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Explaining Irish Inflation During the Financial Crisis

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Explaining Irish Inflation During the Financial Crisis*

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Abstract

The recent financial crisis resulted in a steep contraction in the domestic economy together with a sharp decline in inflation. The Phillips curve model of inflation argues that inflation should be negatively related to economic performance and this would seem to be a potential explanatory factor in the behaviour of Irish inflation during the financial crisis. However, Ireland is a very open economy and the Phillips curve has been criticised as an inappropriate model of inflation for Ireland on the basis that inflation is primarily imported from abroad with little role for domestic factors. We formally assess what role domestic economic activity has on inflation in Ireland. We make a number of findings. First, the deflation in Ireland was unusual by domestic historical and international standards. Second, we find the short-run unemployment gap is the most appropriate way to measure slack in the domestic economy. Third, having controlled for international factors, there is a relationship between the domestic economy and inflation. Fourth, the relationship is not stable over time but seems to depend on the state of the business cycle. Fifth, these types of models predict the actual fall in inflation during the financial crisis quite well. We conclude that these results support the idea that inflation is not purely externally determined in Ireland.

Keywords: Phillips Curve, Financial Crisis, Threshold Model.

Jel Codes: E31, E37.

*The views expressed in this paper are the personal responsibility of the authors. They are not necessarily held either by the Central Bank of Ireland or the ESCB. Any errors are our own.

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Non Technical Summary

Given the highly open nature of the Irish economy, economists have long questioned whether the performance of the domestic economy matters in terms of explaining Irish inflation. Many have argued that Irish inflation is determined by external factors such as the exchange rate, oil prices and import prices with little role given to domestic factors. However, following the onset of financial crisis, Ireland suffered a large decline in output and a dramatic increase in unemployment. A period of sustained deflation ensued. The deflation associated with the financial crisis means that it is natural to re-examine if there is a link between the economic conditions and inflation and, secondly, if this link can explain the fall in prices which followed the onset of the crisis.

The Phillips curve is a theory of inflation where the rate of change of prices in an economy depends on the amount of slack in the economy. When the economy is operating below (above) capacity, inflation is likely to be low (high). In order to assess the link between the activity in the economy and inflation, we conduct our analytical work in three steps. First, we attempt to estimate the degree of slack in the economy. This is difficult in the Irish economy given the highly open nature of the economy in terms of trade, labour and capital as well as the presence of a large multinational sector. We estimate slack measures based on output and labour market variables respectively. Overall, we find the latter to be more credible indicators of slack for Ireland.

The second step is to take these measures of slack and test whether they influence domestic inflation - this amounts to estimating a Phillips curve. Given the highly open nature of the economy, we also control for external influences on inflation. The results of our analysis suggests there is a relationship between economic slack and various measures of inflation and this is more robust when slack is measured using employment variables rather than output.

The third step is to test if the relationship between the economy and inflation is stable over time. Meier (2010) and Stock and Watson (2010) both suggest that measures of slack are more likely to matter during a recession based on the experiences in other countries. The idea is that a collapse in domestic output has deflationary effects. We test this theory by estimating our preferred Philips curve models but allow the coefficients to change depending on whether our slack measure is positive or negative, which aims to capture booms and recessions respectively. Our results support the hypothesis that domestic economy has a greater impact on inflation during a recession. It is also possible to construct forecasts of inflation over the crisis period using our preferred model which align closely with the actual outturn for inflation. This is further evidence to suggest that economic slack has some influence on inflation in Ireland.

1 Introduction

As a consequence of the property collapse and meltdown of the banking system, Ireland experienced a dramatic decline in economic activity with real GDP declining by 14 per cent over the period 2008 to 2010 and unemployment increasing from below 5 per cent to over 14 per cent. Moreover, CPI inflation entered negative terrority during this period reaching a peak deflation rate of -6.6%. The drop in inflation following the economic contraction is potentially consistent with a Phillips curve model of inflation but such a model has frequently been dismissed as unimportant in an Irish context on the grounds that Irish inflation is mainly externally determined and previous research has shown very little role for domestic factors. In this paper, we estimate a Phillips curve for Ireland and conduct a conditional forecasting exercise to assess whether economic conditions have a role in explaining inflation over the crisis period. This is in the spirit of Ball and Mazumder (2011) who conduct a similar analysis for US inflation. We estimate the Phillips curve for Ireland in three steps.

The first step is to estimate measures of economic slack. In terms of output measures, slack has traditionally been proxied by the output gap, which is defined as the difference between actual output and potential or trend output. The factors of production in Ireland are unusally mobile. The large amount of Foreign Direct Investment (FDI), which allowed us to import capital and associated productivity gains, coupled with an internationally mobile workforce means that it is often difficult to identifty the potential productive capacity of the nation. This complicates measurement of potential output in Ireland. In addition, Ireland is the quintessential small open economy. Exports and imports are on a par with GDP. Moreover, goods exports are dominated by multinational firms and these firms are less labour intensive than small and medium enterprises (O'Brien and Scally, 2012). An export-led recovery is hoped for in Ireland but the capital intensive nature of large exporting firms suggests that the employment situation would be slow to improve in this scenario. Thus, even if we overcome issues in relation to the measurement of potential output, there are reasons to believe that the link between output and inflation might be weaker for Ireland relative to other countries. Nonetheless, we construct measures of the output gap for Ireland using a number of statistical filters. We find that they capture some business cycle features but there is considerable heterogeneity among the different estimates.

The alternative is to use labour market variables to construct a measure of economic slack. Changes in the labour market could affect inflation in one of two ways. Changes in the total number of people employed in the economy will affect the amount of aggregate income available for consumer

spending, resulting in demand-side influences on inflation. For this reason, one measure of slack we use is total employment growth. Alternatively, as the unemployment rate increases and there are more people competing for jobs, this can lead to downward pressure on wages and lower production costs, resulting in supply-side influences on inflation.

Traditionally, Phillips curves have been estimated based on the unemployment gap, defined as the difference between actual unemployment and the natural rate or NAIRU.[1]. Moreover, it has been suggested (Blanchard and Wolfers (2000), OECD (2002) and Llaudes (2005)) that the long-term unemployed play a less important role in the labour market relative to the short-run unemployed. Their skills and experience are less current so they exert less influence on prices. In addition, Kruger and Mueller (2011) show that job search intensity declines (fewer hours per week) with duration of unemployment, again indicating that long-term unemployed may be less influential in the job market. For these reasons, we place particular emphasis on labour market variables including employment growth, the short-run unemployment rate and the cyclical component of short-term unemployment in particular. We find that employment based measures provide estimates of slack that accord reasonably closely with the Irish business cycle and there is greater comovement between these slack measures relative to output gaps.

The next step is to test for a relationship between domestic slack and inflation, i.e. test for the existence of a Phillips curve relationship for Ireland. Ireland is frequently cited as a classic example of a small open economy. It is a price taker on international commodity markets, meaning that a component of Irish inflation is largely determined by the external environment, particularly the exchange rate. The prominance of the exchange rate in early research is explained by Ireland's fixed exchange rate with the UK, a link which was maintained until 1979. Geary (1976) conducts a Phillips curve analysis for Ireland and finds that the exchange rate is the dominant factor. He finds the unemployment rate is not statistically significant in a price equation.[2] In later research, the exchange rate is still given a prominent role (Flynn and Honohan (1986), Kenny and McGettigan (1999), Honohan and Lane (2003) and Slevin (2003)) but there is little agreement generally regarding the role of domestic factors in explaining aggregate Irish inflation. The most successful attempts to link domestic factors to inflation split aggregate inflation into a traded and a non-traded or domestically generated component. Domestic factors are then related to the domestic component

[1]The natural nate of unemployment is an equilibrium level of unemployment in the economy such that there is no upward or downward pres- sure on wages or prices. See Estrella and Miskhin (1999) for a distinction between the two concepts.

[2]See Kenny and McGettigan (1997) for an extensive survey of early literature.

of inflation. This approach is adopted by Kenny and McGettigan (1999) (although the evidence for domestic factors is limited to bivariate causation between wages and prices) Myler (1999) and Slevin (2001, 2003). Despite some sucessful research along these lines, a traditional Phillips curve, even one which incorporates external factors, is not considered a workhorse model of Irish inflation.

In keeping with this literature, we also consider different measures of inflation. We examine four different measures of inflation : CPI inflation, CPI excluding mortgage interest (closely corresponds to the Harmonised Index of Consumer Prices), CPI excluding energy and unprocessed food (common measure of core inflation) and services inflation exluding mortgage interest (proxy of non-traded inflation). We find that there is a relationship between economic activity and inflation - evidence in favour of a Phillips curve for Ireland. This relationship is more robust when slack is measured using employment-derived measures particularly the short-run unemployment gap. Indeed, it is possible to estimate a Phillips curve using short-run unemployment gap based measure of slack for all four measures of inflation whereas output gaps do not have any impact on overall CPI inflation.

The third step in our Phillips curve analysis is to assess the stability of the relationship between the domestic economy and inflation. Ball and Mazumder (2011) find that the Phillips curve can explain US inflation during the crisis if core inflation is used as the dependent variable and the coefficient on the output gap is allowed to vary over time. The output gap coefficient changes in line with the level and variance of inflation. This is justified by a theory of costly price adjustment. Bermingham (2012) shows Irish prices showed a high level of price flexibility, particularly during the financial crisis so a model of costly price adjustment is not used to motivate coefficient change in our model .

