THRESHOLDS IN THE RELATIONSHIP BETWEEN INFLATION AND ECONOMIC ACTIVITY

The authors of this article are Pilar Cuadrado and Enrique Moral-Benito, of the Directorate General Economics, Statistics and Research.

This article analyses the sensitivity of inflation to changes in activity in the Spanish economy. The non-linear approach adopted allows this sensitivity to be estimated for different economic growth regimes. Specifically, the estimates for the period from 1983 to 2015 indicate that this sensitivity is higher in periods in which the output gap is very small (deep recessions) and, above all, in those in which it is abnormally large (upturns with strong economic growth). By contrast, in periods of moderate growth or mild contraction, economic activity, as measured by the output gap, is of limited value as an inflation predictor.

Introduction

The relationship between economic activity and inflation is known in the economic literature by the name of the Phillips curve.[1] This relationship is an early detector of inflationary pressure during the expansionary phase of the economic cycle, when capacity utilisation is high, while in downturns the existence of idle resources and the lack of demand put downward pressure on prices. However, in recent years the ability of the various measures of cyclical position to detect early the short-term behaviour of inflation has been questioned.[2] In particular, there is some concern over the reliability of the approaches based on the Phillips curve for characterising the inflation process and over the stability of the functional relationship which links economic activity and inflation over time. Thus, recently the literature has pointed to factors such as globalisation or the imperfect anchoring of inflation expectations as perhaps having affected the stability of this relationship.

In Spain, Álvarez, Gómez and Urtasun (2015)[3] report evidence of certain changes in the sensitivity of inflation to activity in recent years. In the United States, Barnes and Olivei (2003) showed that the relationship between activity and inflation is non-linear. Specifically, these authors estimate Phillips curve equations in which the sensitivity of inflation to economic activity (measured by the output gap) depends on the level of that output gap. Thus, when the absolute value of the output gap is high (whether positive or negative), inflation is usually more sensitive to activity than when the absolute value of the output gap is low. That is to say, only in situations of very high slack (very negative output gap or deep recession) or at times when the economy is using more resources than are usually required (expansion with high growth) will the cyclical position be a good inflation predictor.

A similar approach to that of Barnes and Olivei (2003) is used in this study to estimate Phillips curve relationships for the Spanish economy in which the sensitivity of inflation to economic activity, proxied by the output gap, is permitted to take on a different value when certain output gap thresholds are exceeded. The results of this analysis show that in Spain there is also a non-linear relationship between inflation and activity. Indeed, the estimates for the period from 1983 to 2015 indicate that the sensitivity of inflation to economic activity is higher in periods in which the absolute value of the output gap is higher. This empirical

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1 Named after the author who described this relationship for the United Kingdom in the first half of the 20th century [A. W. Phillips (1958)].

2 See, for example, Stock and Watson (2009).

3 Specifically, Álvarez, Gómez and Urtasun (2015) find that the response of inflation differs in upturns and downturns, being greater in the latter.

evidence leads us to conclude that, during a significant portion of the sample, the information represented by the cyclical position of the economy is of limited use in predicting inflation.

The rest of the article is divided into three sections. Section 2 sets out the data used and gives descriptive evidence for the main findings of the article documented in Section 3, which explains the formal analysis used to identify the non-linear relationship between activity and inflation described earlier. Lastly, Section 4 adds some final considerations.

Data and preliminary evidence

The variables considered in this analysis are inflation, measured by the seasonally-adjusted annualised quarter-on-quarter change in the consumer price index (CPI), and the output gap of the Spanish economy, measured as the percentage difference between the observed GDP and its potential level. The economic slack or output gap is a variable that, since it cannot be directly observed, has to be estimated. Here it is estimated using a production function methodology.[4] The series used in the study have a quarterly frequency and cover the period from 1983 Q1 to 2015 Q4. However, the analysis of robustness makes use of alternative measures of inflation based on wages and on the CPI excluding unprocessed food and energy. Also, the estimates include import prices in order to control for supply factors.

