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Mind the output gap: the disconnect of growth and inflation during recessions and convex Phillips curves in the euro area

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This paper presents research conducted within the Task Force on Low Inflation (LIFT). The task force is composed of economists from the European System of Central Banks (ESCB) - i.e. the 29 national central banks of the European Union (EU) and the European Central Bank. The objective of the expert team is to study issues raised by persistently low inflation from both empirical and theoretical modelling perspectives.

The research is carried out in three workstreams:

1) Drivers of Low Inflation;

2) Inflation Expectations;

3) Macroeconomic Effects of Low Inflation.

LIFT is chaired by Matteo Ciccarelli and Chiara Osbat (ECB). Workstream 1 is headed by Elena Bobeica and Marek Jarocinski (ECB) ; workstream 2 by Catherine Jardet (Banque de France) and Arnoud Stevens (National Bank of Belgium); workstream 3 by Caterina Mendicino (ECB), Sergio Santoro (Banca d'Italia) and Alessandro Notarpietro (Banca d'Italia).

The selection and refereeing process for this paper was carried out by the Chairs of the Task Force. Papers were selected based on their quality and on the relevance of the research subject to the aim of the Task Force. The authors of the selected papers were invited to revise their paper to take into consideration feedback received during the preparatory work and the referee's and Editors' comments.

The paper is released to make the research of LIFT generally available, in preliminary form, to encourage comments and suggestions prior to final publication. The views expressed in the paper are the ones of the author(s) and do not necessarily reflect those of the ECB, the ESCB, or any of the ESCB National Central Banks.

Abstract

We develop a theoretical model that features a business cycle-dependent relation between output, price inflation and inflation expectations, augmenting the model by Svensson (1997) with a nonlinear Phillips curve that reflects the rationale underlying the capacity constraint theory (Macklem (1997)). The theoretical model motivates our empirical assessment for the euro area, based on a regime-switching Phillips curve and a regime-switching monetary structural VAR, employing different filter-based, semi-structural model-based and Bayesian factor model-implied output gaps. The analysis confirms the presence of a pronounced convex relationship between inflation and the output gap, meaning that the coefficient in the Phillips curve on the output gap recurringly increases during times of expansion and abates during recessions. The regime switching VAR reveals the business cycle dependence of macroeconomic responses to monetary policy shocks: Expansionary monetary policy induces less pressure on inflation at times of weak as opposed to strong growth; thereby rationalizing relatively stronger expansionary policy, including unconventional volume-based policy such as the Expanded Asset Purchase Programme (EAPP) of the ECB, during times of deep recession.

Keywords: Phillips curve, nonlinearity, monetary VAR, inflation targeting, monetary policy, euro area

JEL classification: E31, E42, E52, E58

Non-technical summary

The purpose of the paper is to provide a theoretical as well as an empirical discussion about possible nonlinearities in the Phillips curve. It is meant to thereby help shape our understanding of why price inflation has been so difficult to stimulate, as of yet, in the aftermath of the global financial crisis. One of the theories that imply a rationale for such behaviour of inflation during recessions is the capacity constraint model. It argues that if aggregate demand increases during recessions–as a result possibly of successful expansionary monetary or fiscal policy–firms would be able to satisfy the additional demand by producing more and hence see little incentive to raise prices. During times of strong growth, on the other hand, firms produce closer to their capacity constraint and should demand rise further they would react by raising prices. This rationale implies for the Phillips curve coefficient on the output gap to be business cycle-dependent, for it to move up (down) during boom (recession) times. We start our paper by building this very feature into the inflation forecast targeting model by Svensson (1997), to discuss the policy implications of such nonlinearity and to motivate the empirical section of the paper.

Our empirical assessment starts from a series of single equation Phillips curve estimates for the euro area and the individual countries. For the sake of developing a comprehensive, robust assessment, we employ various different measures of economic slack, including statistical along with semi-structural output gap measures developed by the European Commission and the International Monetary Fund as well as measures based on a Bayesian dynamic factor model. Under a significant number of specifications the finding of convexity clearly holds and thereby confirms that the Phillips curve coefficient recurringly increases (decreases) during boom (recession) times.

In addition to the single equation analysis we develop some monetary structural VAR models which we augment by the same regime-switching mechanism as the single equation Phillips curves. An expansionary monetary policy shock (as well as a more direct positive bank credit supply shock) for the euro area turns out to have business cycle stage-dependent consequences: it has much less potential to induce inflation at times of weak growth and stronger potential to do so during boom times. The regime-conditional responses from a model that is further augmented by the euro effective exchange rate suggest that the consequence of an exchange rate shock is also state-dependent, with more upward pressure on prices being expected from unexpected currency depreciation at times of expansion than during recession phases.

Both the theoretical model work and the empirical results let us draw various policy conclusions. Operating with linear Phillips curves while supposing that the convex form does better capture economic reality implies that the linear model would tend to over-(under-)predict inflation during times of recession (expansion). Moreover, the linear model would tend to overestimate the inflationary effect of expansionary policy during recessions and underestimate the disinflationary effect of contractionary policy during boom times. The linear models' deficiency in terms of overpredicting inflation during recessions is illustrated in the paper; along with the fact that the nonlinear model forecasts better capture the realized inflation path over the post-financial crisis period. For the conduct of monetary policy the convex model implies that policy makers may want to consider deploying relatively stronger expansionary policy measures at times of weak growth, via conventional interest rate policy as long as feasible or unconventional measures should short-term interest rates reach the zero lower bound. The sharper expansionary policy can be expected to induce little pressure on prices in the short run for the aforementioned reason that firms have little incentive to raise prices even if demand is successfully stimulated. Given the convex Phillips curve shape, monetary policy might benefit from acting in a preemptive manner which is beneficial also when time is ripe to slow down growth and inflation because the sooner such policy is pursued the less costly it is in terms of lost output.

