Discussion Paper No. 14-067

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Marcus Kappler† and Frauke Schleer‡

September 23, 2014

Abstract

The path of output prior to the financial and economic crisis turned out to be not sustainable and lower than previously estimated in some European crisis countries. Specifically, the output gaps have been underestimated (and inversely potential output overestimated) before the recent crisis. It is fair to say that the employed estimation techniques failed to provide valid real-time assessments of the state of the credit boom driven euro area economies. One reason for this may be the breakdown of the Phillips curve relationship during the last years. Against this backdrop, we comprehensively analyse the validity of the Phillips curve for five European countries with a focus on the recent crisis. We find that a mostly insignificant relation between inflation and the output gap or unemployment gap, which questions the adequacy of the Phillips curve to identify the sustainable level of output in an economy. The credit-driven boom in crisis countries has made clear that (disadvantageous) financial markets conditions may result in structural and long-term real economic distortions that are not yet taken into account in conventional methods for the estimation of potential output and the output gap. Since both, potential output and output gaps, are a key notion in policymaking, incorporating financial factors could improve the reliability of the estimates. Our results point in this direction.

JEL classification: E32, E44, E60

Keywords: Phillips curve, potential output, output gap, financial cycle, credit cycle, NAIRU

*We are grateful to our colleagues Jan Hogrefe und Andreas Sachs for inspiring discussions. We thank Lukas Hoesch for excellent research assistance.

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1 Introduction

Now, six years after the outbreak of the global financial and economic crisis we can be fairly certain that potential output—i.e. the sustainable level of output that can be achieved without creating pressure on prices— was overestimated in many Western market economies and thus, output gaps were underestimated during the years before the crisis, especially in those countries which have seen an enormous credit boom in the years before 2008.

Banks provided massive loans to the private sector which led to an enormous boom in the real economy, in particular in the construction and finance branches (see Figure 1), without considerably increasing price levels.

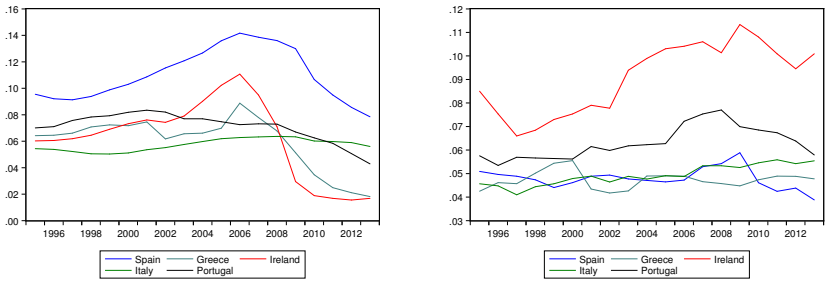

Figure 1: Share of construction (left panel) and finance activities (right panel) of total gross value added

To illustrate this point further, Figure 2 shows the annual growth rate of bank lending to firms and households in Spain, Ireland and Italy and Figure 3 depicts the evolution of price inflation, measured by the harmonised consumer price index. The growth rates of credit in Ireland and Spain were enormous during the years form 2004 to 2007. In Ireland, credit growth peaked at 15% and in Spain above 17% during the heyday of the housing market boom. The inflation rates in these countries, however, moved only slightly above their long-term averages (depicted by solid lines in Figure 3), apart from the temporary surge in the Spanish and Greek inflation rate during 2007/2008, thus providing little signs of economic overheating.

This questions the Phillips curve, that postulates a positive relationship between inflation and overheating in an economy, and is a central equation when estimating potential output or output gaps in a theory-consistent way (see Apel and Jansson 1999*b*). It is unclear, however, whether solely unemployment, output gaps and inflation are sufficient to identify the sustainable level of output in an economy, in particular during periods in which firms and households accumulate enormous debt to finance investment and growth and in which the monetary authority manages to keep inflation rates low, or whether the standard or also the New Keynesian Phillips curve misses relevant factors such as economy-wide financial conditions. Then, output gaps which should be an indicator of

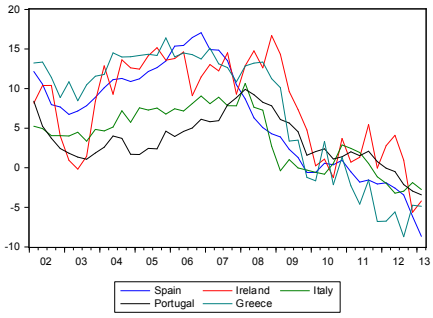

Figure 2: Bank lending to private sector, annual growth rates

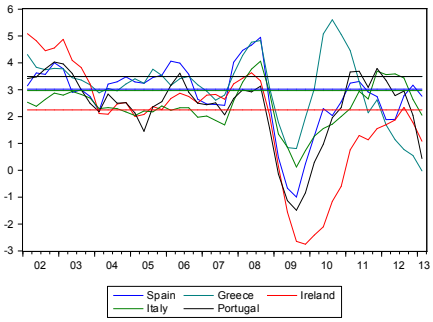

Figure 3: Inflation rates, annual growth rates

overheating or slack were sending misleading signals for those economies (ECB 2013).

The path of output prior to the financial and economic crisis turned out to be apparently not sustainable and lower than previously estimated (see Figure 4). Figure 5 shows output gap vintages by the European Commission for the years 2007 and 2012. As can be seen from the size of the revisions, clearly, the output gaps have been underestimated (and inversely potential output overestimated) in the periphery countries of the euro area before the recent crisis. In contrast, the revisions in output gap estimates have not been very dramatically in Germany. It is fair to say that the employed estimation techniques failed to provide valid real-time assessments of the state of the credit boom driven euro area economies (see also Borio et al. 2013*b*, Borio et al. 2013*a*, and Borio et al. 2014). As pointed out before, one reason for this may be the breakdown of the Phillips curve relationship during the last years. This has been recently emphasized by, for instance, Koop and Onorante (2012), ECB (2013), Alberola et al. (2013), Coibion and Gorodnichenko (2013), and Ormerod et al. (2013).