Instead, it may be the case that the link between the domestic economy and inflation may vary depending on the state of the business cycle. Meier (2010) and Stock and Watson (2010) argue that periods of disinflation are caused by domestic economic conditions and accordingly formulate a theory surrounding a so called "*recession gap*". This highlights that the gap measures of economic slack may only matter during a recession. We test this hypothesis for Irish inflation using recursive estimation and threshold models. Our results confirm that the state of the domestic economy is more important in terms of explaining inflation when the economy is contracting or in a recession. We do not find it necessary to restrict our attention to core inflation, a point subsequently made by Stock (2011) in relation to US inflation.

We use the model chosen based on our Phillips curve analysis to construct forecasts of inflation during the crisis period. Our dynamic forecasts are conditional on actual measures of slack and

external variables. The results show that the decline in inflation is broadly in line with what could have been predicted using the model. We conclude that the deep contraction in the domestic economy had a significant impact on inflation and that the magnitude of this impact was in line with the model predictions. Moreover, our model suggests that such a decline is temporary.

We make a number of contributions to the literature. We show that despite some scepticism, there is evidence in favour of a Phillips curve in Ireland. This relationship is more robust when slack is measured using employment variables, particularly the short-run unemployment gap and echoes the sentiments of Ball and Manzunder (2011), Stock (2011) and Llaudes (2005). The relationship is not stable over time but depends on the position of the economy in the business cycle. The forecasting results during the crisis, during a period of strong deflation, which is rare for industrialised countries, provide important evidence supporting the Phillips curve. Comparable to the results for the US economy, we find that the coefficient on the gap changes over time although the theoretical justification for that change is different. While Meier (2010) used an event study to look at the idea of recession gaps, our results provide complementary econometric evidence to that of Stock and Watson (2010) using an alternative time series approach. This evidence is important as the small open nature of the Irish economy provides a different test of the theory compared to the US evidence in Stock and Watson (2010).

2 Putting Irish Inflation during the Crisis in Context

In seeking a preliminary assessment of whether inflation declined by as much as expected during the crisis period, one useful gauge is to examine the historical evolution of inflation over a long time period. This gives a sense of the usual range of values for inflation. The price level and inflation rate for Ireland since January 1932 are plotted in Figures 1 and 2. Both series indicate that a period of falling prices (negative inflation) is very rarely observed in an Irish context. The drop in the price level associated with the recent financial crisis breaks a long upward trend in prices. It is noteworthy that the only other comparable decline in the price level (negative inflation) over an eighty year period was observed during the Great Depression.

How does the performance of Irish inflation during the crisis compare with other countries experiences? In Figures 3 and 4 the HICP year on year inflation rates for Germany, France, Italy, Spain, Portugal, Greece and the UK are plotted.[3] In terms of Northern European countries, we see

[3]Two eurozone countries, Portugal and Greece, are on a program of financial assistance similar to that of Ireland while Spain and Italy have come under pressure in terms of government bond yields.

that the UK has the highest inflation rate over the period while the northern eurozone countries experienced a brief and very mild period deflation during the financial crisis.

The "Southern/Periphery" european countries, which groups the three program countries together with Spain, display somewhat different inflation dynamics. The average inflation rates are higher for this group in the pre-crisis period. Deflation in these countries is also greater in both magnitude and duration during the crisis. Greece and Ireland stand out amongst these countries but for different reasons. The Greek economy did not experience deflation despite the severity of the crisis there. In contrast, the deflation witnessed in Ireland is greater in magnitude than the other countries. More salient, however, is the length of the period of deflation in Ireland. Other countries return to inflation quickly but Ireland remained in deflation for 22 consecutive months. Returning to our research question, it seems that the period of deflation experienced in Ireland was unusual by international standards. It was also unusual by Irish historical standards. If a Phillips curve model can explain pricing dynamics in such an unusual period of deflation, it is compelling evidence in support of the theory.

3 Measuring Slack in the Economy

3.1 Output Approaches

The first step in terms of estimating a Phillips curve is to develop some measure of slack in the economy. A standard approach is to estimate an *output gap*, defined as the difference between actual and the trend level of output. The trend may be interpreted as representing potential output. However, the trend is unobservable and instead must be estimated. There is no universally accepted approach to estimating the trend but the most common approach is to use a statistical filter and this is the approach adopted here.[4] The sample for the GDP data is from 1980Q1-2011Q4. The data are taken from the quarterly national accounts from 1997Q1 onwards but quarterly data prior to that are interpolated from annual series. The data are also seasonally adjusted.

The most common statistical filter used to extract a trend from a series is the Hodrick Prescott (HP) filter. This is a simple mechanical detrending procedure and assumes that the trend and

[4] Alternative approaches include assuming an aggregate production function for the economy and assessing actual relative to potential supply of each of the factors of production such as labour and capital as well as technology or based on a fully articled model of the economy.

cyclical component are uncorrelated.[5] Despite its popularity, the underlying assumptions may not always hold in practice. A standard empirical problem associated with the filter is the so called end-point problem. The filter uses future and past information in order to calculate the trend at a particular point in time. At the end of the sample, there are no future data points so the filter becomes one sided. This can have an undesirable impact on the trend.

The exponential smoother is an alternative method of extracting a trend from a series. At each point in time, the current trend is equal to a weighted average of the trend in the previous period plus the observed value of the series in the previous period:

$$\tau_t = \alpha y_{t-1} + (1 - \alpha)\tau_{t-1} \tag{1}$$

where τ_t is the trend at time t and y_t is the observed series, which is real GDP in this case. The parameter, α, determines the weight that is given to the previous observation with a weight of $(1-\alpha)$ given to the previous trend. Larger values of α means that the trend tracks the actual series more closely. For quarterly data, a value of 0.05 is commonly chosen so that the trend in the previous period is given a weight of 0.95. This means that the trend changes very slowly over time. As our GDP series has been seasonally adjusted and is already relatively smooth, we calibrate α to 0.35 so that the observation from the previous period gets a bigger weight. One clear advantage of the exponential smoother over the HP filter is that it does not use future observations to construct the trend from the current period. This means that it does not suffer from the end-point problem.

The third approach utilised here is to estimate a state space model. GDP is assumed to have a trend and a cyclical component. The cyclical component is assumed to follow an AR(2) process. These models require some choice surrounding the stochastic properties of the data in order to model the trend. We estimate three variants of the state space model based on differing assumptions regarding the trend in output. The first assumes that real GDP is I(1), the second is that it is I(1) but with a broken deterministic trend while the third model assumes that output is I(2). The model assuming output is I(1) around a broken trend appears to most closely match the Irish business cycle so we focus on this variant as our state space estimate.

3.2 General Comparison of Output Gap Estimates

The three output gaps are presented in Figure 5. The state space estimate is the most volatile with its associated output gap experiencing relatively large swings. The HP filter alternates frequently

[5] This may not strictly hold in the data but assumptions of this type are often used in state space models in a similar fashion.

between positive and negative gaps. It marks out the 1980's as a period of economic malaise although the negative gap estimates are not as large as the state space model suggests. Similar to the state space model, it has a large negative gap in 1993. One anomalous feature is the peak in the output gap at the end of the boom in 2007, while the other measures were already beginning to trend downwards. The exponential smoother characterises the 1980's as a period of small positive gaps rather than negative gaps. As the technical definition of a recession was not often met in the eighties, this is a plausible characterisation of the period based only on output data.

We have concerns regarding the general plausibility of the output gap measures. The volatility associated with these gaps is higher than one would expect of a variable which aims to capture the business cycle. Secondly, each measure has periods during the sample in which the gap estimate is contrary to our prior expectations even when the end of sample behaviour is excluded. Finally, there is a lower level of comovement between the series than one would expect from competing output gap measures. This highlights the technical problems involved in arriving at a credible estimate of the output gap.

3.3 Employment Approaches

While the output gap is a standard measure of economic slack, the original Phillips curve representation was based on the labour market variables. One way to implement this approach is to simply use the yearly growth rate of total employment. Using the growth rate avoids the econometric issues associated with the estimation of trends and gaps. The original Phillips curve was couched in terms of the unemployment rate in the economy with latterly the unemployment gap (difference between actual unemployment and the trend unemployment rate) taking prominence. Of course such a measure is unobservable and needs to be estimated by methods similar to those for constructing the output gap.[6]

Many argue that the duration of unemployment is important. For example, Laudes (2005) breaks the unemployed into a short-term and long-term component with the former referring to those unemployed for less than one year. The usefulness of such a dichotomy stems from the belief that the long-term unemployed may not exert a significant influence on wages or prices with the

[6]There is a distinction made in the literature between the natural rate of unemployment and the non-accelerating inflation rate of unemployment (NAIRU), see Estrella and Mishkin (1997). The former refers to the unemployment rate that would be observed once short-term cyclical variation had played itself out. The latter refers to the unemployment rate consistent with inflation being stable in short to medium term.

pool of desirable candidates in the labour market being the employed or the newly unemployed. Firms are less keen to hire the long-term unemployed as their human capital may have depreciated substantially and it may be more costly to retrain them. In this sense, the long-term unemployed are not considered an active part of the labour market so they should not exert pressure on wages or prices. Alternative mechanisms which imply such a distinction include union based insider outsider models of unemployment or efficiency wage type stories. Finally, Kruger and Mueller (2011) show that job search intensity declines (fewer hours per week) with duration of unemployment, again indicating that long-term unemployed may be less influential in the job market.