1 Introduction

This study is about the dynamics of price inflation and their relation to the business cycle — a subject that is a well known one for macroeconomists. Starting from the original work by Phillips (1958) there has been a long-lasting interest in the topic; from the late 1960s during which Friedman (1968) and Phelps (1967) criticized the Phillips curve, claiming that nominal variables cannot influence real variables, which led in the 1970s to the development of the expectation augmented Phillips curve, as a result of its inability to explain that inflation and unemployment rose simultaneously in the 1970s (in the face of the oil price shock). The question as to why inflation rates are so persistently low and difficult to stimulate in the aftermath of the global financial crisis ranks high, for obvious reasons, also on the agenda of major central banks around the world.[1]

Over time, three Phillips curve specifications have turned out to become the conventional ones: the *Traditional* (or New Classical), the *New Keynesian* and the *Hybrid Phillips curve*. In the New Classical form of the curve, inflation is a function of lagged expected inflation and a contemporaneous measure of excess demand. The underlying theoretical work by Phelps (1967) suggests that current and lagged expected inflation shall move one-to-one. The parameter on excess demand, the measure of marginal cost, indicates the degree to which prices are flexible, with a higher coefficient implying less sticky prices. Roberts (1997) suggests that sticky price models, as the one developed by Calvo (1983), shall imply that the inflation process should have a forward-looking component, which led to an alternative specification in which current inflation is related to currently expected future inflation, along again with a measure of excess demand. In this New Keynesian specification, lagged inflation may only play a role through its interaction with expected inflation at time t and it is not explicitly incorporated in the model. Finally, in the hybrid Phillips curve equation structure inflation depends on currently expected future inflation as well as lagged realized price changes, along with contemporaneous economic slack, a theoretical model for which has been developed by Gali and Gertler (1999). The underlying assumption is that not all firms reset prices in a forward-looking manner. Some firms may not get the chance to adjust prices optimally and rather use simple rules as a function of historic aggregate price behaviour (partial indexation). Non-optimizing firms set prices to an average price level observed over recent history and this renders inflation dynamics to some extent forward- and backward-looking.

The focus of our study is on the potential for the relation of inflation and output dynamics to be nonlinear, which rested in the back of economists' minds since long. Phillips in his original work already revealed a convex relationship (based on wage inflation and unemployment) and it is since then dubbed a Phillips *curve* in fact, and not *line*. Evans (1986) notes that eight of nine textbooks he reviewed at the time feature short-run aggregate supply curves that were convex, not linear. As usefully summarized e.g. in Dupasquier and Ricketts (1998), there are five major theoretical frameworks that give rise to some nonlinearity, either of direct or indirect nature with respect to the sensitivity of inflation to some measure of economic slack.

The capacity constraint theory (Clark et al. (1995), Macklem (1997)) starts from the rationale that firms have spare capacity during recession times, thus are able to satisfy additional demand should it increase, with little or no incentive in this case to raise prices. Only when firms move closer to their capacity constraint, during boom times, would they face more of an incentive to raise prices, as they would be less able to satisfy demand by increasing production. This rationale implies convexity with regard to the coefficient on the measure of slack, which would itself be an increasing function of the *level of slack* (if the latter is measured in output space).

The signal extraction model (Lucas (1972), Lucas (1973)) suggests that the slope of the curve

[1] See for example the agenda of the Jackson Hole Symposium hosted by the Federal Reserve Bank of Kansas City in August 2015: `https://www.kansascityfed.org/publications/research/escp/symposiums/escp-2015`, with a speech related to inflation dynamics, including a possible role for nonlinearities, by the ECB's Vice President, Vítor Constâncio (`https://www.ecb.europa.eu/press/key/date/2015/html/sp150829.en.html`).

shall depend on the volatility of aggregate demand and supply shocks. If aggregate prices are volatile (more volatile during high inflation regimes for instance), then it is less easy for economic agents to infer whether price changes are of relative or aggregate nature, and hence more of a change would be attributed to aggregate price shocks. Disinflation during recessions, coupled with lower inflation volatility, would imply a more pronounced reaction of output. In comparison to the implication of the capacity constraint model, the convexity of the coefficient on slack is therefore not on slack itself, but via the dependence on the *volatility of inflation*.

The costly adjustment model (Ball et al. (1988), Ball and Mankiw (1994)) starts from the assertion that prices are not fully flexible due to the presence of menu costs. The more firms that decide to change their prices, the more responsive would the aggregate price level become to demand shocks. As inflation rises, aggregate demand shocks will have less of an effect on output and more on prices. An implication of this theory is that the convexity of the coefficient on the measure of slack arises via its dependence on the *level of inflation*.

The fourth theory starts from the assumed presence of downward nominal wage/price rigidities (Fisher (1989), Akerlof et al. (1996)). The rationale is that workers naturally are more reluctant to accept a decrease in their wages than an increase. The effects of nominal wage floors is thought to be more likely to be relevant at low inflation rates (during recession times) because at higher levels of inflation it becomes less likely that nominal wage cuts are required for a given decline in real wages. Hence, according to this theory, the convexity of the coefficient on the measure of economic slack is again with respect to the *level of inflation*, though in this case only at times of excess supply; unlike under the costly adjustment model where the convexity with respect to inflation holds also during times of excess demand.

A fifth theory implying a nonlinear trade-off between inflation and output comes under the header of monopolistic competition (Stiglitz (1984), Stiglitz (1997), Eisner (1997)). In a monopolistically competitive economy, or oligopolistic markets respectively, firms are expected to lower prices relatively swiftly to undercut rivals and not lose market share. During boom times that come along with rising inflation, the same is assumed. This theory implies a nonlinear dependence on the measure of slack directly, just as the capacity constraint model, yet of the opposite shape; it is the only one among the five theories implying concavity in the relation between inflation and economic slack.