Against this backdrop, we comprehensively analyse the stability and validity of the Phillips curve relationship for the periphery countries of euro area, namely Spain, Italy, Greece, Ireland, and Portugal, that are linked to unsustainable (sector-specific) financial as well as debt developments and suffer most from the recent crisis. We find an insignificant link between inflation and the output gap or unemployment gap, which questions the validity of the Phillips curve to identify the sustainable level of output, thus inflation-

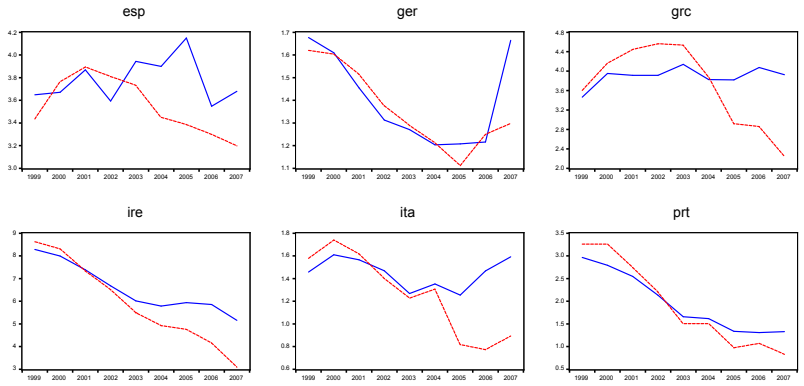

Figure 4: Potential Output Revisions by the European Commission

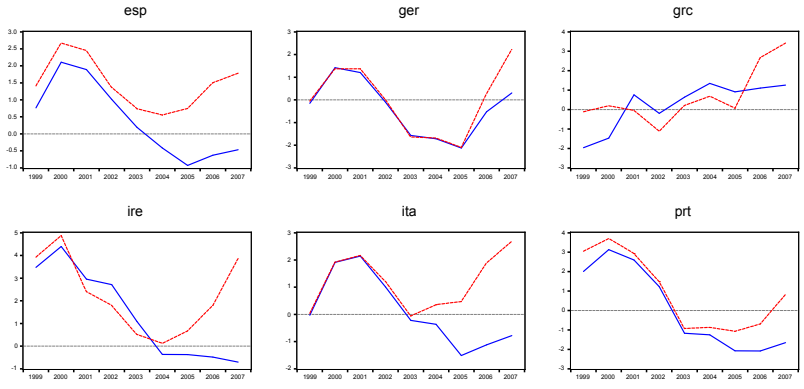

Figure 5: Output Gap Revisions by the European Commission

neutral output, in an economy. The credit-driven boom in crisis countries has made clear that (disadvantageous) financial markets conditions may result in structural and long-term real economic distortions that are not yet taken into account in conventional methods for the estimation of potential output and the output gap. Since both, potential output and output gaps, are a key notion in policymaking, incorporating financial factors could improve the reliability of the estimates and thus result in more effective policy, especially in times of economic crisis.

2 The Phillips curve

2.1 Theoretical considerations and econometric specification

The traditional Phillips curve relation is still often taken as key theoretical element for measuring potential output. In this section, we comprehensively analyze the validity and stability of the Phillips curve in European crisis countries, Spain, Italy, Greece, Ireland, and Portugal which has not be done before.

In order to check whether the relation between inflation and economic conditions, i.e. overheating or slack, is stable over time or existent at all, we take a theory-consistent Philips curve specification as a basis. The default specification is based on Gordon's triangle model (Gordon 1997), where we replace adaptive inflation by forward-looking inflation expectations. This is an important modification. In fact, it is well-known that the postulated inflation–unemployment relation has its weaknesses. Both the (expectation-augmented) neoclassical, where adaptive expectation are included, as well as the New-Keynesian Phillips curve, which is augmented by current expectation of future inflation, do not match empirical data well (Koop and Onorante 2012). The so-called hybrid New-Keynesian Phillips which accounts for current expectation of future inflation and lagged inflation – to account for inflation persistence – seems to be more reasonable and also recently suggested by Koop and Onorante (2012) for an empirical assessment of the Phillips curve. Moreover, the hybrid New Keynesian Phillips curve, put forward by Gali and Gertler (1999), is by now a wide-spread tool in macroeconomic models. The empirical Phillips curve specification looks as follows:

$$\pi_t \;=\; \alpha + \rho\pi^e_{t+h|t} + a(L)\pi_t + \eta(L)(y_t - y^p_t) + \omega(L)z_t + \epsilon_t, \tag{1}$$

where α denotes a constant, π_t denotes inflation, $\pi^e_{t+h|t}$ inflation expectation up to horizon h, y^p_t is potential output and hence $y_t - y^p_t$ the output gap, and z_t is a vector of additional exogenous price shock variables. In system approaches to estimate potential output and the NAIRU output gap and unemployment gap are linked via Okun's law $y_t - y^p_t = \phi(u_t - u^n_t)$, where u^n_t is the non-accelerating inflation rate of unemployment (NAIRU)) (see Fabiani and Mestre 2004, Apel and Jansson 1999*a* or Schumacher 2008.). Thus,

we will estimate another specifications, where $y_t - y_t^p$ is replaced by $u_t - u_t^n$ to test the stability of the Phillips Curve relation for both possible measures of the degree of slack or overheating in an economy.

The vector z_t contains the HWWI raw material price index, labor productivity, and terms of trade. The HWWI is added to capture the influence of an increase in raw-material prices on inflation in the economy. Terms of trade or the price wedge reflects various factors such as competition in the goods market and productivity differences. For instance, in case of low competition, market power is high and firms can easily raise prices, resulting in a high difference between consumer and producer prices. Productivity difference between the sector for investment goods and the consumption goods sector may also be reflected in the price wedge. Higher productivity in the development of investment goods relative to the consumption goods sector increases producer prices relative to consumer prices, resulting in a wider gap between PCE and GDP deflator. Hence, controlling for the price wedge in the Phillips curve equation is of crucial importance to account for exogenous price movements. Moreover, labor productivity is included to account for increases in the price level caused by increased productivity. The latter variables are included as they are crucial determinants of inflation by means of exogenous price movements. Leaving them out in the estimations would result in an omitted variable bias.

Moreover, we include inflation expectation ($\pi^e_{t+h|t}$), and lagged inflation ($a(L)\pi_t$) in order to capture inflation persistence. Using inflation expectation instead of adaptive inflation is an important innovation to the empirical literature.[1] The importance of including inflation expectations is also documented by Koop and Onorante (2012) and Coibion and Gorodnichenko (2013). In summary, our approach is based on theoretical considerations of the hybrid New Keynesian Phillips curve and consistent with as well as expanding standard approaches in the literature (Gordon (1997), Apel and Jansson (1999*b*), Gali and Gertler (1999), Franz (2005), Fitzenberger et al. (2007), Basistha and Nelson (2007), Koop and Onorante (2012), to name a few).

2.2 Data issues

As measure for inflation, the harmonized rate of consumer prices (HCPI) is used. This will serve as default specification, but we check robustness of the results by using another specification. It relies on the Gross Domestic Product (GDP) deflator for measuring price inflation in terms of producer prices. The dependent variable, π_t, is the first difference of annualized log growth rates of the price index.[2]

[1] Solely Koop and Onorante (2012) capture "true" inflation expectation by ECB's survey of professional forecasters.

[2] Empirical analyses do not result in clear-cut evidence whether inflation is an I(0) or I(1) process (see e.g. Romero-Ávila and Usabiaga 2009). Thus, as robustness check, we also apply the second difference of the annualized inflation rates to rule out spurious results due to non-stationarity of inflation rates. The

Inflation expectations are provided by Consenus Economics that conduct a comprehensive macroeconomic survey. Consensus collects forecasts from several institutes and banks and publishes the mean for each variables as Consensus forecast. We use consumer price expectation as it is available for all countries, whereas wages, producer prices or the GDP deflator is only partly covered.

