshold is 2% growth).

Validation tests do not evidence misspecification in the estimated models. Nonlinear models show an important explanatory power in comparison with the linear ones; the variance ratios point out that estimated STRs explain 18 to 62% of the residual variance of the linear models. In summary, we evidence a nonlinear short-run dynamics in the economic activity; the main underlying factors in this asymmetric evolution are the deviations of GDP and the movements of prices. Our two sets of countries do not behave in a completely different manner regarding GDP growth; this might be a symptom of real convergence between the economies.

Conclusion

This paper examines the relationship between inflation and economic growth for six European countries over 1991-2015; three of them are representative of core countries and the other three are economies which have recently joined the EU (some of them experienced high inflation episodes). As theoretical and empirical literature states, the relationship and effects of inflation on economic growth is far from being clear; we restrict the analysis to this sense of causality. Our main objective is to analyse this relationship in the long and the short run, focussing special attention on the existence of nonlinearities. It may be sensible that economic growth behaves differently depending on the evolution of certain events or variables.

To examine the extent to which prices explain the long-run path of GDP, we use cointegration theory. We provide empirical evidence supporting long-run relationship between prices and GDP in the six countries. Moreover, we prove the nonlinear nature of the short-run dynamics of economic activity in all countries; short-run evolution mainly depends on GDP deviations from the long-run path and the behaviour of prices. We evidence the fundamental role played by prices of goods and services in the evolution of any economy. In addition, deviations from equilibrium are both determinants of the economic growth structure and main drivers of GDP nonlinear behaviour. Then, policymakers should pay close attention to divergences from the equilibrium state, as well as to the evolution of prices, to promote economic growth.

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