Concerning the empirical evidence, there is a meanwhile comprehensive set of studies that address nonlinearities in the Phillips curve. Since four out of the five established theories imply convexity, one may expect that the finding of convexity might dominate empirically; assuming all five theories have their merit. Table 1 summarizes the papers that address nonlinearities and confirms that indeed the finding of convexity dominates. We do not discuss all papers listed in Table 1 in detail and leave it at noting that the majority of empirical studies with a view to nonlinearity are centred on the US, and with the majority of them finding convexity, hence giving direct or indirect support to the first four of the five above-mentioned theories. In Total, 40 of 51 studies find convexity, 3 concavity, and 8 reject nonlinearity in favour of linearity.

Empirical work for the euro area or EU aggregate is still scarce and the eight studies appearing in Table 1 appear somewhat inconclusive or mention the non-negligible uncertainty surrounding the estimates. The early studies working on euro area aggregate data in the 2000s may face, in our view, the problem that they employ synthetic euro area aggregate data, often going back to the 1970s. The econometric model estimates based on such aggregates may, hence, suffer from aggregation (attenuation) bias as a result of the fact that business cycles, with regard to real activity, expectations, inflation, etc. were not sufficiently synchronized before the introduction of the euro. After more than 15 years since the inception of the common currency we can be positive that basing an empirical analysis on only post-1999 data is now of avail, as business cycles did indeed become more synchronized since then. In particular the global financial crisis has also served to synchronize them even more as it was a common shock that hit all economies rather symmetrically. Attenuation biases should have become less of a concern for these combined reasons. Since the sample length since the introduction of the euro has become sufficiently long, we start the samples for all empirical analyzes in 1999, to avoid confounding the estimates by significant structural changes, induced in particular by the introduction of the common currency that delineate the periods before and after 1999.

In Section 2 we develop a theoretical model that captures a nonlinearity of the kind implied by the capacity constraint model. The theoretical framework is an extension of the inflation forecast targeting framework by Svensson (1997) and is meant to shape our understanding of what a convex Phillips curve implies, in particular already also for policy. The theory motivates the empirical chapter, Section 3, insofar as the model coefficients are made an explicit function of the state of the economy, i.e. they are not just time-varying in an unconditional manner. We start from the estimation of single equation Phillips curves for the euro area and for the individual euro area and the remaining non-euro area EU countries. We take the hybrid form of the Phillips curve as a point of departure for the single equation analysis while being agnostic however with respect to the time displacement by which inflation expectations enter the model, and while considering various different measures of economic slack, in order to thereby see that the finding of convexity in the Phillips curve is robust to the choice of the output gap measures. Involving numerous different either purely statistical filter-based, reduced-form econometric model- or semi-structural model-implied output gap measures we see as useful to providing a comprehensive assessment of possible nonlinearities in the Phillips curve. In addition, we present a linear and regime-switching VAR model-based impulse response analysis that further corroborates the finding that there is, indeed, a non-negligible state dependence of the responses of price inflation to otherwise identical monetary policy (or credit supply) shocks during times of expansion versus recession. Section 4 concludes.

2 A monetary policy model with a nonlinear Phillips curve

In this section we present a monetary policy macro model with an IS equation, a nonlinear Phillips curve and an optimal Taylor rule as monetary policy rule. We employ here the Svensson (1997) model. We develop our model in continuous time (while Svensson's model was formulated in discrete time), and we do, moreover, consider building in the state dependent response coefficients in the Phillips curve to thereby mimic the rationale of the capacity constraint model.

With respect to the formulation of the model in continuous time, we follow Werning (2012) and will discretize the model when solving it with a new numerical procedure, referred to as Nonlinear Model Predictive Control (NMPC), which allows for a finite decision horizon (see Gruene et al. (2015)). The finite decision horizon is a feature that is in contrast to previous models, such as New Keynesian models, which work with an infinite time horizon.

We pursue a more realistic strategy and build a model based on a short-term behavior of agents that features regime changes. The infinite horizon framework implies a pronounced smoothness in the evolution of the choice variables by construction, as discussed in Gruene et al. (2015). We first start with a model involving a quadratic objective function and linear state equations. Then we introduce a regime change in the state equations, which resembles a structure that we will approach empirically in Section 3.

2.1 Linear response coefficients in the Phillips curve

We start by outlining the model as proposed by Svensson (1997), i.e. the model with linear coefficients in the state equations. The model defines the feedbacks of the output gap and inflation rate to both the inflation rate in the Phillips curve and to the output gap in the IS equation. The coefficients are fixed. The dynamics will be presented first by using the basic Svensson model, i.e. with one delay. Since there are two state equations we may already observe cyclical – and not only uni-directional – changes of inflation and output.[2]

Accordingly, the eqs. (6.2)-(6.5) in Svensson (1997) can be written in continuous time for shorter time horizon as[3]

$$V(\pi, y) = \min_{i_t} \int_0^T e^{-\rho t} \frac{1}{2}((\pi_t - \pi^*)^2 + \lambda y_t^2) dt \tag{1}$$

subject to

$$\dot{\pi}_t = \alpha_1 \pi + \alpha_2 y_t \tag{2}$$

$$\dot{y} = \beta_1 y_t - \beta_2 (i_t - \pi_t - r) \tag{3}$$

In eq.(1) there is a quadratic penalty function which has to be minimized by choosing an interest rate i_t, as the central bank's decision variable, which may be bounded by zero. Whereas π_t is the actual inflation rate the term π^* represents the target inflation rate for the central bank. There is a weight λ attached to the output gap. The parameter ρ defines the discount rate.