Chart 1 shows the relationship between inflation and the cyclical position (output gap) of the Spanish economy over the last 32 years in Spain. This evidence reveals the coexistence of periods in which, when the output gap is positive (upturn) —or negative (downturn)—, inflation increases —or decreases—, and others in which this relationship is not so evident. This relationship seems to be stronger for higher absolute values of the output gap, i.e. in sharp upturns or downturns. This is seen most plainly in the upturn in the middle of the first decade of this century and in the last downturn, particularly from 2011 to 2014. These two are characterised by output gaps that lie outside the range extending from -3 percentage points (pp) to +3 pp, as illustrated by the output gap bands included in Chart 1.[5]

El Chart 2 depicts an alternative way of analysing the relationship between the output gap and inflation, in which the same information included in Chart 1 is shown in the form of a scatter diagram, distinguishing between inflation levels above and below a certain output gap threshold. Also, the quarters in which the output gap is above 3 pp or below -3 pp are distinguished from the rest. As seen in Chart 2, the relationship between the two variables is more significant in the red dots, which correspond to quarters in which the output gap is above (below) +3 pp (-3 pp). By contrast, the relationship seems weak in the other quarters, in which the output gap has less extreme values. The next section formally analyses this preliminary evidence.

Non-linearity in the relationship between inflation and activity

The Phillips curve relationship traditionally seen in the literature considers a linear relationship between inflation and an economic cycle indicator, such as the output gap, controlled by other variables that may give rise to price changes, such as expectations of inflation or other production costs. Thus, a linear Phillips curve relationship would adopt the form of equation 1 below:
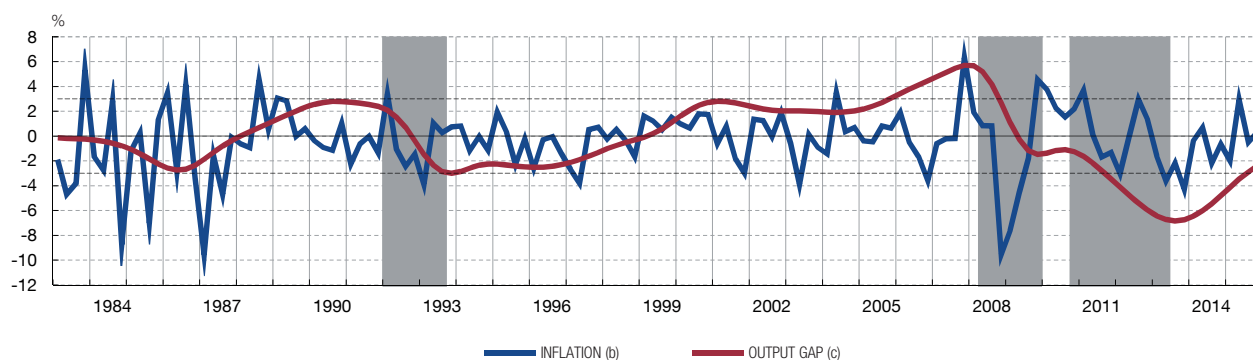
$$\pi_t = \mu + \beta OG_{t-1} + \gamma Z_t + u_t \qquad [1]$$

where π_t is the annualised quarter-on-quarter rate for the overall consumer price index, OG_{t-1} is the output gap and Z_t represents a vector of additional variables including supply

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4   Seé Cuadrado and Moral-Benito (2016).
5   In the econometric analysis in the next section, statistical criteria are used to identify alternative ranges.
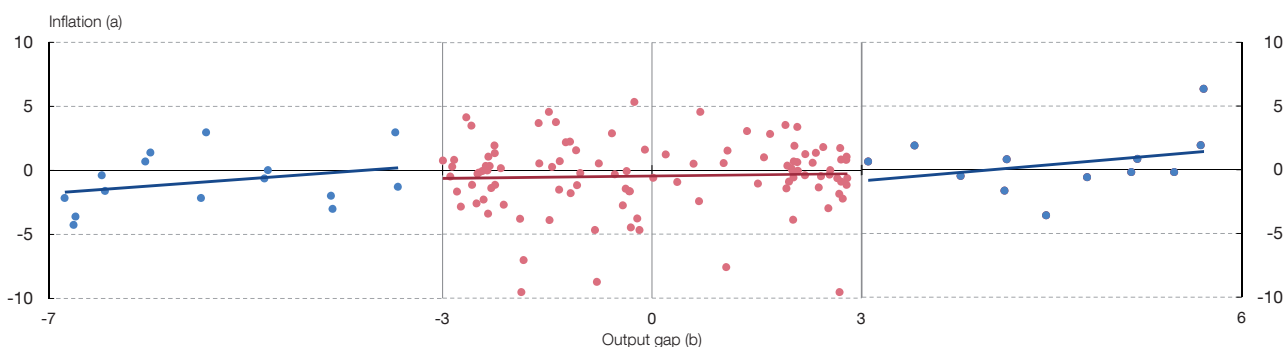
INFLATION AND OUTPUT GAP IN THE SPANISH ECONOMY