Rather than use the short-term unemployment rate directly, we construct the trend in the short-term unemployment rate using a HP filter. We then calculate the short-run unemployment gap (cyclical component), which we label STURGAP, as the difference between the actual rate and the trend. We have also calculated the short-run unemployment gaps using alternative detrending methods: the exponential filter and state space methods. We now briefly compare these estimators.

3.4 General Comparison of Employment Variables

In Figure 6, the growth rate of total employment is shown. Employment growth is negative during the early part of the sample with the economic problems of the 1980s more apparent with employment data as compared to output gaps. There is a sharp fall in employment growth during the financial crisis. Figure 7 shows estimates of the short-term unemployment gap based on the HP, exponential and state space filtering. There is greater commonality amongst these gaps relative to the output gaps. We use the HP version of short-term unemployment gap in our estimates but the strong comovement of these gaps means that the results of the quantitative analysis presented later are not sensitive to the choice of gap estimator. Broadly speaking, these measures of slack are more credible than those based on output measures. They accord more closely with the evolution of the economy over the sample. In addition, they are far less volatile with cycles that are more closely aligned to business cycle frequencies.

4 Traditional Phillips Curve Models

4.1 Specification of Model

Having constructed measures of slack, the next step is to test if there is a relationship between these measures of slack and domestic inflation. This amounts to estimating a Phillips curve relationship. There are many potential formulations of the Phillips curve. In this section, we estimate models which generally correspond to Robert Gordon's (1997,98) triangular approach in which a Phillips curve is estimated with three different types of explanatory variable. The specification is:

$$\pi_t = \beta_0 + \beta_1 \pi_{t-1} + \beta_2 (y_{t-1} - y^*_{t-1}) + \beta_3 Z_t + \epsilon_t \tag{2}$$

The first explanatory variable in equation (2) is the lag of inflation. This captures the persistence of the inflation process and is consistent with a backward looking Phillips curve specification where lagged inflation proxies inflation expectations. The second type of variable is the activity variable, generally specified in gap form. The third variable is normally a supply side variable. Given the open nature of the Irish economy, we consider both oil prices and the nominal effective exchange rate as supply variables. Specifically, we calculate the growth rates of these variables and then take a lagged four quarter moving average. This captures persistent trends in these variables.

We consider a number of inflation measures as our dependent variable. The first measure is the overall CPI inflation rate, which is the benchmark measure of domestic inflation. The Harmonised Index of Consumer Prices (HICP), which is a standardised measure of inflation would also be appropriate. Unfortunately, the HICP is not available over the full sample so we instead use the CPI excluding mortgage interest series (CPIXM). Mortgage interest is the main difference between CPI and HICP inflation in Ireland. As a measure of core inflation, we include the CPI excluding unprocessed food and energy (CPIXAD). This is the most common definition of core inflation. The rationale for focusing on the core inflation rate is that domestic economic slack may have more impact on this type of inflation rate relative to overall inflation, which is subject to volatile movements in international food and energy prices. Finally, we also include CPI services inflation excluding mortgage interest as an alternative proxy the nontraded element of domestic inflation.

4.2 Phillips Curves with Output Gaps

Tables 1 to 3 present estimates of the Phillips curve when the output gap is used as the activity variable. Each table presents results for a specific output gap measure. There are three main

findings from these tables. First, no output gap is statistically significant with the dependent variable being the CPI inflation rate. This echoes the findings of many earlier researchers who failed to find a Phillips curve relationship in Ireland. Second, for the other inflation rates, the output gap is statistically significant. The only exception is the exponential output gap in the equation for services inflation. Thus, there is a relationship between economic activity and inflation for more refined measures of inflation. Third, the exchange rate variable is important in terms of explaining Irish inflation. It is significant in most regressions.

4.3 Phillips Curves with Employment Growth

Labour market variables can also be used as the activity variable. The first employment variable we consider is employment growth. Contrary to the output gaps, this variable is observed. The results are presented in Table 4 and the coefficients are displayed by row. The t-stats show that employment growth is statistically significant for all inflation rates, albeit at the 10% level for CPI inflation. Thus, the link between economic activity and inflation is evident even for the CPI when we use employment as the activity measure. The exchange rate is significant for all inflation rates except services inflation. The fit of the models, measured by the adjusted R^2, is very similar to that of the output gap models.

4.4 Phillips Curves with Unemployment Duration

We present estimates of models based on short-run unemployment gaps in Table 5. We also considered the long-run unemployment gap and the aggregate unemployment gap but using the short-run gap leads to the best results. See the Appendix for more details on the model selection process. The coefficients on the short-run unemployment gap are statistically significant at the 1% level for all inflation rates considered, including overall CPI inflation. The high level of statistical significance suggests a robust relationship between inflation and the cyclical component of short-run unemployment. The exchange rate coefficients are also significant, indicating that external factors are also important.

Hence, our results to this point suggest that there is a link between the domestic economy, particularly when proxied by labour market variables such as the short-run unemployment gap, and inflation, having controlled for external factors. This link is absent between output gaps and CPI inflation and this maybe one reason that previous research may have failed to attribute some role for the domestic economy in terms of explaining Irish inflation. Output gaps help to explain other

measures of inflation which are more narrowly defined. The employment variables are more credible measures of the Irish business cycle and can be linked with all measures of inflation. In conclusion, the second step in our research suggests that there is a role for the domestic economy to play in terms of explaining inflation.

5 Model Stability

Having established a relationship between the domestic economy and inflation, the third step in our research is to establish if this relationship is stable. We begin by estimating the models recursively and graphing the resulting coefficients. From the previous section, the models which use employment variables as the activity measure are the most robust in the sense that they help to explain all inflation rates. In the remainder of the paper, we concentrate on these employment variable models and do not report any further results in relation to output gaps.

The coefficients are estimated using data until 1990Q1 and one data point is added to the sample each time. Figure 8 plots the coefficients associated with employment growth when the Phillips curve is estimated recursively for all four inflation rates. There are two notable features. First, the employment growth coefficient is not statistically significant for a large part of the sample. Second, there is a spike in the coefficient at the end of the sample, beginning at the start the financial crisis. These two features are common to all inflation rates. They suggest that the statistical significance of the coefficients might be derived almost entirely from the crisis period.

Figure 9 plots the coefficients when the Phillips curve is estimated recursively with the short-run unemployment gap as the activity variable. This coefficient is statistically significant over the whole sample for both our core and services inflation measures, representing the more sheltered sectors of the economy. It is significant for most of the sample for CPI inflation but is mainly insignificant for CPIXM inflation. Recalling that the relationship between unemployment gap and inflation is negative, there is also an increase in the absolute value of the coefficients at the end of the sample for all the inflation rates. These graphs indicate that the relationship between short-run unemployment gap and inflation is more robust than the corresponding relationship between employment growth and inflation. They also show a spike in the absolute value of the coefficients during the period corresponding to the financial crisis. The recursive estimates show that the parameters are not stable over time and we now investigate a more structured way of dealing with this parameter change.

6 Asymmetric Phillips Curve Models

The recursive models support the view that our measures of slack appear to have a greater effect on inflation during the financial crisis. Stock and Watson (2010) make this argument based on the empirical properties of inflation during recessions in the US. All major disinflations in the US in the post-war period have occurred during or following a recession but it is far more difficult to pin down any single cause of inflationary periods. For this reason, they advocate an asymmetric approach to modelling inflation. Meier (2010) conducts a cross country analysis of 25 episodes in advanced economies where output remained below potential for a long period of time. These periods are associated with a strong decline in inflation although disinflation has tended to dissipate at low levels of inflation rather than lead to deflation.

6.1 Positive and Negative Values of Activity Variable

One way to capture asymmetric behaviour is to estimate a threshold model. This type of model allows parameters to change far more quickly than the recursive models, as there are discrete changes in parameter values when there is a change in regime. The approach splits the sample in two based on the value of a threshold variable. If we select our measure of slack as the threshold variable, the sample can be split in two based on positive and negative values of this threshold variable. To allow a different response to positive and negative values of slack variable under consideration, define the following indicator variable, I_t:

$$I_t = \begin{cases} 1 & \text{if } \Delta z_t > 0 \\ 0 & \text{if } \Delta z_t \leq 0 \end{cases}$$

and z is our measure of slack. The model can then be expressed as:

$$\pi_t = \beta_1 X_t, \;\; I_t = 1 \tag{3}$$

$$\pi_t = \beta_2 X_t, \;\; I_t = 0 \tag{4}$$

where β is a vector of coefficients and X_t collects the data on the variables to be included in the model including our measure of slack z. The coefficients are allowed to change depending on whether our measure of slack is positive or negative. This is the most general version of the model in the sense that all coefficients are allowed to change between the different regimes.

We consider two measures of slack: employment growth and the short-run unemployment gap. We define the first threshold model in terms of positive and negative values of the six quarter

smoothed growth rate in employment.[7] Figure 10 graphs the smoothed growth rate with the shaded area used to highlight periods of negative employment growth. The graph shows that there are two periods of negative employment growth. The first is during the 1980's and the second is during the recent financial crisis. Although the technical definition of a recession was not often satisfied in terms of output during the eighties, this graph shows that the employment situation was worse than the output data would suggest. The second employment variable is the short-run unemployment gap and this is graphed in Figure 11. Periods with positive gaps, which correspond to poor economic performance, are again shaded. Relative to employment growth, there are far more shaded areas.