The estimations of equation (1) test the validity of the Phillips curve by using OLS regressions by taking the NAIRU as well as potential output as given.[3] Therefore, we use a Hodrick-Prescott(HP)-filter to extract potential output and the NAIRU and construct the output and unemployment gap, respectively. This appears to be a valid approach. The measures derived by the HP-filter and those calculated by other institutions—Oxford Economics and the OECD—are highly correlated as can bee seen in Table 1. The HP-filter is, moreover, still a wide-spread tool to derive output gaps (see Cerra and Saxena (2000), Cotis et al. (2003), Cusinato et al. (2013)).

Table 1: Correlation between different gap measures

	ESP	GRE	IRE	ITA	PRT
u^n: ZEW/OE	0.9179	-	0.9041	0.9128	0.8589
y_t^p ZEW/OE	0.9967	0.8132	0.9639	0.9533	0.9616
$y_t - y_t^p$: ZEW/OE	0.5321	0.6887	0.3854	0.5606	0.4780
$y_t - y_t^p$: ZEW/OECD	-	-	0.3086	0.5505	-

The ZEW measure uses an HP-filter to construct potential output or the NAIRU, OE denotes data from Oxford Economics and OECD the respective data from the OECD.

Vector z_t contains exogenous inflation-determining variables, namely raw material prices, labor productivity, and terms of trade that are relevant variables influencing the inflation rate in an economy. The HWWI index is highly correlated with oil prices, but is a broader measure for raw materials including oil prices and other raw materials. Thus, we prefer the more comprehensive index. To ensure stationarity, the raw material index is transformed into annual growth rates. Labor productivity is measured as GDP per hours worked provided by Eurostat. The terms of trade or price wedge, which we define as the difference between consumer prices, measured by the PCE (Personal Consumption Expenditure)-deflator and measured by private final consumption expenditure provided by the OECD, and producer prices, approximated by the GDP deflator. We use lagged (first difference of) terms of trade as well as the first difference of labor productivity and its first lag.

2.3 Analyses and results

Recall that our default specification is the hybrid New-Keynesian Phillips curve based on consumer price inflation. To check robustness, the second specification uses the GDP

main results do not change.

[3]We do not aim at estimating potential output here, but take a step back and check the validity of the Phillips curve and thus do not employ a system estimator.

deflator.[4] We rely on quarterly data, whereas the sample periods start in 1994q2 for Italy, in 1998q1 for Ireland, 1996q1 Portugal and in 2001q1 for Spain and Greece. Several tests are performed to analyse the validity of the Phillips curve implications; specifically, the link between inflation and the status of an economy measured by the output or unemployment gap. We perform rolling window OLS-estimations of equation (1) from 2006 to 2012 for the periphery countries of the euro area and test whether the coefficient η in front of the gap-variable has significant explanatory power. This would imply that there is a statistical significant link between inflation and overheating or slack in economy that would support the implications of the Phillips curve, otherwise the results would question the proposition suggested by the Phillips curve.[5]

Figures 6 – 9 show the recursive coefficients (η) and $+/-2$ standard error bands for the output or unemployment gap variable for Spain (ESP), Italy (ITA), Portugal (PRT), Ireland (IRL), and Greece (GRC) of equation (1) using either hcpi inflation or the gdp deflator.

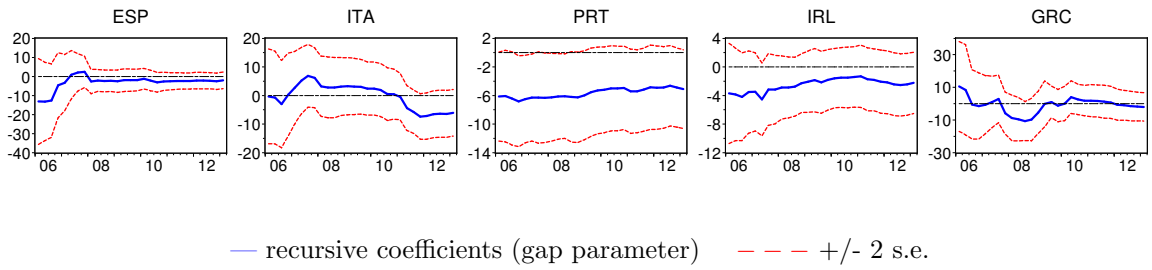

Figure 6: Recursive coefficients, HCPI inflation measure, unemployment gap

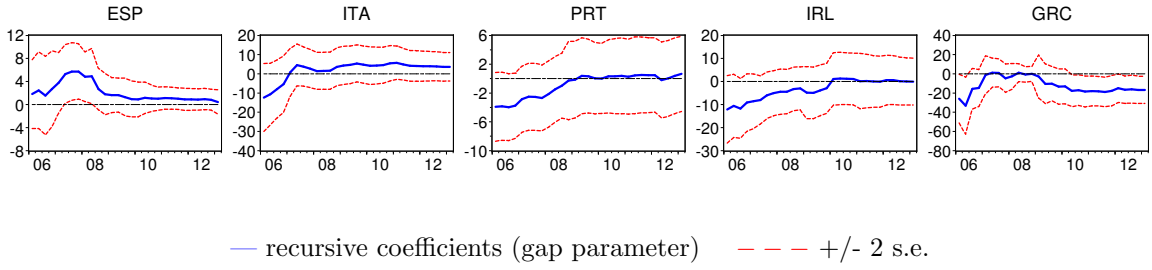

Figure 7: Recursive coefficients, GDP-deflator inflation measure, unemployment gap

As can be seen from the figures, there seems to be no stable, significant relation between

[4]Additionally, the specification suggested by the European Commission (EC) will be applied. The results can be found in the appendix. This type of Phillips curve specification can be derived by a standard labor market model and relies on wage inflation as measure for inflation. The EC uses this Phillips curve specification, for instance, to identify the so called Non-Accelerating Wage Rate of Unemployment (NAWRU) which is employed to derive the potential labour input within a production function approach to estimate potential output and output gaps. The EC methodology is described in detailed by D'Auria et al. (2010).

[5]Additionally, we check potentially remaining serial correlation by the Durbin Watson statistic. In general, the estimations do not point towards a serial correlation problem in the error terms.

inflation and the unemployment gap. The recursive coefficient is mostly insignificant for all countries and both measures imply that the unemployment gap does not seem to be an important determinant of the evolution of inflation over the period from 2006 to 2012. A significant and negative η-coefficient, which would indicate a relevant link between unemployment and inflation, are rare and can only be found for Portugal in Figure 6 and Greece in Figure 7. Interestingly, the results for Portugal (based on hcpi inflation) confirm the inverse relation between unemployment gap and inflation in the run-up to the financial crisis, which then begins to loosen and disappears during the times of crisis at mid of 2008. In contrast, in Greece the Phillips curve proposition seem to be confirmed more recently, whereas previous 2010 neither gdp nor hcpi inflation reveals a significant link with the unemployment gap measure. Currently, high unemployment rates and low inflation in Greece may reinforce the Phillips curve implications.