Eq. (2) represents the Phillips curve as a differential equation that defines the reaction of the change of the inflation rate to the inflation rate and output gap. As in Svensson, in a first step, those reaction coefficients, $\alpha_1 \leq 0$, $\alpha_2 > 0$ are assumed to be constant, i.e. state-independent. Eq. (3) is the continuous time variant of the IS equation representing the output gap, y_t given the log of actual output, y minus potential output, y^*. The change of the output gap is driven by the output gap and the excess of the real interest rate over the natural interest rate r, this excess being zero at the steady state.[4] Eq. (3) is also a differential equation with constant coefficients, with $\beta_{1,} \leq 0$ $\beta_2 > 0$.

Our model is written in a way that resembles the New Keynesian model version in continuous time as in Werning (2012). The latter derives the continuous time form from an approximation of the Euler equation of a nonlinear model with preferences, as used in the New Keynesian literature on monetary policy models. In Werning (2012) however – and that is a characteristic of New Keynesian models – the inflation rate responds negatively to the output gap, since he uses a purely forward-looking inflation expectation term driving the actual inflation in a Phillips curve relationship of inflation and output.[5] [6]

[2]Note that already a 2-dimensional linear differential equation may have cyclical solutions if it has complex parts of the eigenvalue.

[3]For details of how such type of short decision horizon model can approximate models with longer time horizons well on the basis of much less information for the agents, see Gruene et al. (2015).

[4]The Wicksellian natural rate is used here as a steady state benchmark for returns on capital. Though in recent discussions on secular stagnation the natural rate has been assumed to be a moving one, we will include it here as a constant.

[5]Note that the result may change when one does not use the purely forward-looking but the hybrid Phillips curve where also a lag of the inflation rate is included on the right hand-side of the equation, see Semmler et al. (2005), ch. 4. Our modeling of price expectations in the Phillips curve resembles the price expectations as derived from the survey data (more on that in the empirical section).

[6]Yet note that the Phillips curve of eq. (2) does not necessarily represent an adaptive expectation version. Our solution method NMPC gives us approximately the correct (infinite horizon) paths of the state and control variables and thus represents in principle also forward-looking behavior. When the decision horizon gets very large, the control and state variables represent model consistent forward-looking behavior. See Gruene et al. (2015).

Since such a purely forward-looking Phillips curve, as in Werning (2012), does not perform well in empirical estimations, see Ball and Mazumdar (2011)[7] and Gordon (2011), we use here the Svensson (1997), and Rudebusch and Svensson (1999) version for the Phillips curve.[8] Note that the New Keynesian literature also uses an infinite horizon version of the optimal control problem. We here employ a finite horizon decision model which presumes some limited information agents in the sense of Sims (2006).

From Fig. 1 we observe that, with the output gap being zero at potential output equal 2, for all three initial conditions the inflation rate (vertical axis) and the output gap (horizontal axis) converge. We can also observe that there are only small changes in the inflation rate in the region of a negative output gap (see region from 1.5 to 2) and a faster rising inflation rate in the region of a positive output gap, where the economy operates beyond normal capacity. Thus, as Fig. 1 shows, already the linear response coefficient in the Phillips curve creates, through the feedback effects between the output gap, inflation and interest rate,[9] a nonlinear shape that would be at odds with the assumption of linearity.

2.2 Nonlinear response coefficients in the Phillips curve

We now allow for regime switching in the response coefficients in the Phillips curve, specifically the one that relates inflation to the output gap. We develop a model of regime-switching in the Phillips curve in which we allow for a weaker response of the inflation rate in the region of a negative output gap and a stronger reaction in the regime of overutilization of capacity and a positive output gap (corresponding to the empirical model that will be presented in Section 3). We can employ a regime switching Phillips curve such as the following:

$$\dot{\pi}_t = \alpha_1 \pi + \alpha_2(y_t) y_t \tag{4}$$

$$\alpha_2(y_t) = 0.05, \quad for\ y < 0 \tag{5}$$

$$\alpha_2(y_t) = 0.12, \quad for\ y > 0 \tag{6}$$

Thus the regime switching occurs with regard to the reaction of the inflation rate to the output gap dependent on the output gap being negative or positive, reflecting thereby an asymmetric reaction of the inflation rate to different output gap levels.

In Fig. 2 the model with regime dependent inflation reactions to output gap is solved. As before, potential output is at 2 and thus the output gap is zero at 2. For the initial conditions we assume $\pi(0) = 0.04$ and for output $y(0) = 0.5$. The inflation rate (vertical axis) and output gap (horizontal axis) are shown for the region of a negative output gap, with reaction coefficient $\alpha_2(y_t) = 0.05$,and for the positive output gap with reaction coefficient $\alpha_2(y_t) = 0.12$.

We observe a very small response of the inflation rate to the output gap in the region of a negative output gap. In the region of a positive output gap, with response coefficient $\alpha_2(y_t) = 0.12$, a strong

[7] Ball and Mazumdar (2011) employ also a time varying slope in the Phillips curve.

[8] We want to note, however, that the hybrid New Keynesian Phillips curve, using survey data for price expectations, improves the empirical results of the New Keynesian Phillips curve somewhat, see Semmler et al. (2005), ch. 4.