6.1.1 Results

We first present results based on positive and negative periods of employment growth with the estimated results reported in Table 6. For all inflation rates, the activity coefficient is not significant in the positive regime, with t-stats far from standard confidence levels. In contrast, there is strong statistical significance for the employment coefficient in the negative regime. This supports the hypothesis that the economy influences the inflation rate more during a recession. The results for the exchange rate show that it is significant for all inflation rates except for services inflation. For oil prices, we have borderline significance during the boom periods but no statistical significance during the recession. The negative subsample has only 28 observations so, taken in isolation, the results are subject to some robustness concerns. However, we next present results from the short-run gap to act as a robustness check.

Table 7 estimates the threshold model when the sample is divided into periods of positive and negative short-run unemployment gaps. The coefficient on the gap is always greater in magnitude during the periods of negative economic performance. For periods of positive economic performance, the gap is statistically significant only for the CPI inflation rate. The results are similar to those based on employment growth. The data from the Irish economy suggest that the link between the economy and inflation is stronger during recessions rather than booms, supporting the hypothesis of Stock and Watson (2010) and Meier (2010).[8]

[7] The results are not sensitive to the choice of this smoothing operation. The results are qualitatively unchanged if the threshold is defined in terms of unsmoothed growth rates. However, the smoothed rate is used to capture trends in employment growth.

[8] Corroborating results for short-run gaps estimated using alternative detrending procedures and results for output gap models are available upon request.

7 Inflation Prediction during the Financial Crisis

Taking the coefficients estimated over the period 1988 to end of 2006, prior to the onset of the crisis, we construct dynamic forecasts of the various inflation measures over the crisis period conditional on the known values for the independent variables used in the regression. This is in the spirit of Ball and Zumander (2011) who do a similar exercise for the US. Our preferred measure of slack is the short-run unemployment gap. By taking known values for the unemployment gap and other variables, we can determine if the model provides an accurate description of inflation over the forecast period, abstracting from possible mistakes made when forecasting these independent variables. For comparative purposes, we also generate forecasts using coefficients estimated over the full sample to predict the fall in inflation during the crisis.

Figure 12 shows the results for observed CPI inflation vis-a-vis predicted inflation based the pre-crisis period (labelled F Short), and the predicted values based on the full sample coefficients (labelled F Full). When the full sample coefficients are used, the predicted fall is very close to the actual fall. This is to be expected as it is effectively the in-sample fit of the model. When we take the short-sample coefficients and construct forecasts over the crisis period, we see that the expected fall is again in line with expectations. Using actual employment gap data over the forecast period means we also know which set of threshold coefficients to use.

Figure 13 shows the results for the CPI excluding mortgage interest. As before, the forecasts based on full-sample and short-sample coefficients are in blue and green respectively. These both track acutal inflation, depicted in black, quite closely. The coefficients of the model do not change considerably when the model is estimated over the shorter sample period. The core inflation results in Figure 14 show that the use of full sample coefficients again leads to a close fit but the coefficients from the short sample predict a much larger fall in core inflation than was observed during the crisis. The final set of results in Figure 15 relate to services inflation. The blue line shows the full sample fit is good and the short-sample forecast is almost identical.

As we have shown in section 2, the magnitude of the fall in inflation was unusual by historical and international standards. We can now say that, according to our model, the fall in inflation during the crisis is as large as we would have expected. The only exception is core inflation. The caveat is that we have assumed that we know the data. This means that it is not a real time exercise, as a different model may have been chosen given the data available at the time. However, our aim is not to test the accuracy of a standard forecasting model. Our aim is to gauge if inflation fell by as much as expected given what we know about the economy.

Given the relatively accurate forecasts of the threshold model, it is natural to ask to what extent is the short-run gap driving the forecasts. In models with lagged dependent variables, it is possible to get a good fit and good forecasts based purely on the lagged variable.[9] We construct a second forecast of CPI inflation during the crisis in which we omit the short-run gap from the model specification. In every other way, the forecast is constructed in the same way as it was for Figure 12. We graph the forecast when the gap is absent from the model in Figure 16 and include the comparable forecast using pre-crisis coefficients from Figure 12. The results show that the inclusion of the gap in the forecasting model allows us to capture the decline in inflation during the crisis period. The model without the gap never picks up the fall in inflation as the autoregressive part of the forecasts is based on earlier period forecasts rather than earlier period inflation. The importance of including the gap variable in the forecasting model highlights the link between slack in the economy and inflation, particularly during this crisis period.

8 Conclusion

The question that we address in this research is whether inflation fell by as much as expected during the financial crisis. This amounts to a test for the existence of a Phillips curve in Ireland. The Phillips curve is a relationship between domestic economic slack and inflation. If this relationship holds for Ireland, then the fall in domestic output that occurred during the financial crisis should have led to a large fall in inflation. In term of output, real GDP contracted by 14 per cent between 2008 and 2010 alone. There followed a period of sustained deflation. This represents an opportune time to test for an Irish Phillips curve and contribute to the international debate regarding the Phillips curve during the financial crisis.

The Irish CPI inflation rate reached a low point of -6.6 per cent in October 2009. Deflation of a similar magnitude had not been experienced in Ireland since the thirties, in the period immediately following the Great Depression. Relative to other European countries, including those on programs of international financial assistance, the deflation experienced in Ireland was greater in magnitude and longer in duration. Indeed, Meier (2010) notes that deflation is rare even for countries which experience large and persistent negative output gaps. Thus, the deflation experienced in Ireland was severe by historical and international standards. This makes Ireland an interesting case study for

[9]Note that we construct forecasts dynamically over the sample in the sense that the forecast for the previous period is used as the autoregressive term. This means that the forecast accuracy is not a result of using actual values of lagged inflation in the forecasting process.

the Phillips curve, particularly given a large degree of national scepticism regarding the existence of a Phillips curve in Ireland.

Given that the Phillips curve is a relationship between domestic economic slack and inflation, the first step is to construct measures of economic slack. We construct measures of slack based on both output and employment. No one measure of slack captures all aspects of the Irish business cycle so to ensure the robustness of the results, it is important to have a suite of estimators. We find that slack measures based on employment are more plausible than output gaps.

The second step is to relate our measures of economic activity to inflation. We have a number of findings. The models show that there is a link between the domestic economy and inflation. This link is absent between output gaps and the CPI inflation rate, which is one reason that previous research may have failed to attribute some role for the domestic economy in terms of explaining Irish inflation. However, output gaps help to explain other measures of inflation which are more narrowly defined. If employment variables are used rather than output gaps as the measure of domestic activity, it is possible to link the domestic economy to all inflation rates. In this sense, the link between employment and inflation is more robust than the link between output and inflation.

The third step is to establish if the relationship between economic activity and inflation is stable over time. The results suggest that the relationship between inflation and the economy may depend on whether the economy is expanding or contracting. Stock and Watson (2010) and Meier (2010) both suggest that the domestic economy helps to explain inflation in a recession. They argue that output declines cause disinflations and provide evidence using event studies and time-varying parameter models respectively. We instead use threshold models but again find that this pattern holds for Ireland.

Having characterised the relationship between the economy and inflation, it is possible to address the question of whether the fall in inflation was as large as expected from an econometric viewpoint. Taking coefficients estimated until the end of 2006, just before the onset of the crisis, we construct forecasts over the crisis period using known values for the independent variables. The forecasts generated using this approach generally match the fall in inflation quite closely. Our econometric model indicates that the fall in inflation was as large as expected. The ability to characterise inflation during such a turbulent period is compelling evidence in favour of the Phillips curve.

Our final summary is as follows. First, the deflation in Ireland was unusual by historical and international standards. Second, having controlled for international factors, there is a relationship

between the domestic economy and inflation. Third, this relationship is more robust when the domestic economy is measured using employment variables rather than output gaps. Fourth, the relationship is not stable over time but seems to depend on the business cycle. Fifth, these types of models predict the actual fall in inflation quite well.