The results change slightly when the output instead of the unemployment gap is used in equation (1), but are still far away from supporting the stable link between inflation and the output gap and thus, the implications of the Phillips curve. We find, however, some periods for some countries which point towards a statistically relevant link between slack or overheating and inflation (see the following Figures 8 and 9).

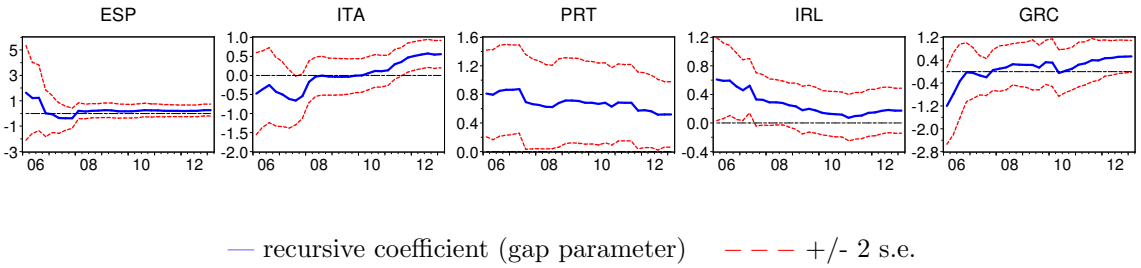

Figure 8: Recursive coefficients, HCPI inflation measure, output gap

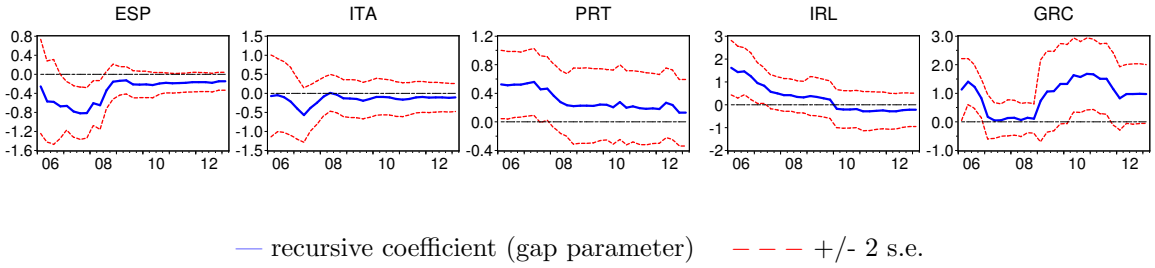

Figure 9: Recursive coefficients, GDP-deflator inflation measure, output gap

Again, the results differ with respect to the measure of the gap variable. Based on hcpi inflation, the slack parameter seems to have a significant impact on inflation in Portugal. This result, however, does not hold for the gdp measure of inflation, where we only find significance at the beginning of the period under study which becomes insignificant

afterwards. The same pattern can be found for Ireland, where the output gap influences inflation significantly at the beginning of the period under study; thus in the pre-crisis period. This is also partly true for Greece.[6] When the financial crisis set in heavily, the proposition of the Phillips curve do not longer hold. Thus, estimations of potential output or the output gap that are based on the Phillips curve may then may fail to provide reliable estimates.

To check the stability of the complete model, we perform Cusum and Cusum Q tests being suggestive for parameter or variance instability. Moreover, we calculate the recursive one-step Chow forecast test which shows points in time where the equation was least successful in explaining inflation. These results can be found in Appendix A.2. In general, they point toward rather stable parameter and variance over time. This is in line with the previous results of the recursive coefficients, where we also find a rather clear-cut and stable picture of a gap measure having an insignificant explanatory power over time.

As there might be some persistence in the link between the gap measure and inflation, we also test the statistical relevance of the contemporaneous and lagged gap measure jointly by means of a Wald-test. There are some approaches in the literature, see for instance Apel and Jansson (1999*b*), that include the first lag of the gap-variable in their Phillips curve specification. Thus, we check whether the gap variables are jointly different from zero which would confirm the validity of the Phillips curve implications. However, the results in Table 2 and 3, where p-values smaller than 0.05 are marked orange (for the Wald-test mentioned above), reinforce the previous results that the unemployment or output gap does not seem to be a relevant determinant for inflation in recent years. Again, Portugal and Ireland seem to be at least for some periods an exception. However, overall we find even less periods with a significant link compared to the precious specification.

	output gap					unemployment gap				
	ESP	ITA	PRT	GRC	IRL	ESP	ITA	PRT	GRC	IRL
2006Q1	0.68	0.62	0.05	0.25	0.08	0.48	0.78	0.09	0.23	0.54
2006Q2	0.67	0.77	0.06	0.21	0.06	0.42	0.74	0.13	0.24	0.46
2006Q3	0.62	0.84	0.05	0.27	0.04	0.39	0.63	0.10	0.21	0.36
2006Q4	0.98	0.62	0.04	0.23	0.04	0.61	0.59	0.08	0.22	0.37
2007Q1	0.98	0.50	0.04	0.19	0.05	0.57	0.57	0.08	0.18	0.35
2007Q2	0.81	0.28	0.03	0.14	0.01	0.42	0.33	0.11	0.18	0.16
2007Q3	0.71	0.13	0.13	0.10	0.10	0.35	0.18	0.11	0.14	0.44
2007Q4	0.64	0.17	0.12	0.40	0.10	0.32	0.20	0.10	0.25	0.41
2008Q1	0.72	0.52	0.12	0.35	0.12	0.16	0.56	0.10	0.26	0.42
2008Q2	0.84	0.40	0.12	0.50	0.11	0.20	0.81	0.09	0.23	0.40
2008Q3	0.57	0.33	0.12	0.64	0.13	0.15	0.81	0.09	0.15	0.42
2008Q4	0.68	0.36	0.10	0.66	0.27	0.17	0.77	0.12	0.18	0.56
2009Q1	0.61	0.44	0.08	0.66	0.24	0.18	0.71	0.13	0.27	0.54
2009Q2	0.45	0.47	0.07	0.87	0.39	0.10	0.70	0.15	0.43	0.57
2009Q3	0.68	0.48	0.07	0.87	0.26	0.36	0.70	0.21	0.43	0.48
2009Q4	0.67	0.48	0.08	0.71	0.32	0.35	0.72	0.22	0.49	0.58
2010Q1	0.60	0.52	0.08	0.75	0.50	0.31	0.75	0.23	0.79	0.62
2010Q2	0.72	0.61	0.08	0.96	0.51	0.38	0.68	0.25	0.51	0.68
2010Q3	0.61	0.52	0.06	0.93	0.67	0.38	0.54	0.25	0.59	0.68
2010Q4	0.68	0.51	0.08	0.90	0.68	0.41	0.53	0.24	0.48	0.74
2011Q1	0.65	0.52	0.05	0.75	0.88	0.38	0.46	0.20	0.69	0.67
2011Q2	0.69	0.31	0.05	0.70	0.57	0.41	0.31	0.19	0.72	0.51
2011Q3	0.67	0.15	0.05	0.53	0.59	0.39	0.25	0.22	0.89	0.47
2011Q4	0.67	0.04	0.11	0.49	0.27	0.38	0.19	0.25	0.88	0.33
2012Q1	0.69	0.03	0.09	0.32	0.25	0.44	0.19	0.23	0.99	0.30
2012Q2	0.67	0.02	0.09	0.29	0.19	0.39	0.24	0.23	0.98	0.23
2012Q3	0.66	0.01	0.12	0.21	0.14	0.37	0.30	0.25	0.95	0.20
2012Q4	0.47	0.02	0.09	0.19	0.20	0.33	0.28	0.21	0.91	0.22
2013Q1	0.22	0.01	0.05	0.16	0.15	0.38	0.30	0.17	0.86	0.26