INFLATION (b)   OUTPUT GAP (c)

SOURCES: INE and Banco de España.

a The shaded areas indicate the recessions identified by the Dating Committee of the Spanish Economics Association.
b Year-on-year rates of change of the inflation rate.
c Percentage difference between observed and potential GDP, expressed with respect to potential GDP.

LINEAR ADJUSTMENTS BETWEEN CYCLICAL POSITION AND INFLATION

SOURCES: INE and Banco de España.

a Year-on-year rate of change of the inflation rate.
b Percentage difference between observed and potential GDP, expressed with respect to potential GDP.

factors and expected inflation. [6] All the variables are observed quarterly and are seasonally adjusted.

The parameter of interest in this equation is β, which quantifies the sensitivity of inflation to economic activity. Usually, this sensitivity is constant regardless of the output gap level, as in equation 1. However, based on prior preliminary evidence, the Barnes and Olivei (2003) specification, whereby this relationship may change depending on the size of the output gap, has been adopted. Specifically, it allows the sensitivity between inflation and the cyclical position, reflected by the coefficient β, to adopt two different values: β_1 if the output gap is small and β_0 if it is extreme (either very positive or very negative). In accordance with the descriptive evidence set forth in Section 2, it is expected that sensitivity will be greater in cases of extreme output gap, i.e. $\beta_0 > \beta_1$.

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6   Specifically, it includes the annualised quarter-on-quarter rate for the imports of goods and services deflator to approximate supply factors, and a weighted average of past inflation rates to approximate inflation expectations (the weights are estimated on the basis of the data observed without imposing any restrictions on coefficients).

	Symmetrical thresholds (b)	Asymmetrical thresholds (c)	Asymmetrical thresholds and differing effect depending on the sign of the output gap (c)
β_I	-0.05	-0.40*	-0.40*
	(0.54)	(0.05)	(0.05)
β_O	0.16***	0.14***	
	(0.00)	(0.00)	
β_O^-			0.59***
			(0.01)
β_O^+			0.89**
			(0.05)
Number of observations	131	131	131
F	355.21	329.60	263.65
Prob > F	0.00	0.00	0.00

SOURCE: Banco de España.

a The figures in brackets are p-values based on Newey-West heteroskedasticity and autocorrelation consistent standard errors. The asterisks *, ** and *** indicate significance at a confidence level of 90%, 95% and 99%, respectively.
b Symmetrical thresholds of 4.8 pp for the output gap.
c Asymmetrical thresholds of -1.3 pp and 4.4 pp for the output gap.

In order to estimate the thresholds that define whether the output gap is moderate or extreme, the Peach, Rich and Cororaton (2011) methodology, which chooses the thresholds that provide a better adjustment of the data in terms of mean square error, is used. This procedure identifies a threshold of 4.8 pp in absolute terms for the output gap relating to the Spanish economy data sample used in this article. In other words, the relationship between inflation and activity would be different if the output gap were greater than 4.8 pp or lower than -4.8 pp. This occurred, in the sampling window considered, during the later quarters of the 1995-2007 boom, as well as during the later quarters of the 2008-2013 recession. Additionally, if asymmetrical thresholds are permitted, the estimate identifies -1.3 pp as the lower limit and 4.4 pp as the upper limit. In this case, certain less severe recessions, such as those of the mid-80s and early 90s, when the output gap was below -1.3 pp, would be considered extreme output gap episodes.