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Figure 1: **Irish CPI Price Level January 1932 - June 2012**

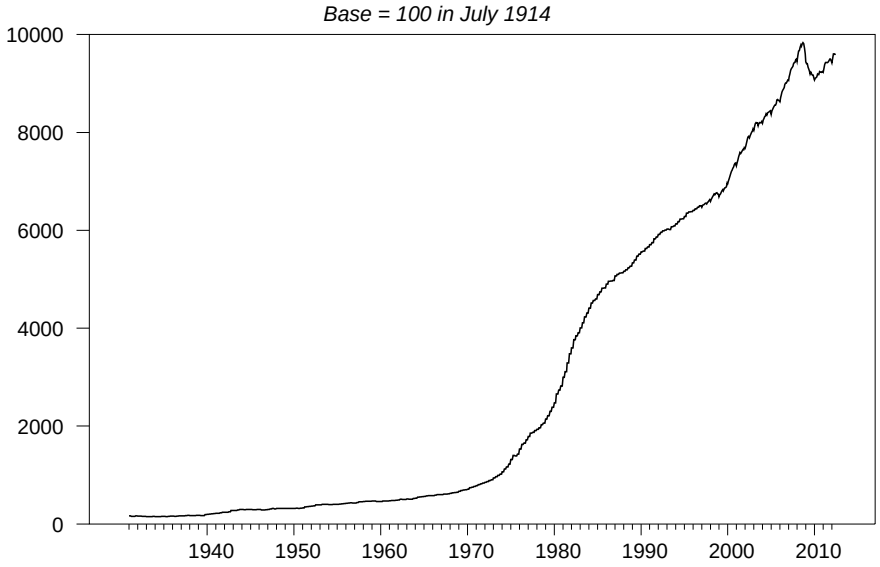

Figure 2: **Irish CPI Inflation January 1932 - June 2012**

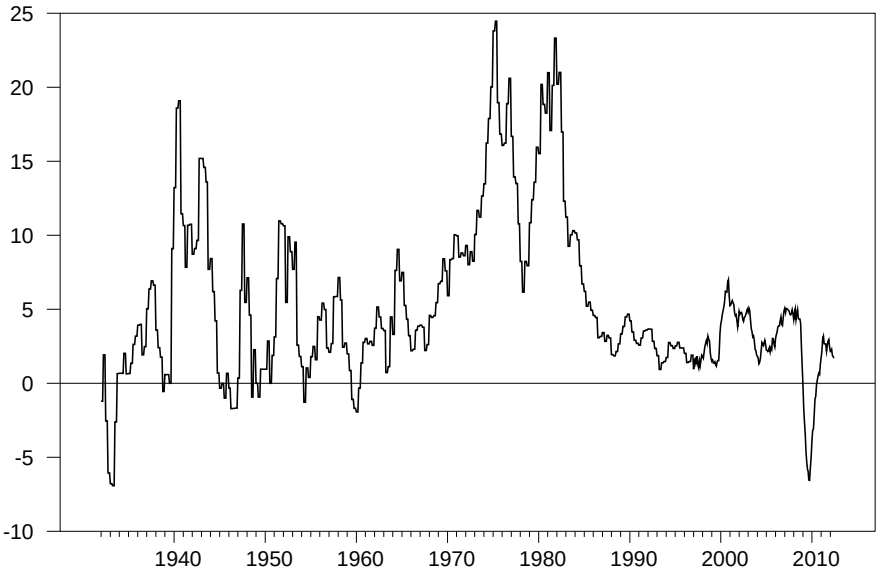

Figure 3: **HICP Inflation Rates for Northern Europe**

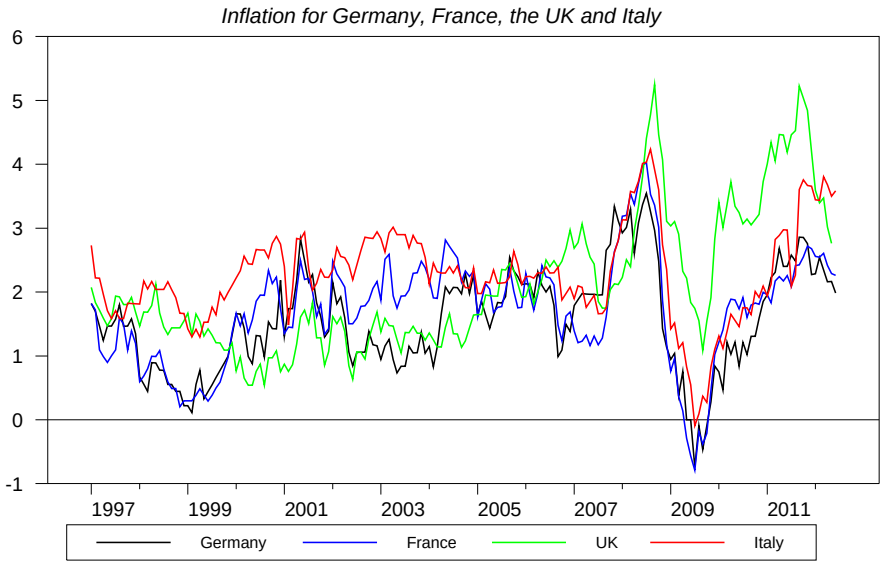

Figure 4: **HICP Inflation Rates for Southern Europe**

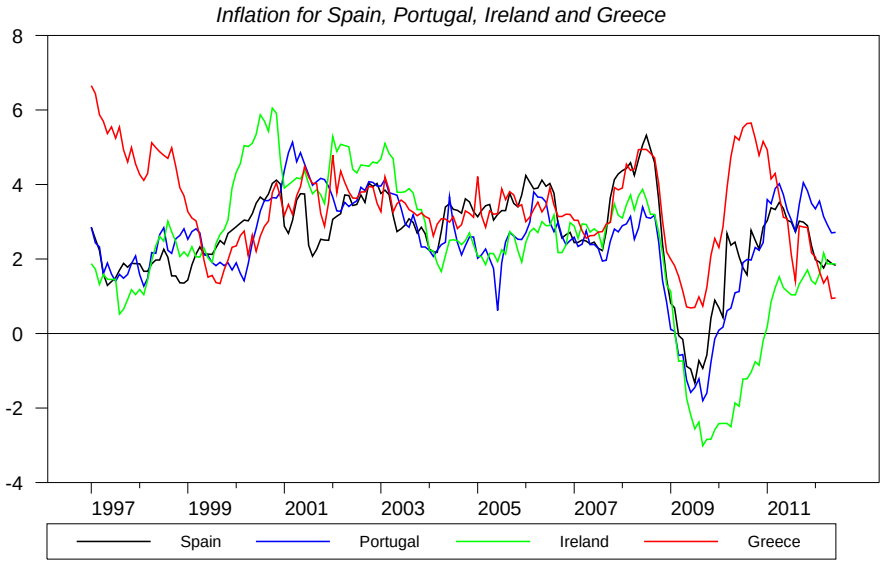

Figure 5: **General Comparison of Output Gaps**

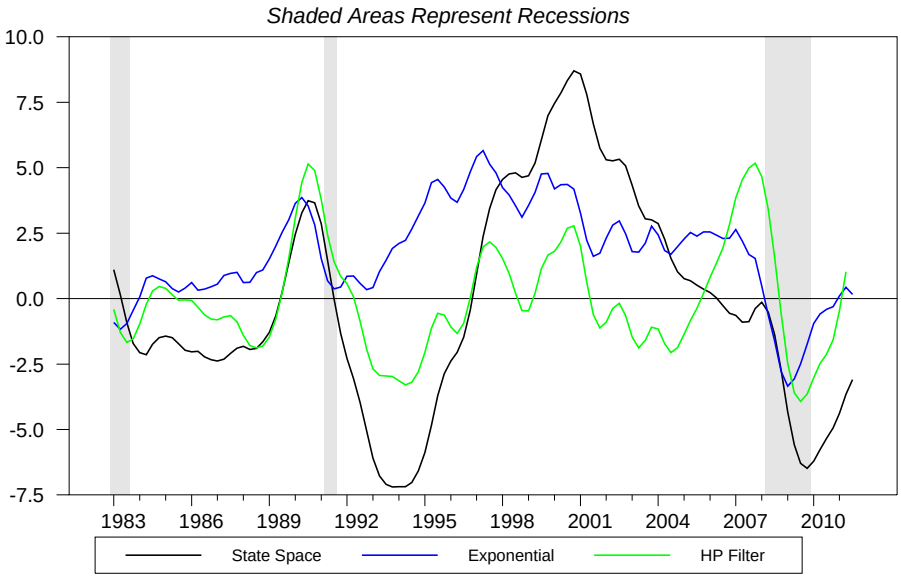

Figure 6: **Employment Growth**

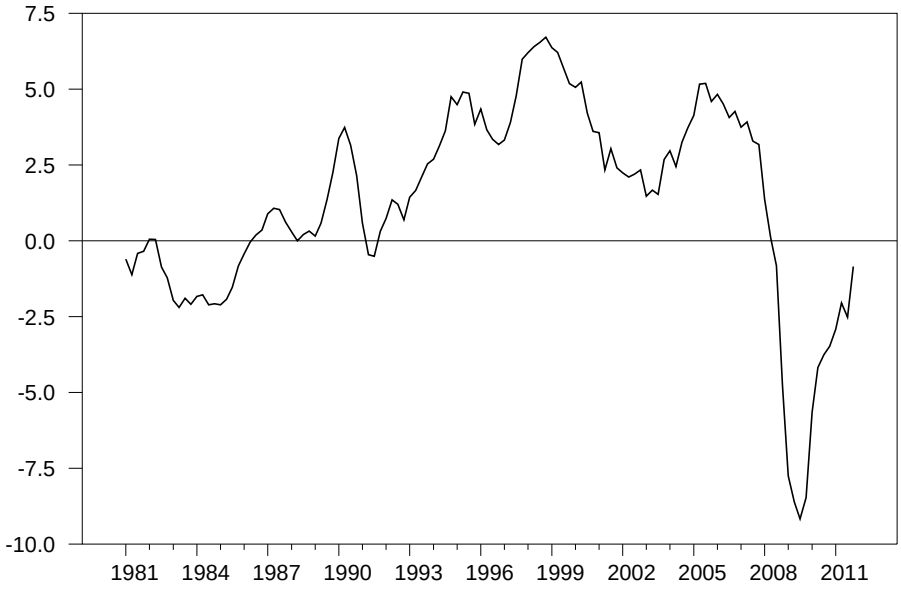