Table 2: Wald test, lagged and contemporaneous gap measure, HCPI inflation

The results are in line in one way or another with those of some recent studies. Our

[6]The recursive coefficient of the gap-measure is also significant for Spain between 2007 and 2008, but shows a counterintuitive sign.

	output gap					unemployment gap				
	ESP	ITA	PRT	GRC	IRL	ESP	ITA	PRT	GRC	IRL
2006Q1	0.79	0.98	0.05	0.09	0.00	0.46	0.09	0.05	0.09	0.10
2006Q2	0.44	0.99	0.06	0.01	0.00	0.46	0.09	0.06	0.18	0.13
2006Q3	0.33	0.98	0.05	0.01	0.00	0.26	0.11	0.05	0.42	0.07
2006Q4	0.14	0.87	0.04	0.04	0.00	0.14	0.24	0.04	0.38	0.07
2007Q1	0.06	0.62	0.04	0.21	0.00	0.08	0.26	0.08	0.41	0.08
2007Q2	0.05	0.30	0.02	0.40	0.00	0.02	0.44	0.15	0.35	0.07
2007Q3	0.03	0.46	0.03	0.37	0.01	0.01	0.42	0.11	0.36	0.21
2007Q4	0.02	0.65	0.02	0.42	0.03	0.01	0.40	0.14	0.18	0.33
2008Q1	0.04	0.84	0.06	0.35	0.15	0.01	0.37	0.17	0.44	0.43
2008Q2	0.08	0.80	0.12	0.34	0.16	0.02	0.23	0.22	0.32	0.43
2008Q3	0.28	0.95	0.29	0.28	0.11	0.04	0.24	0.31	0.70	0.40
2008Q4	0.67	0.85	0.40	0.24	0.08	0.06	0.22	0.44	0.59	0.41
2009Q1	0.66	0.68	0.46	0.31	0.54	0.05	0.35	0.46	0.39	0.65
2009Q2	0.68	0.70	0.54	0.16	0.53	0.07	0.30	0.52	0.50	0.61
2009Q3	0.21	0.64	0.54	0.22	0.69	0.74	0.31	0.52	0.44	0.66
2009Q4	0.16	0.66	0.51	0.20	0.69	0.84	0.37	0.49	0.28	0.70
2010Q1	0.15	0.60	0.51	0.20	0.60	0.85	0.34	0.49	0.29	0.47
2010Q2	0.16	0.59	0.68	0.07	0.48	0.71	0.33	0.80	0.13	0.45
2010Q3	0.14	0.53	0.56	0.07	0.49	0.67	0.29	0.77	0.12	0.44
2010Q4	0.12	0.46	0.73	0.05	0.47	0.63	0.23	0.78	0.08	0.33
2011Q1	0.12	0.47	0.67	0.04	0.59	0.54	0.19	0.82	0.08	0.25
2011Q2	0.11	0.46	0.72	0.07	0.58	0.54	0.19	0.81	0.07	0.24
2011Q3	0.12	0.65	0.73	0.08	0.63	0.57	0.17	0.79	0.05	0.23
2011Q4	0.18	0.69	0.70	0.14	0.62	0.67	0.16	0.82	0.11	0.22
2012Q1	0.18	0.65	0.72	0.24	0.56	0.66	0.21	0.81	0.14	0.20
2012Q2	0.17	0.63	0.56	0.10	0.56	0.66	0.21	0.89	0.08	0.20
2012Q3	0.13	0.63	0.60	0.09	0.56	0.61	0.20	0.96	0.10	0.19
2012Q4	0.17	0.55	0.86	0.06	0.55	0.68	0.22	0.94	0.08	0.18
2013Q1	0.00	0.58	0.54	0.06	0.53	0.88	0.21	0.92	0.08	0.18

Table 3: Wald test, lagged and contemporaneous gap measure, GDP-deflator inflation

outcomes are similar to those derived by Koop and Onorante (2012) who estimate the Phillips curve for the Euro area. They also find an insignificant gap-coefficient. They show instability of the Phillips curve for the euro area as a whole. Similarly, the ECB (2013) presents a decreasing importance of the slack parameter for inflation in the euro area. In general, one explantation—besides other developments[7]—could be that credit is missing in the Phillips curve equation. This would question the Phillips curve equation in its traditional form and the relation between inflation and slack or overheating in economy might be influenced by other variables—besides the ones we already controlled for. Thus, the measurement for potential output could be distorted.

3 Implication for potential output measurement: Is a credit cycle missing?

There is a strand of literature showing the long-lasting impact of credit booms and the financial crisis on economic activity as well as output evolution, see for instance, Cerra and Saxena (2008), Koo (2011), Jordá et al. (2013), Schleer and Semmler (2013) for the recent financial crisis. Moreover, the impact of a credit or financial cycle on potential output is documented by Bijapur (2012), Furceri and Mourougane (2012), Borio et al. (2013*b*;*a*; 2014), Benati (2013), Karfakis (2013), Alberola et al. (2013). Moreover, Juselius and Juselius (2013) question the functioning of the Phillips curve during balance sheet recessions.

These findings in combination with our central empirical result—the instable link between inflation and overheating—might point towards a missing variable such as a financial or credit cycle in the Phillips curve specification. This idea was put forward also by Borio et al. (2013*b*;*a*). In the following Table 4 , we show that both the output gap as well

[7]See ECB (2013) for some ideas.

as the unemployment gap are mostly highly correlated with credit growth. The output gap is positively correlated with credit growth, in that a higher credit growth is related to a higher output gap. The correlation is significant for Spain, Italy and Portugal. Specifically, in the European crisis countries this might imply that the unsustainable credit-boom was then linked to higher (revised) output gaps. Unfortunately, we are not able to use real-time data of potential output or output gap estimates which only exist on annual frequency. Therefore, we are not able to analyse the correlation over time in a reliable manner. We would expect that prior to the crisis, potential output and credit growth were highly positively correlated, whereas the correlation decreases afterwards when potential output was adjusted downward. Then, we could analyze whether the correlations were more pronounced in the countries with unhealthy financial or sector developments in the run-up to the crisis.