[9] Note that the interest rate is itself a feedback solution of the state variables since we are using here an optimal Taylor rule.

response of inflation to a positive output gap is observable; see the region to the right of the output gap of zero. Looking at a closer range, from 1.8 to 2.0, there is a weekly changing inflation rate, but there is a strongly changing inflation rate to the right of the output gap of zero. Moreover, a substantial negative output gap, from 0.9 to 2 is needed to change the inflation rate from 0.01 to -0.011, whereas the same change occurs already with an overutulization of capacity going from zero to 0.2.[10]

2.3 Policy implications

The implication of operating with linear Phillips curves, while assuming for a moment that a convex nonlinear form indeed does better capture reality, are the following[11]: A linear model (with exogenously given output gap) would tend to overpredict inflation at times of recession and underestimate it during times of expansion. The linear model would, moreover, tend to overestimate the inflationary effect of expansionary policy at times of recession and underestimate the disinflationary effects of contractionary policy during boom times. The deficiency of linear models in terms of overpredicting inflation during times of recession will be illustrated later in the paper.

The implications for monetary policy arising from a convex relationship are the following: Monetary policy would consider deploying relatively sharper expansionary monetary policy measures at times of weak growth, via conventional interest rate policy as long as feasible or as well via unconventional easing measures should short-term interest rates reach the zero lower bound. The sharper expansionary policy is expected to induce limited pressure on prices (in the immediate short run) for the aforementioned reason that firms have only little incentive to raise prices even in case that demand is successfully stimulated. Thinking here of the inverse of the Phillips curve coefficient on the slack measure — the sacrifice ratio (i.e. the cost of disinflation in terms of lost output): this ratio would now be a decreasing function of inflation and not constant as in a linear model. Hence, the output cost of disinflation is lower (higher) when the initial level of inflation is high (low).[12] From this viewpoint, preemptive monetary policy shall therefore be beneficial also when time is ripe to slow down growth and inflation because the sooner such policy is pursued the less costly it would be in terms of lost output.

In the inflation forecast targeting framework as the one we present here, the error that one would commit with a linear model can be seen from yet another angle. If policy makers overpredict inflation in the recession, while setting policy rates in a forward-looking manner to target the forecast, they would do too little expansionary policy. This too weak reaction would let the recession last longer and possibly be deeper as it would if relatively stronger expansionary policy on the basis of a convex Phillips curve rationale would be pursued. The opposite line of reasoning holds again for the strong growth regime: the linear model would tend to underpredict future inflation and hence policy makers would have insufficient incentive to employ contractionary policy measures. The economy may overheat, to some extent more than if the policy maker had the convex relationship in mind. This latter line of reasoning implies that the false assumption of a linear relation might make policy makers render business cycles slightly more volatile; both the length of business cycles phases as well as variance and

[10]Note that we could allow for a reaction coefficient $\alpha_2(y_t)$ as a continuous function of a state variable, this would not change our results qualitatively.

[11]When referring here to 'linear' we mean, more precisely speaking, a model involving a Phillips curve with a state-independent coefficient relating inflation to an output gap. The system dynamics overall do not necessarily need to imply linear joint dynamics for inflation and output growth together, as exemplified in the first version of our theoretical model building on Svensson, with state-independent coefficients.

[12]A state dependence of the sacrifice ratio with respect to the initial level of inflation has been convincingly documented in Zhang (2005). He finds a significant log-linear negative relationship between inflation levels and sacrifice ratios based on a cross-country panel regression model. Such a finding is consistent with convexity in the Phillips curve. The New Keynesian model by Ball et al. (1988), for instance, gives full support to such a finding, as wage contracts are expected to be more frequently renegotiated during high inflation periods, hence reducing nominal rigidities at such times.

skew of the cycle may be larger if policy is based upon the false perception of linearity.

3 Empirical analysis

3.1 Linear and regime-switching Phillips curves for the euro area

The Phillips curve analysis that we let our empirical assessment depart from starts from the following equation structure.

$$INF_t = \alpha_r + \beta_r GAP_t + \gamma_r INF_{t-1} + \delta_r INFE_{t-s} + \epsilon_t \tag{7}$$

INF denotes the year-on-year (YoY) log difference of the euro area harmonized consumer price index (HICP), $INFE$ denotes an inflation expectation variable which is lagged, under different model variants later, by the parameter s, and GAP denotes a gap measure, also referred to as a measure of *slack*. All variables are seasonally adjusted euro area aggregates, with changing composition, with monthly frequency covering the Jan-1999–Mar-2016 period (207 obs.). Fig. 3 shows the euro area series. The r in eq. 7 denotes the possible regime dependence of the model coefficients, which also applies to the variance of the inflation residuals, which, conditional on a given regime, are assumed to be i.i.d. Normal. Along with the regime-switching specification of the equation we also estimate a standard linear version, for which the r subscripts drop from the equation.

The inflation expectation variable was derived from categorical data on inflation expectations contained in the European Commission (EC)'s Consumer Survey.[13] On purpose, we have chosen a consumer survey for the measurement of inflation expectations as they cover the expectations of the broad public.[14] The use of survey-based expectations has the advantage that there is no need to employ a rational expectation assumption which numerous researchers have meanwhile backed by theories that explain why biases can occur, or why it may in fact be rational to be biased (in the presence of asymmetric loss functions for instance).[15] The average bias of consumer expectations equals -0.4pp over the Jan-1999M1–Mar-2016 sample period. One of the roles of the intercept term, α_r, is to capture such expectation biases.[16]

Since the quantification of measures of economic slack are subject to a significant margin of uncertainty, we employ various alternative measures that we base the estimates of eq. 7 upon. We consider six different variables (see Fig. 4). A first is a Hodrick-Prescott (HP) filter-based measure of the output gap, with a lambda set to 14,400 applied to euro area real GDP, and the gap being defined as the log difference between observed output and the trend estimate.[17] Along with the statistical measure we employ the output gap estimates from the European Commission (EC) which are available through the EC's statistical data warehouse, as well as the International Monetary Fund's (IMF) output gap

[13] See Carlson and Parkin (1975) for details about how the quantification works. See also Buchmann (2009) for an application.