Figure 7: **Short-Run Gap Estimates from Various Statistical Filters**

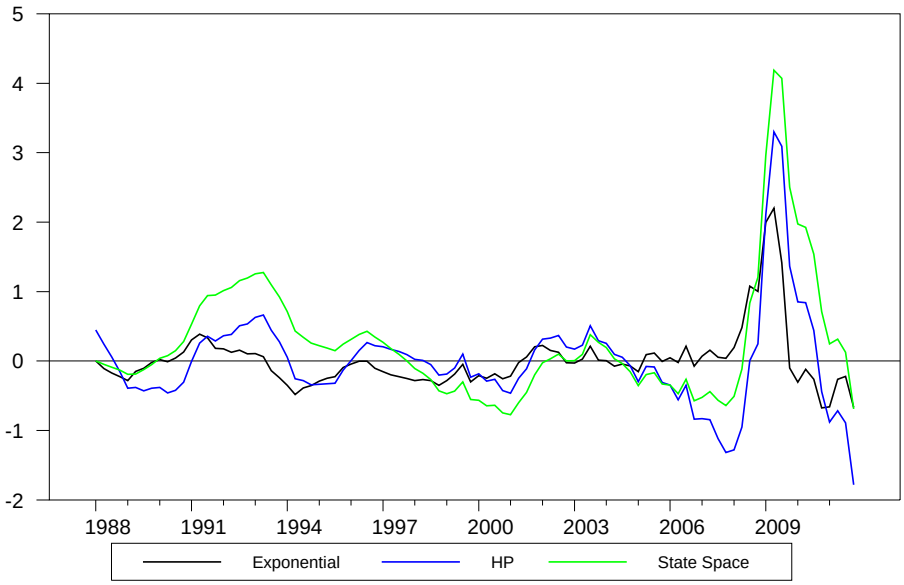

Figure 8: **Recursive Estimates of Employment Growth Coefficient**

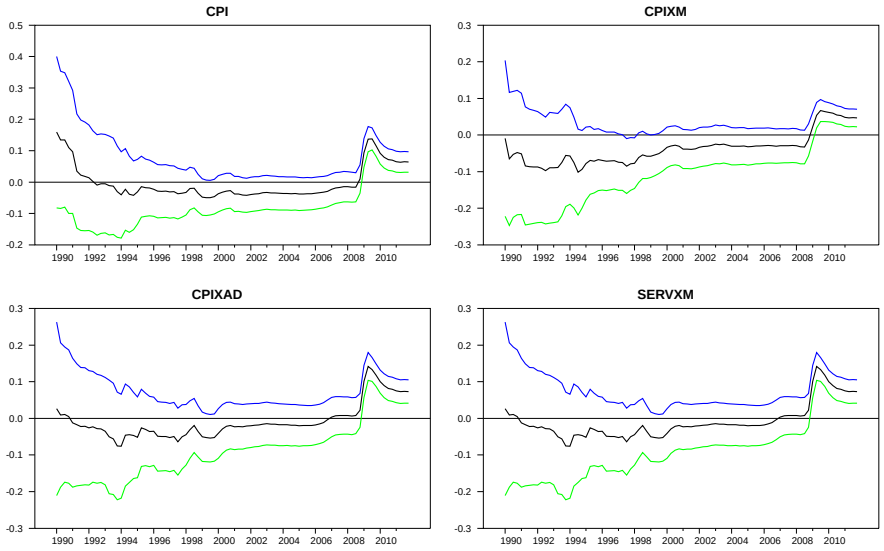

Figure 9: **Recursive Estimates of Short Run Gap Coefficient**

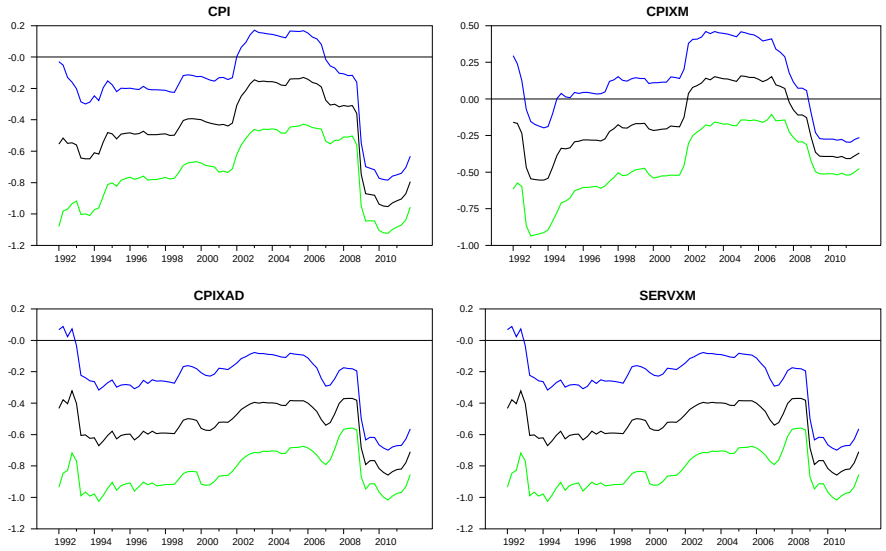

Figure 10: **Smoothed Growth in Total Employment**

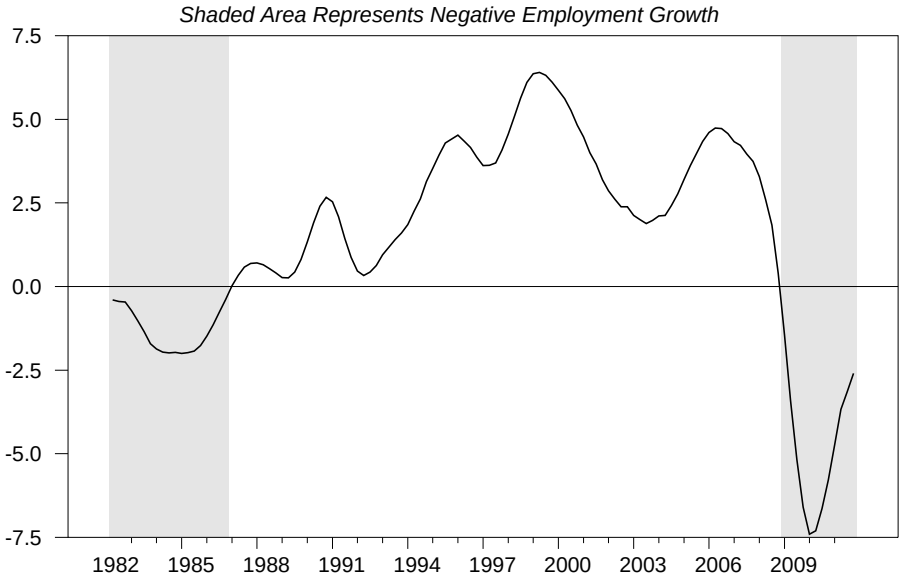

Figure 11: **Short-Run Unemployment Gap**

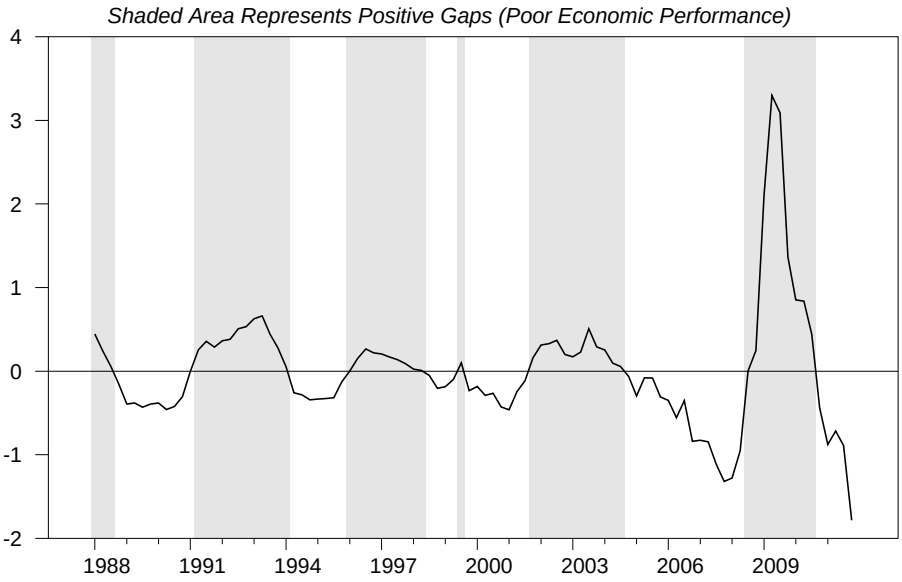

Figure 12: **CPI Forecast Using Ex-Post Data**

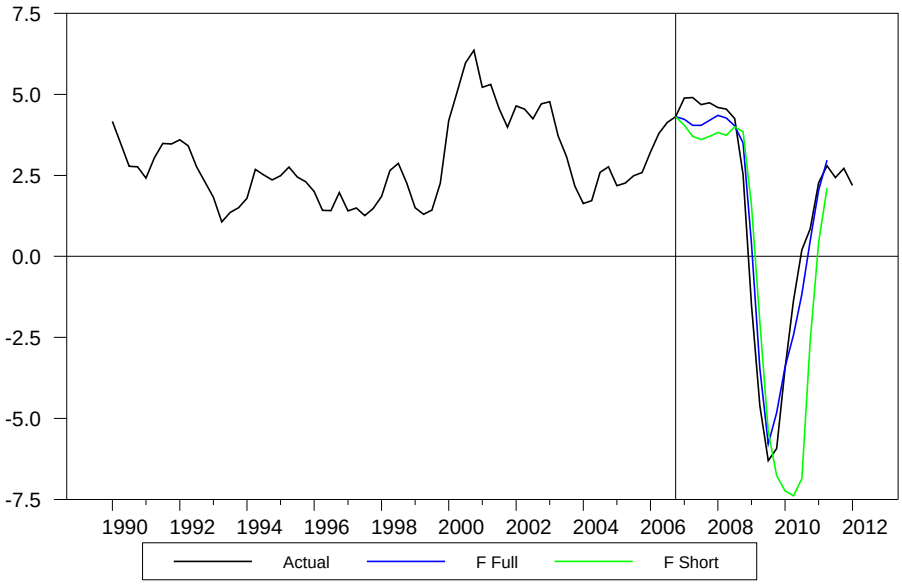

Figure 13: **CPIXM Forecast Using Ex-Post Data**

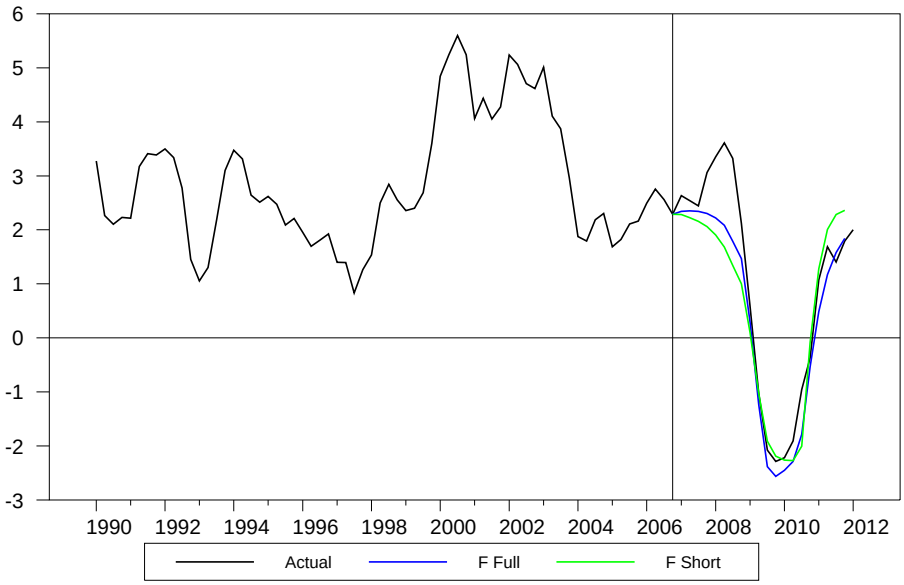