Table 4: Correlation credit growth and output gap

	corr	p-val.
ESP	0.3649	**0.0108**
ITA	0.4188	**0.0001**
GRE	0.2649	0.0552
IRL	0.1825	0.1629
PRT	0.3513	**0.0033**

The significant link between the output gaps and credit growth supports the idea that a credit or financial cycle is important in order to derive valid output gaps which might be particularly relevant for crisis-times. Moreover, based on a New Keynesian model Liu and Minford (2012) show that "[...] the credit channel is the main contributor to the variation in the output gap during the crisis". As a consequence, in a next step, it may be interesting and technically more appealing to estimate a state-space model augmented by credit which might be of crucial importance for determining output gaps and thereby, for estimating the Phillips curve reliably. There are approaches where potential output estimations are corrected for a financial cycle. Borio et al. (2013*a*) and Borio et al. (2014) can be seen as seminal papers in this context. They, however, do not present a structural model, but rather an ad hoc way of incorporating credit in a type of multivariate HP-filter equation. In the following, we briefly sketch an preliminary idea of a system approach.[8]

The system of equation 3 is based on the model presented by Apel and Jansson (1999*b*), but augmented by a financial cycle $fc_t = \xi fc_{t-1} + \epsilon_t^{fc}$. Both unemployment and output have financial cycle component y_t^{fc} and u_t^{fc}. This financial cycle or common component is extracted from a set of indicators that drive financial conditions in an economy. In our example, this could be credit growth cr_t, residential property prices rp_t, and a financial condition index fci_t. The estimations of this state-space model might be performed in a time-varying way to account for changing dynamics. Capturing a kind of non-linearity, i.e.

[8]The formal notation can be found in Appendix 3.

a threshold that needs to be exceeded so that financial conditions impact the sustainable level of output adversely. Potential output measurement based on a system of equation could be a promising approach for future research.

4 Conclusion

Overall, we show that the output gap or unemployment gap are mostly statistically insignificant determinants of inflation. Thus, our results question the Phillips curve implication – a link between inflation and overheating or slack in an economy. Besides several other arguments, one reason for the failure might be that a financial cycle is missing that is important to determine a sustainable level of output, i.e. potential output. The fragile Phillips curve and the failure of capturing a financial cycle adequately may then have led to the biased estimations of potential output in pre-crisis times, in particular in the periphery countries of the euro area. We suggest to account for a financial cycle in a system approach of estimating potential output and therefore, in some sense, obtain a correction for the inflation–output link which may "repair" the Phillips curve.

A Appendix

A.1 Approach of European Commission

The EC Phillips curve equation reads as follows:

$$\pi_t \quad = \quad \alpha + \eta(L)(\text{gap}_t) + \omega(L)z_t + \varepsilon_t \tag{2}$$

The method defines the depended variable (π_t) as change in wage inflation. The latter is explained by a constant α, the unemployment gap (gap_t)—actual unemployment minus the Non-accelerating inflation rate of unemployment (NAIRU)—, and a vector of additional variables (z_t), including the wage share, labor productivity, and terms of trade (Roeger 2006; Denis et al. 2006).

The European Commission Phillips curve specification includes three exogenous shock-variables, contained in vector z_t, capturing the response of short-run nominal wages to productivity shocks, labour demand shocks and terms of trade (TOT) shocks (Roeger 2006). Productivity shocks have an effect on nominal wages via two channels, a productivity channel (with a positive response of wages to productivity) and an inflation channel (negatively responding to productivity changes). Shocks to labour demand are approximated by changes in the growth rate of the wage share. Since adverse labour demand shocks have a negative effect on inflation, they also have a negative effect on the nominal wages via the interest rate channel. Worsening economic conditions result in lower interest rates, employment of capital gets cheaper and thereby, the demand for labor decreases which puts pressure on nominal wages. Finally, a TOT shock drives a wedge between consumer and producer prices as measured by the gdp deflator with nominal wages responding positively.

In the econometric analyses, the EC-method relies on the first difference of the annualized wage inflation as a dependent variable and the first difference of terms of trade to ensure stationarity of the respective variable. We follow this approach.[9] Also in line with the EC, we augment the equation by the lagged wage-share, lagged terms of trade, the second difference of the wage share, the first difference of labor productivity and its first lag. We do not include the lagged labor productivity and the second lag of the wage share as the matrix of regressors cannot be inverted anymore as it is near singular.[10]

The results are presented in the following Figure and Table. Our main result—a statically insignificant relation between inflation and unemployment— is also confirmed for the Phillips curve specification of the EC based on wage inflation.

[9] We follow the EC-approach as closely as possible in order to have a specification that is widely spread and commonly accepted.

[10] For a detailed overview of the specification, have a look at the country interfaces of the GAP program, provided by the European Commission. An overview of the included variables can be downloaded from `https://circabc.europa.eu/sd/d/ead5993a-ef3d-470a-a722-7862520c74ea/readme.doc`.