[14] Surveys from among professional (institutional) forecasters are an alternative, but capture the expectations of only a portion of the population which may bias the assessment due to the fact that professionals have an advanced understanding of economic and financial processes. For real activity at the aggregate economy level, expectations of the broad public (supposedly including professionals) shall matter more – as the economic behaviour of the aggregate as a function of expectation matters – and would for that reason be the better choice in the models presented here (and in the literature).

[15] See e.g. Capistran and Timmermann (2009), Forsells and Kenny (2002), Badarinza and Buchmann (2009) and references therein.

[16] See also Chan et al. (2015) in that respect.

[17] We compute the HP-filter-based gap directly at the euro area level. An alternative would be to take for instance a nominal GDP weighted average of the area-underlying country specific HP gap estimates. The two measures are very close, in fact, for that choice to not matter.

measures (in plural, as both for the area aggregates and later for the country level analysis). Both the EC and the IMF develop their trend and gap estimates based on a production function-type approach, i.e. there is a role for capital, labor, and total factor productivity (TFP) that output is linked to.[18] Potential output is the model-implied fit of output conditional on "normal" levels of capacity utilization, labor input levels that are consistent with the natural rate of unemployment, and with TFP being assumed to stand at its trend. Such an approach to quantifying potential output and an output gap can be seen as semi-structural, not as purely statistical as a filter-based approach, and not as fully structural as implied by structural general equilibrium models.

The fifth and sixth measure we employ are adopted from Jarocinski and Lenza (2016) who have developed a Bayesian dynamic factor model for the euro area to imply the estimates of the unobservable output gaps which are consistent with observed inflation dynamics. The authors develop seven variants of their output gap measure, resulting from different, combined assumptions for the real activity variables they include in the model, the inclusion of a long-term inflation expectation measure, and the functional form of the trends they assume for the real activity variables. From their model, we take two measures as an input to our assessment, that is, their Model 4 and Model 6, to which we from now on refer as JL4 and JL6. The two models best represent the two polar views related to the notion of secular stagnation in Europe. The JL4 model is consistent with the view that trend and potential growth have not changed significantly, for the current output gap to be sizable rather temporarily (albeit being persistent) and the potential for it to be closed via demand side stimulus. The JL6 measure on the other hand is more consistent with the hypothesis that trend growth has fallen due to structural reasons, and the output gap hence being smaller (closer to the EC and IMF measures, see Fig. 4). Structural, supply side reforms would rather be warranted in this case to revive growth. The JL4 measure is shown by the authors to be the best performing gap measure in terms of predicting inflation in real time, which is confirmed visually by the fact that it is the only measure that implies a non-increasing gap, in line with flat inflation rate dynamics, over the 2012-2016 period. Moreover, as Jarocinski and Lenza (2016) argue, the JL4 measure is subject to a rather limited risk of being revised substantially in real time due to new data arrival, which is a concern that is relevant in particular for filter-based measures (see Orphanides and van Norden (2002)).

Finally, as a sixth measure, we employ real GDP growth directly, which is not as such a measure of slack but does correlate strongly in fact with measures of slack (see Fig. 4), and is meant merely to be yet another alternative to assess the empirical link between price inflation and real activity. Real GDP is not initially available at monthly frequency; it was interpolated as a function of industrial production.[19]

In eq. 7, the six slack measures[20] serve two purposes at the same time. When a measure is included as the GAP variable in the equation (the first purpose), it also informs the underlying regime process of the equation (second purpose). For that second purpose, we follow two slightly different approaches. The first is to estimate a regime-switching (Markov-switching) single equation with the gap measure as a dependent variable, and an intercept and variance-switching equation residual, to infer a series of smooth regime probabilities. We estimate these simple equations using a standard Expectation-Maximisation (EM) algorithm.[21] As a second approach, we derive a 0-1 indicator series simply conditional on the sign of the gap measures (or the sign of GDP growth), i.e.

[18] For some details about the IMF methodology for deriving output trends and gaps see De Masi (1997). For the EC output gap methodology, see Havik et al. (2014).

[19] The results that we present that involve monthly real GDP are robust to using industrial production as such directly in the models, or an unconditional interpolation method for GDP (e.g. a quadratic trend method).

[20] From now on we refer to the GAP variables in short as slack measures, without always repeating that one of them, the real GDP measure, is not in fact a slack measure.

[21] It is a standard regime switching specification as developed in Hamilton (1989) and Hamilton (1990a). The transition probabilities are assumed to be constant. The model coefficients as well as the error variance are allowed to switch regimes. For estimating the auxiliary regime switching equation we employ an EM algorithm. See Dempster et al. (1977).

set the indicator (probability) to 1 if positive, and 0 if negative. These two approaches to deriving regime probabilities/indicators from the gap measures we refer to as the R- and the I-approach, respectively, throughout the rest of the paper. Specifically, we will refer to the 6x2=12 approaches as, GDP-R, GDP-I, HP-R, HP-I, and so forth, and we will denote the two regimes that we infer based on them in short as *expansion* and *recession*, minding that for some of the underlying measures this terminology is not fully appropriate as the regimes do not concur with a conventional definition of expansion and recession. The two different sets of regime probabilities are then used to condition eq. 7, using a weighted least squares method, as it is as such embedded in any Markov-switching single equation or system estimation (see Hamilton (1990b)).[22]

The smooth regime probabilities inferred based on the R-approach from the six gap measures are presented in Fig. 5. The indicator series resulting from the I-approach are not separately plotted but can easily be imagined in the same graphs where the gap measures turn between positive and negative territory. The R-approach implies that the regime probabilities do not turn as abruptly, but rather smoothly over a few periods, from zero to one or vice versa around the months when the economy moves from a positive to a negative gap regime. Hence, in the Phillips curve equation such periods close to the turning points receive some non-zero weights for both regimes and thereby inform the parameter estimates of both regimes. The use of both approaches is, just as the use of multiple gap measures, meant to add an additional layer by means of which we assess the robustness of the estimation results. Some of the gap measures and resulting regime probabilities suggest, for instance, that the burst of the dot-com bubble around the 1999-2001 period is to be seen as a negative output gap episode; or significantly depressed, generally speaking, as the GDP-R measure for instance suggests, which does not come along with negative year-on-year GDP growth at the euro area level though. The HP, IMF, and JL6 measures, suggest that the window around 2001 was characterized by depressed macroeconomic conditions. Four of the measures employed, the EC, IMF, and both the JL4 and JL6 measures suggest that the euro area still faces a negative output gap by the end of the sample period in March 2016.