Figure 14: **CPIXAD Forecast Using Ex-Post Data**

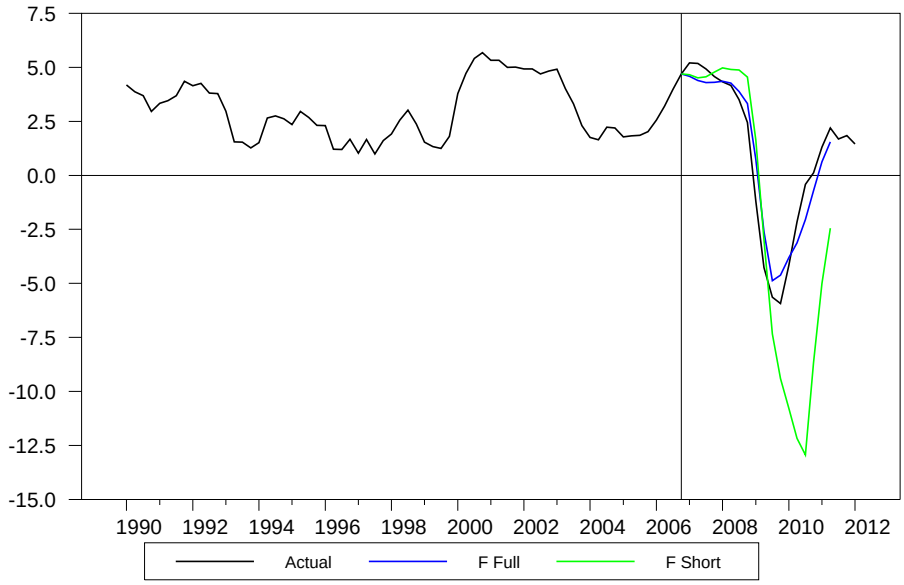

Figure 15: **SERVXM Forecast Using Ex-Post Data**

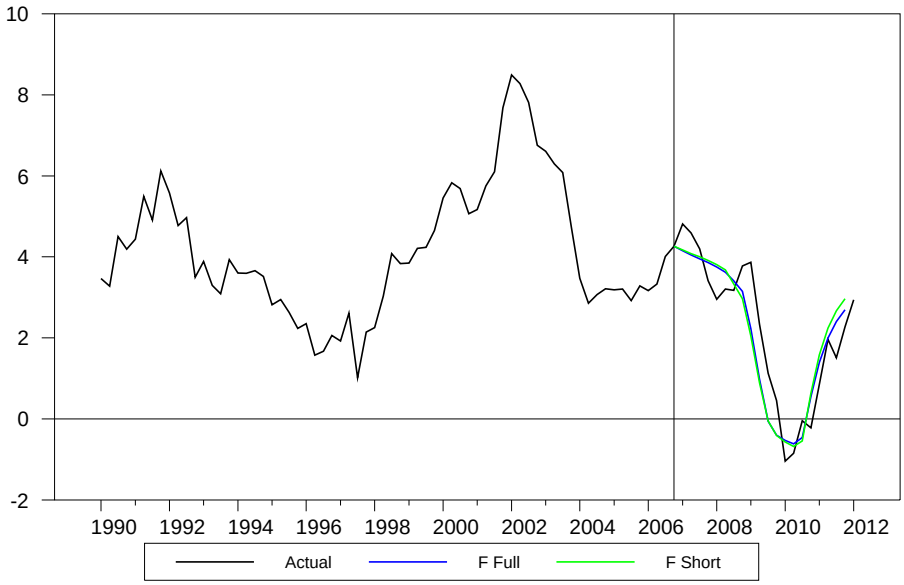

Figure 16: **CPI Forecast Without Uemployment Gap**

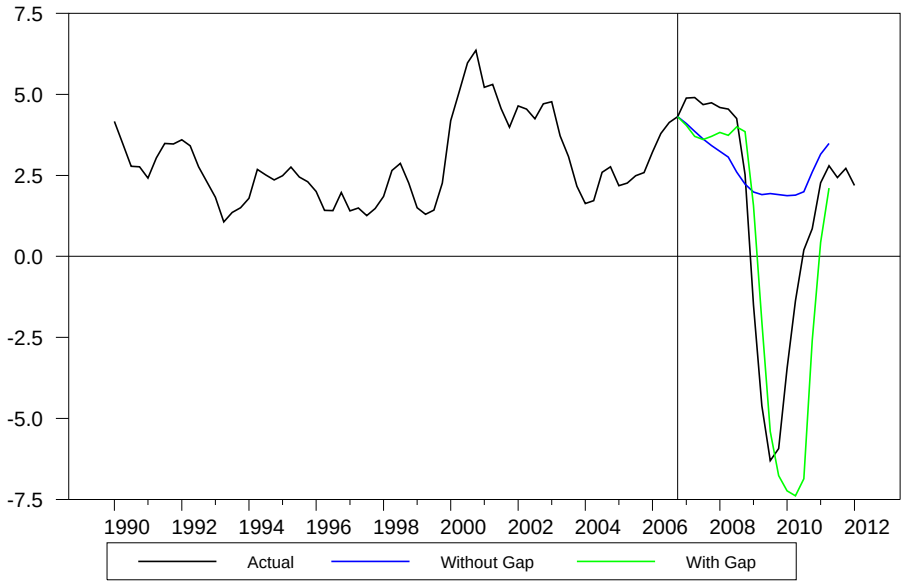

Table 1: **Phillips Curve Models for HP Output Gap**

REGRESSORS	CPI	CPIXM	CPIXAD	SERVXM
Constant	0.28	0.30	0.29	0.47
	(1.67)	(2.57)	(1.80)	(3.27)
π_{t-1}	0.88	0.88	0.89	0.87
	(20.26)	(22.28)	(21.87)	(23.87)
NEER	-0.04	-0.04	-0.05	-0.02
	(-3.43)	(-4.78)	(-4.49)	(-2.38)
OIL	0.01			
	(2.44)			
HP_{t-1}		0.05	0.08	0.09
		(1.83)	(3.17)	(2.92)
R^2	0.91	0.94	0.91	0.89