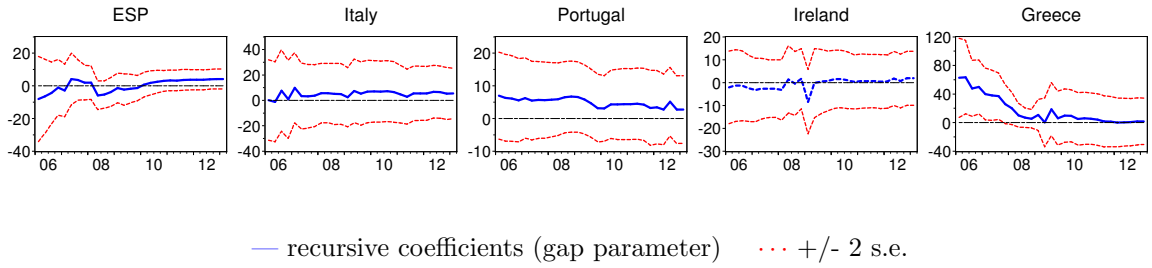

Figure 10: Recursive coefficients, EC-specification

	ESP	ITA	PRT	GRC	IRL
2006Q1	0.65	0.59	0.59	0.11	0.43
2006Q2	0.67	0.39	0.65	0.07	0.42
2006Q3	0.75	0.45	0.66	0.06	0.40
2006Q4	0.89	0.63	0.70	0.03	0.34
2007Q1	0.80	0.61	0.61	0.10	0.35
2007Q2	0.50	0.91	0.67	0.09	0.35
2007Q3	0.47	0.92	0.64	0.07	0.36
2007Q4	0.64	0.90	0.64	0.15	0.30
2008Q1	0.60	0.82	0.61	0.19	0.32
2008Q2	0.43	0.88	0.58	0.36	0.91
2008Q3	0.46	0.92	0.51	0.52	0.84
2008Q4	0.59	0.92	0.49	0.69	0.82
2009Q1	0.95	0.97	0.49	0.21	0.29
2009Q2	0.52	0.81	0.56	0.83	0.24
2009Q3	0.64	0.83	0.67	0.33	0.23
2009Q4	0.65	0.75	0.83	0.66	0.22
2010Q1	0.44	0.74	0.83	0.51	0.17
2010Q2	0.38	0.76	0.70	0.51	0.17
2010Q3	0.27	0.83	0.73	0.52	0.19
2010Q4	0.21	0.84	0.73	0.57	0.18
2011Q1	0.14	0.87	0.72	0.56	0.12
2011Q2	0.20	0.92	0.72	0.57	0.11
2011Q3	0.11	0.73	0.74	0.53	0.12
2011Q4	0.11	0.74	0.76	0.51	0.09
2012Q1	0.10	0.74	0.74	0.52	0.08
2012Q2	0.11	0.70	0.76	0.53	0.08
2012Q3	0.14	0.74	0.47	0.53	0.09
2012Q4	0.08	0.80	0.67	0.44	0.09
2013Q1	0.08	0.78	0.67	0.43	0.09