For a base specification we set $s = 6$ for the inflation expectation variable to be lagged by half a year as the in-sample predictive ability of the model with the lagged expectations terms slightly outperforms other lag settings (robustness checks will follow and confirm that this choice is not crucial for the results). Along with the actual coefficient estimates we report standardized coefficients which are computed by multiplying the initial coefficients by the ratio of the standard deviation of the independent variable (slack measure) and the dependent variable (price inflation). The standard deviations used to that end are weighted, regime-conditional, i.e. specific to each one of the twelve regime probability settings. See Table 4. Unlike the actual coefficients, the standardized coefficients can be compared across models, across variables, and later across countries.

Fig. 6 and Table 2 show the estimates of the linear and the regime-switching single equation euro area Phillips curves under all twelve regime probability settings. Across all specifications, the coefficient on the output gap measures is larger under Regime 1 (expansion) than under Regime 2 (recession). On average across specifications the coefficient under the expansion regime is about 4 times as large as under the recession regime. The p-values in Table 2 suggest that in eleven out of twelve specifications the coefficient on the gap measure is significantly positive under the expansion regime (only for GDP-R it is not), while in only one case it is significantly different from zero under the recession regime (JL6-I). For eight of the twelve specifications, the likelihood ratio test results suggest a significant outperformance of the regime-switching equations relative to the linear counterparts (see last column in Table 2). As a first robustness test regarding this main result set, Table 3 shows the

[22] Our model approach to allow for regime dependence in a piece-linear manner is meant to capture the implication of the capacity constraint model, but still means some remaining "dissent" with the theory because within the expansion regime the coefficient on the output gap does not increase with a further rising output gap, and in the recession regime it does not fall with further falling output gaps. A model variant with continuous regime dependence can be considered to that end (e.g. a smooth transition model).

alternative estimates involving an inflation expectation measure that uses a 2-year window, instead of a 5-year window for the main specification, for the rolling window based on which a regression generates the underlying inflation perceptions. The corresponding expectation measure was plotted in Fig. 3. The results remain robust.

To reveal the earlier mentioned potential for linear models to overpredict inflation during times of pronounced economic slack, as they neglect the convexity in the Phillips curve relationship, we visualize the outcome of a conditional out-of-sample forecast exercise, starting from the forecast origin being June 2013, i.e. with all relevant models being estimated first up to only June 2013. Fig. 7 visualizes the forecasts of HICP inflation, conditional on realized history of the right hand-side variables of the underlying equations, over the 2013M07-2016M03 period derived from these models (33 obs.).[23] The chart reveals an upward bias of the linear models, while the regime-switching models' conditional forecasts are better centred around the realization. The suite of models underlying the area plots was generated by considering all combinations of equation structures made out of the different lag settings concerning the expectation variable ($s = 0, 6, 12$), the different output gap measures (six in total), and the different regime indicator/proability (I- vs. R) approaches that further multiply the number of equations in the regime-switching case.

Further robustness checks that we have conducted, results related to which we do not present to not overload the paper, included, first, an unemployment rate that we used instead of the output gap measures in the equations and using it to inform the regime process. The pronounced convexity in the relation remains, with the slope coefficient being significantly different both in statistical and economic terms between high and low unemployment rate regimes. The result that convexity holds up in the model with unemployment is consistent with the finding of no significant evidence for nonlinearity between unemployment and the output gap, i.e. in favour of linearity between the two, in Ball et al. (2013) in their Okun's law-related analysis. As a further robustness check with regard to the inflation expectation measure, we have replaced the consumer survey-based quantified inflation expectation variable by i) the expectation 'score' from the EC consumer survey, which is a pure measure of the inflation expectations, which is not, however, measured at the same scale as inflation itself (as not quantified), though informative for how expectations evolve over time nonetheless; and ii) by Consensus inflation forecasts for the euro area instead of the consumer survey-based measure. In both cases, the finding of convexity with respect to the output gap variables clearly kept holding. A third check in that respect was to drop the inflation expectation term altogether from the equation, in which case, too, the finding of convexity still held.[24]

3.2 Country-level Phillips curve estimates

We now turn to estimating eq. 7 for all euro area and the remaining non-euro area EU countries individually. For the inference of the regimes, again the R- and the I-approach are employed. In terms of economic activity/slack measures, we focus on the HP-filtered output gap, the ones from the EC and the IMF, as well as the countries' real GDP growth measures as such. Fig. 8 plots all the measures for all 28 EU countries, to give a visual impression of how they all evolved; without being able to identify any single country therein, except the euro area aggregate. The inflation expectation variable was derived for 26 EU countries (Fig. 9), excluding Denmark and Luxembourg as the underlying survey expectation data was not available for these countries. All country level

[23] The forecasts are *dynamic* conditional forecasts, meaning that the lag in the model along the forecast horizon is filled with previous-period predicted values, not observed values. Only for the here-exogenous right hand-side variables of the model, i.e. for inflation expectations and the slack measure, realized history is used. Moreover, the regime probabilities are consecutively re-fitted from observed slack measures using the estimated regime process and associated parameters up to 2013M06.