Robust t-statistics in brackets. Sample:1980Q1-2011Q4

Table 2: **Phillips Curve Models for Exponential Output Gap**

REGRESSORS	CPI	CPIXM	CPIXAD	SERVXM
Constant	0.28	0.17	0.02	0.33
	(1.67)	(1.24)	(0.09)	(2.12)
π_{t-1}	0.88	0.89	0.91	0.89
	(20.26)	(23.48)	(23.95)	(24.10)
NEER	-0.04	-0.04	-0.04	
	(-3.43)	(-4.22)	(-4.11)	
OIL	0.01			0.01
	(2.44)			(2.75)
EXP_{t-1}		0.05	0.12	
		(1.45)	(1.92)	
R^2	0.91	0.94	0.91	0.89

Robust t-statistics in brackets. Sample:1980Q1-2011Q4

Table 3: **Phillips Curve Models for State Space Output Gap**

REGRESSORS	CPI	CPIXM	CPIXAD	SERVXM
Constant	0.28	0.32	0.25	0.60
	(1.67)	(2.64)	(1.49)	(4.15)
π_{t-1}	0.88	0.88	0.91	0.84
	(20.26)	(21.58)	(21.90)	(24.01)
NEER	-0.04	-0.04	-0.05	-0.02
	(-3.43)	(-4.55)	(-4.29)	(-1.84)
OIL	0.01			
	(2.44)			
SS_{t-1}		0.03	0.03	0.06
		(1.98)	(1.80)	(3.95)
R^2	0.91	0.94	0.91	0.90

Robust t-statistics in brackets. Sample:1980Q1-2011Q4

Table 4: **Phillips Curve Models with Employment Growth**

REGRESSORS	CPI	CPIXM	CPIXAD	SERVXM
Constant	0.211	0.20	0.14	0.27
	(1.09)	(1.72)	(0.77)	(1.94)
π_{t-1}	0.88	0.89	0.90	0.89
	(20.52)	(23.64)	(24.92)	(26.00)
NEER	-0.04	-0.04	-0.04	
	(-3.79)	(-4.30)	(-4.24)	
OIL	0.01			0.01
	(2.16)			(2.41)
ΔEmp_t	0.06	0.05	0.07	0.04
	(1.65)	(2.37)	(2.06)	(2.25)
R^2	0.92	0.94	0.91	0.89

Robust t-statistics in brackets. Sample:1980Q1-2011Q4

Table 5: **Phillips Curve Models with Unemployment Duration**

REGRESSORS	CPI	CPIXM	CPIXAD	SERVXM
Constant	0.59	0.30	0.41	0.18
	(4.18)	(4.02)	(2.89)	(1.23)
π_{t-1}	0.76	0.88	0.84	0.95
	(14.19)	(27.95)	(18.19)	(25.40)
$STURGAP_t$	-0.79	-0.37	-0.71	-0.27
	(-4.13)	(-5.49)	(-4.37)	(-3.20)
NEER	-0.04	-0.04	-0.05	-0.03
	(-4.63)	(-4.24)	(-5.39)	(-2.31)
OIL	0.01			
	(2.17)			
R^2	0.92	0.91	0.93	0.89

Robust t-statistics in brackets. Sample 1988Q1-2011Q4.

Table 6: **Threshold Model based on Positive Employment Growth**

π_t	α_0	π_{t-1}	ΔEmp_t	$SNEER_t$	$SOIL_t$	R^2
Δ CPI						
Positive	0.321	0.891	0.004	-0.042	0.004	0.851
	(1.494)	(17.156)	(0.102)	(-5.044)	(1.571)	
Negative	2.338	0.668	0.547	-0.154	-0.001	0.962
	(5.959)	(9.689)	(6.450)	(-3.607)	(-0.172)	
Δ CPIXM						
Positive	0.522	0.845	-0.020	-0.041		0.820
	(2.669)	(16.588)	(-0.700)	(-4.802)		
Negative	0.980	0.820	0.229	-0.074		0.971
	(4.435)	(16.420)	(5.832)	(-4.253)		
Δ CPIXAD						
Positive	0.126	0.941	0.012	-0.044	0.005	0.856
	(0.684)	(22.469)	(0.436)	(-5.310)	(1.720)	
Negative	2.616	0.625	0.638	-0.162	-0.012	0.918
	(8.643)	(17.629)	(10.209)	(-4.565)	(-2.313)	
Δ SERVXM						
Positive	0.287	0.914	0.006		0.005	0.828
	(1.407)	(19.861)	(0.186)		(1.887)	
Negative	0.918	0.828	0.166		0.005	0.942
	(2.964)	(17.690)	(3.053)		(1.137)	

Coefficients of models in Table 4 when sample is split into periods of positive and negative employment growth. Robust t-statistics in brackets. Sample:1980Q1-2011Q4

Table 7: **Threshold Model based on Positive Short Run Unemployment Gaps**

π_t	α_0	π_{t-1}	$STURGAP_t$	$SNEER_t$	$SOIL_t$	R^2
Δ CPI						
Positive	0.503	0.790	-0.346	-0.044	0.001	0.891
	(0.004)	(0.000)	(0.032)	(0.000)	(0.002)	
Negative	1.124	0.680	-1.474			0.942
	(0.000)	(0.000)	(0.000)			
Δ CPIXM						
Positive	0.532	0.791	-0.194	-0.038		0.859
	(3.077)	(13.656)	(-1.468)	(-3.199)		
Negative	0.429	0.916	-0.551	-0.056		0.942
	(4.086)	(28.859)	(-9.893)	(-4.622)		
Δ CPIXAD						
Positive	0.337	0.879	-0.141	-0.041	0.007	0.902
	(2.264)	(21.736)	(-0.912)	(-3.717)	(2.550)	
Negative	0.852	0.780	-1.201	-0.031		0.946
	(4.667)	(15.601)	(-7.498)	(-2.146)		
Δ SERVXM						
Positive	0.557	0.894	0.141			0.854
	(2.025)	(13.973)	(0.676)			
Negative	0.278	0.940	-0.425			0.893
	(1.352)	(20.461)	(-4.445)			

Coefficients of models in Table 5 when sample is split into periods of positive and negative short-run gap. Robust t-statistics in brackets. Sample:1988Q1-2011Q4.

Appendix: CPI Unemployment Models

Table A4 provides Phillips curve estimates when we include unemployment variables. The dependent variable is the year-on-year CPI inflation rate in all cases. As can be seen from the first specification, the unemployment gap (URLGAP) is significant with the correct sign. Next we assess whether dividing the unemployment rate into the short-term and long-term unemployment alters the results. The former has a negative effect on inflation but the latter has a positive effect. A possible rationalisation for this result is that individuals who are short-term unemployed are deemed more employable by firms while long-term unemployed are viewed less employable and actually represent a reduction in the potential capacity of the economy. In this specification we have entered the variables in levels. However, there are unit root issues with the levels of the unemployment rates so we don't place much emphasis on these results.

Next we examine whether filtering the short-term unemployment rate into a trend and cyclical component alters our results. The logic here is that there is a trend in short-term unemployment which reflects the institutional arrangements in the labour market as individuals are matched with firms but this may vary over time. Shocks to economy may have differential effects on this trend. Hence, we create a new variable (STURGAP) which is the gap generated by HP filtering the short-term unemployment rate and subtracting this trend from the actual short-term rate. This variable is highly significant in specification (4) gives the highest explanatory power of the regression specifications. As a robustness test we also include the difference between the unemployment gap and the short-run gap as an additional regressor. This variable, LTUGAP, has a positive sign and gives further credence to the notion that in the presence of long-term unemployment, unemployed workers have a differential effect on inflation. This result is complementary to the findings of Llaudes (2005) who finds for a number of european economies that short-term unemployment is much more important in terms of explaining inflation and also that there is merit in decomposing such movements into a cyclical and trend component.[10]

The results point to an important role for the short-term unemployment rate. It is negative and significant when entered directly in regressions and the short-run gap, which is derived from the short-term rate, also has explanatory power for inflation. The results surrounding the

[10]Llaudes uses state space techniques to decompose unemployment into a trend and cyclical component while distinguishing between short-term and long-term unemployment. He finds that for a number of countries including Ireland that nearly all the weight is given to the short-term cyclical component.

significance of the long-term gap conflict with the theory that the long-term unemployed have no impact on inflation. The sign of the coefficient is puzzling as one would expect an increase in long-term unemployed to reduce inflation. However, when we conduct a similar model selection exercise on the other inflation rates, the long-term gap is not significant for any other inflation rate. Given that it fails this robustness check, we choose specification (3), which includes only the short-run gap. This is the most robust model specification across all inflation rates.

Table A4: Unemployment Models for CPI Inflation

	(1)	(2)	(3)	(4)
Constant	0.42	0.39	0.67	0.62
	(2.44)	(2.27)	(5.07)	(4.69)
π_{t-1}	0.81	0.75	0.73	0.76
	(13.29)	(11.15)	(14.26)	(15.02)
$URLGAP_t$	-0.28	-0.23		
	(-2.48)	(-2.57)		
OIL_t	0.01	0.01	0.01	0.01
	(3.99)	(3.81)	(2.51)	(2.55)
$NEER_t$	-0.05	-0.04	-0.04	-0.03
	(-4.44)	(-4.18)	(-4.39)	(-3.95)
ΔEmp_t		0.08		
		(1.90)		
$STURGAP_t$			-0.90	-0.85
			(-5.13)	(-5.60)
$LTUGAP_t$				0.21
				(2.32)
Rbarsq	0.89	0.90	0.93	0.93

Robust t-statistics in brackets.