Table 1 details the results of the regressions. In general, a positive effect of the output gap on inflation that is more marked in situations of extreme output gap ($\beta_0 > \beta_1$) can be observed. The first column of Table 1 reflects symmetrical thresholds, and a positive and significant impact of the cyclical position on inflation is estimated only when the latter exceeds the estimated thresholds. Conversely, for cyclical situations characterised by a moderate output gap, the cyclical positions would not show a significant relationship with inflation. Column 2 depicts the case of asymmetrical thresholds, obtaining significant coefficients inside and outside the thresholds, but, in line with the results of the first column, with greater sensitivity of inflation to the output gap outside the thresholds identified when the output gap is extreme.

In any event, the magnitude of the estimated effect for the output gap outside the thresholds is relatively small.[7] For example, an increase in the output gap of 1 pp (less economic

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[7] This result is in line with the results of Álvarez, Gómez and Urtasun (2015), who also find, in the best of cases, lower sensitivity of inflation to the cycle in the case of Spain.

slack) would be associated with an increase in inflation of between 0.14 pp and 0.16 pp, which is low in comparison with the results obtained for other countries.[8]

Similar results are obtained when alternative means of measuring inflation are used (core inflation measured by the CPI excluding energy and unprocessed food or wage inflation). Therefore, the sensitivity of inflation to economic activity is significantly higher when the excess (or lack of) demand is very pronounced, whereas in less extreme situations, economic activity has scant predictive power over inflation.

The results discussed so far are based on the assumption that the effect of the output gap on inflation is the same when the output gap is very positive (extreme expansion) and when it is very negative (extreme recession), the coefficient being β_0 in both cases. Alternatively, we will consider an even more flexible model where the sensitivity of inflation to the cyclical position changes not only on the basis of the size of the output gap in absolute terms, but also depending on whether the economy is in a period of expansion or recession. Thus, the sensitivity coefficient may have three different values: β_1 when the output gap is moderate, β_0^- when it is very negative, and β_0^+ when it is very positive.

The third column of Table 1 shows the results of estimates under the more flexible model. The results suggest that the relationship between inflation and economic activity is especially strong when output gaps are large and positive; i.e. in periods of extreme expansion the output gap would signal future changes in inflation, being less significant during recessions, even if the output gap is very negative. The estimated effect of an output gap higher than 4.4 pp is economically significant: an increase of 1 pp in the output gap would entail an increase of 0.89 pp in inflation, while a decrease of 1 pp in the output during a recession would result in inflation being 0.59 pp lower.[9]

Therefore, empirical evidence would point to a more significant effect of economic activity on inflation in exceptional situations, i.e. when the output gap is either very positive or very negative. In addition, the main source of this sensitivity in extreme situations seems to come more from expansions than from recessions, and the sensitivity of inflation to activity is slightly higher when the output gap is very positive, as depicted in the third column of Table 1. Conversely, in situations of moderate expansion and recession, the reaction of inflation to changes in economic activity is limited.

Conclusions

The recent economic recession has led to renewed interest in the relationship between the cyclical position of an economy and inflation. Specifically, the debate has focused on the effect that the economic downturn had on price behaviour and, more recently, with the end of the crisis and the consequent closing of the output gap, on determining to what extent rises in inflation can be forecast in the future.

Our analysis contributes to this debate by showing empirical evidence that the relationship between the productive capacity of Spain's economy and its inflationary process is not linear, as is usually assumed when estimates of Phillips curve relationships are made. In particular, our results indicate that the predictive power of the output gap over inflation is significant when it exceeds certain thresholds, especially in the case of expansionary phases where the output gap is very large. Based on these results, the gradual closing of

8   For example, Matheson and Stavrev (2013) estimate sensitivity to be around 0.5 for the United States in recent years.

9   Note that the effect during expansions is estimated on the basis of seven quarters between 2006 and 2007, while the effect during recessions uses 51 quarters in the three recessions identified in the sample.

the output gap that is accompanying the current economic recovery would be compatible with the absence of inflationary pressure if the output gap is still far from the thresholds estimated to be required for its positive relationship with inflation to be significant.

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