Table 5: Wald test, lagged and contemporaneous gap measure, EC procedure

A.2 Additional Results

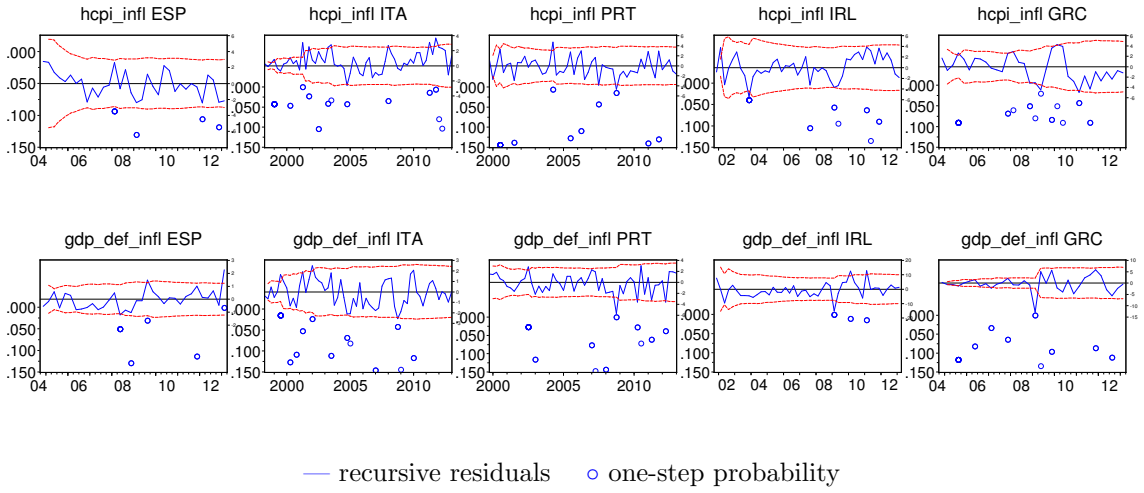

Figure 11: Chow test, unemployment gap

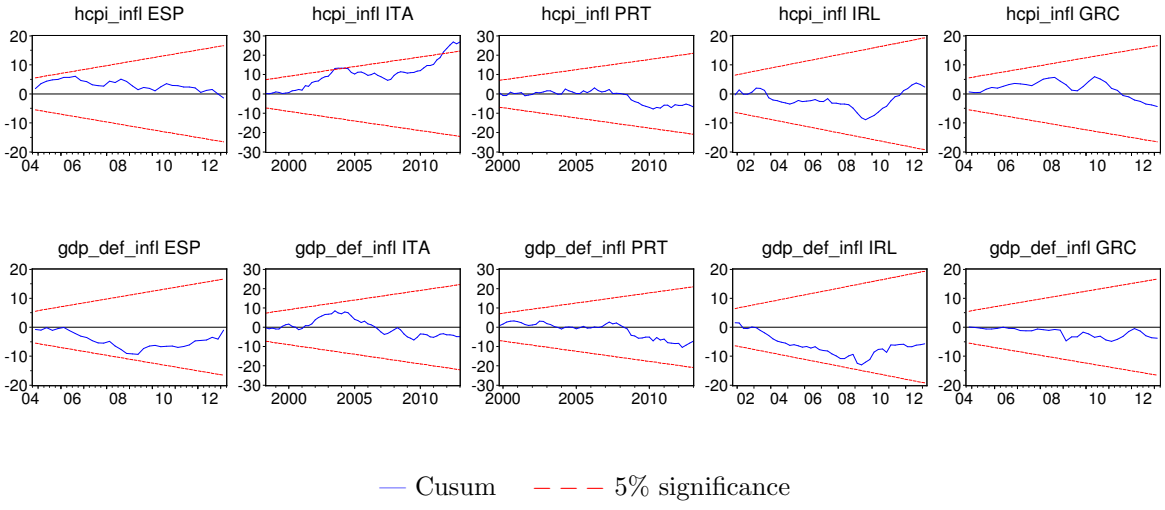

Figure 12: Cusum test, unemployment gap

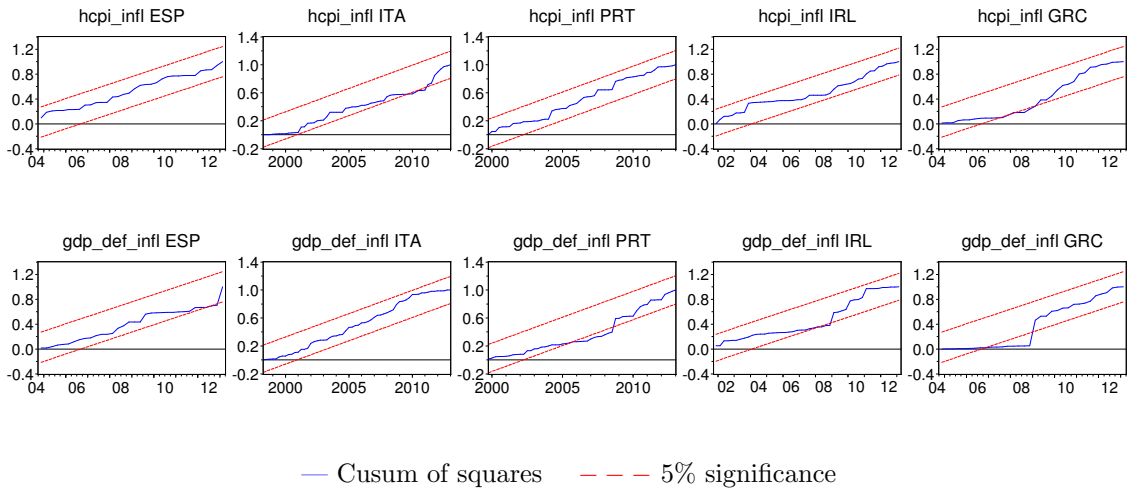

Figure 13: Cusum q test, unemployment gap

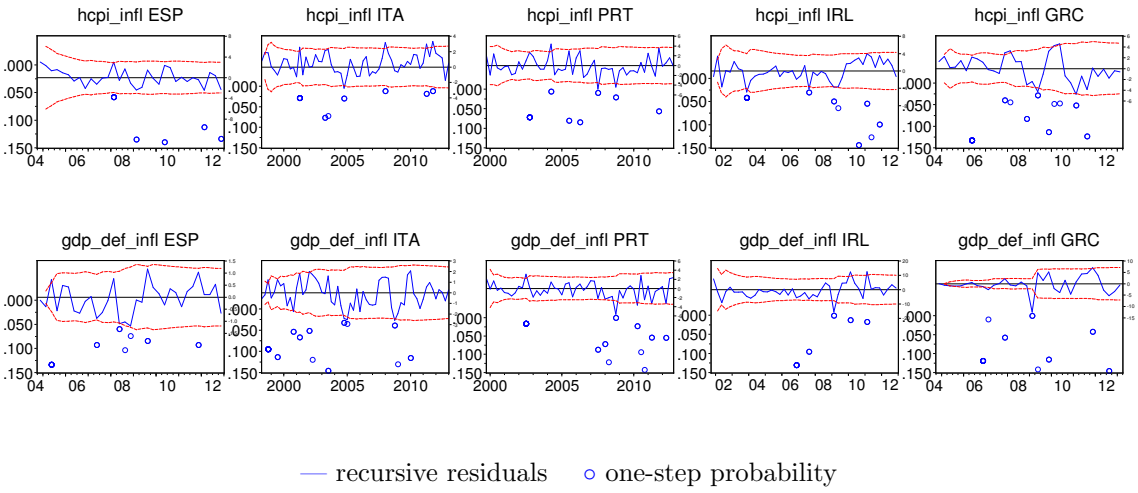

Figure 14: Chow test, output gap

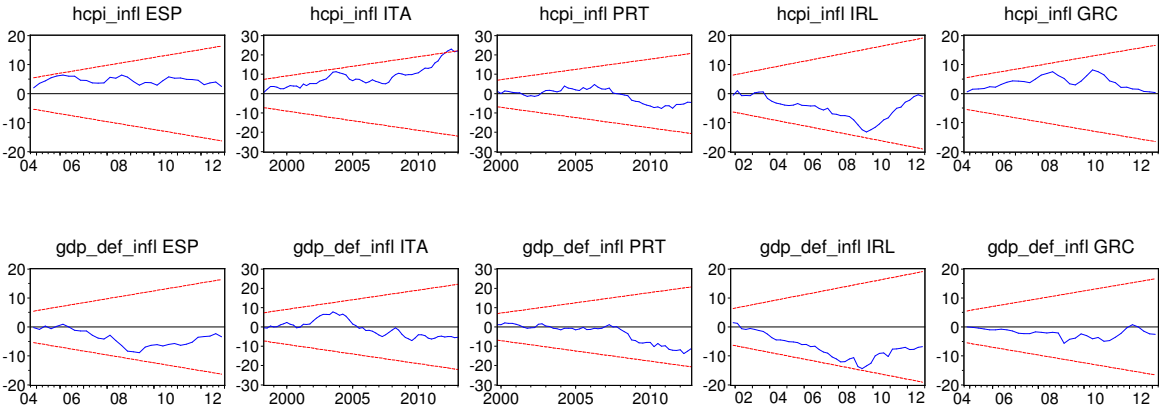

Figure 15: Cusum test, output gap

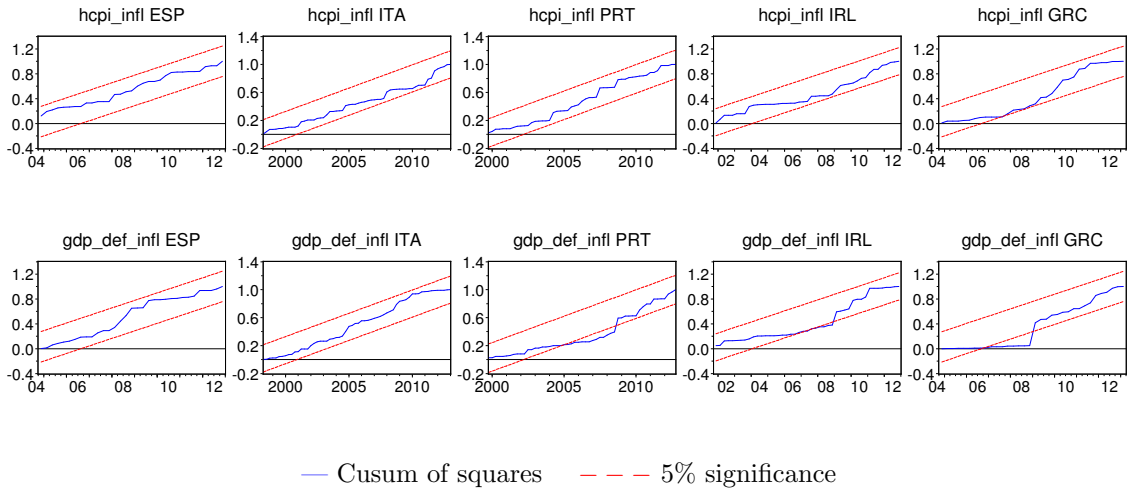

Figure 16: Cusum q test, output gap

A.3 System of Equations

$$
\begin{aligned}
\pi_t &= \alpha + \rho\pi^e_{t+h|t} + a(L)\pi_t + \eta(L)(u_t - u^n_t) + \omega(L)z_t + \epsilon^{pc}_t \\
y_t &= y^p_t + y^c_t + y^{fc}_t \\
u_t &= u^n_t + u^c_t + u^{fc}_t \\
\\
y^{fc}_t &= \beta_y fc_t + \epsilon^{yfc}_t \\
u^{fc}_t &= \beta_u fc_t + \epsilon^{ufc}_t \\
\\
cr_t &= \lambda_{cr} fc_t + \epsilon^{cr}_t \\
rp_t &= \lambda_{rp} fc_t + \epsilon^{rp}_t \\
fci_t &= \lambda_{cr} fc_t + \epsilon^{fci}_t
\end{aligned}
$$

State equations:

$$
\begin{aligned}
y^c_t &= \phi(L)u^c_t + \epsilon^{ol}_t \\
y^p_t &= \zeta_1 + y^p_{t-1} + \epsilon^p_t \\
u^n_t &= \zeta_2 + u^n_{t-1} + \epsilon^n_t \\
u^c_t &= \delta(L)u^c_t + \epsilon^c_t \\
fc_t &= \xi fc_{t-1} + \epsilon^{fc}_t
\end{aligned}
$$

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