[24] The estimation results from the alternative specifications concerning the unemployment rate and the inflation expectation variables are available from the authors on request.

results will be presented in the following for the 26 EU countries excluding the latter two countries.

Tables 5-10 show the estimated coefficients on the slack measures under three different settings for the displacement parameter for the inflation expectation variable ($s = 0, 6, 12$ months), and across tables for the six different regime inference settings: HP-R, HP-I, EC-R, EC-I, IMF-R, IMF-I. As a visual support, those countries where coefficients are larger under the expansion than under the recession regime are highlighted in gray. Moreover, p-values below 10% are marked in gray, too. A summary of the estimates across countries is presented in Table 11, where the nominal GDP-weighted aggregate euro area and EU parameters can be compared to the direct euro area aggregate estimates presented earlier, for the euro area aggregate models now also showing the estimates for the alternative displacement parameters ($s = 0$ and $s = 12$). The results suggest that the finding of convexity with respect to the parameter on the slack measure clearly prevails.

Table 12 provides a count of the number of countries for which the slope coefficient on the gap measures under the different regime approaches was larger under the expansion than under the recession regime. The average percentage across the table amounts to 72%, with the minimum and maximum, respectively, equalling 62.8% (EC-I, regarding actual coefficients) and 82.1% (IMF-R approach, regarding normalized coefficients). As mentioned earlier, the normalized coefficient estimates shall be the better basis for a cross-country comparison; hence the percentages in the second row of the table are more relevant than those in the first.

Further based on the normalized coefficients, Table 13 shows a cross-country ranking, reflecting the degree of convexity across countries. This ranking is shown for the six regime approaches separately, as well as at the left end of the table based on an average of the ranks across the six approaches. Euro area countries for which the degree of convexity is most pronounced include Germany, Slovenia, Finland, and Lithuania. Four further sizable economies apart from Germany, that is, France, Italy, Spain, and the Netherlands, attain ranks 17, 20, 12, and 22, out of 26. Such rankings which are quite far from the higher ranked countries do not necessarily mean that the degree of convexity is not significant, either in economic or statistical terms, which they are in many cases; see the detailed results in Tables 5-10, as well as Table 14 which summarizes once again all likelihood ratio test results for the regime-switching against the linear model specifications across countries. The results are summarized for the 18 cases, made out of six regime probability/indicator approaches and the three lag settings for the inflation expectation variable. For 11 countries we can see more than half (i.e. at least 9 or more out of 18) specifications under which the p-value is less than 10%, i.e. indicating significant outperformance of the nonlinear over the linear Phillips curve structure. From among the euro area countries, the evidence is particularly strong for Germany, Estonia, Greece, Ireland, Lithuania and Latvia. For the non-euro area countries, for five of the seven the evidence is relatively strong, with between 11 and 16 of the 18 specifications per country resulting in p-values below 10%. The significance of the predictive gain is less pronounced for Romania and Sweden.

Finally, Fig. 10 provides a visualization of the extent to which the Phillips curve parameters on the slack measures shift across countries under the expansion and the recession regimes. There are three Kernel density plots, corresponding to the HP, the EC, and the IMF measures. The results from the R- and I-approach behind each measure are pooled in each graph, just as the three different settings concerning the displacement parameter for the inflation expectation variable. The Kernel density estimates provide a visual support to the conclusion that the parameter shift across all countries is non-negligible.

3.3 Linear and regime-switching monetary VAR analysis

We now extend the single equation-based analysis by employing a series of linear along with a regime switching vector autoregressive (RS-VAR) model for the euro area. A system-based analysis is useful to address potential endogeneity concerns (due to reverse causality for instance) possibly arising when pursuing single equation-based analyses as in the previous chapter and to thereby also be in a position to simulate dynamic shock scenarios for which the assumed exogeneity of the right hand-side variables as in eq. 7 ought to be relaxed. The RS-VAR structure can be written as follows.

$$y_t = c_r + \sum_{i=1}^{p} A_r y_{t-i} + B_r z_t + u_{rt} \tag{8}$$

where $y_t = (y_{1t}, ..., y_{Kt})'$ is a vector of dimension $K \times 1$ comprising K endogenous variables, c_r are the intercept coefficients under the two regimes $(r = 1, 2)$, A_r are $K \times K$ matrices of coefficients, and B_r are $K \times G$ coefficient matrices loading an exogenous variable vector $z_t = (z_{1t}, ..., z_{Gt})'$ of length G. The u_{rt} is a K-dimensional error term whose covariance matrix $E(u_{rt}u'_{rt}) = \Sigma_r$ is allowed to be regime-specific, too. For the linear variant of eq. 8 without regime dependence we let the r subscripts drop. Concerning the regime process, one conventional way of defining and estimating the process is via a Markov-Switching (MS) structure (see Hamilton (1994)). We do not, however, infer the regime process from the VAR system and instead take the regime probabilities that were already inferred based on the MS process applied to only the slack measures as a basis to then make all VAR system parameters including the residual covariance matrix depending on the regimes. The reasons for doing so are twofold and related: first, the regimes that result from a VAR system do not necessarily reflect growth regimes, as the model contains many variables beyond the output measures, and moreover with a month-on-month transformation, masking the lower frequency business cycle dynamics; second, we want to build in the specific rationale of the capacity constraint model by making the regime process a direct function of economic slack only, to then condition the overall model dynamics, i.e. all coefficients of the VARs, on the implied regime probabilities.

We consider again twelve settings, representing as before the 6x2 variants made of six real activity and gap measures and times two for the R- vs. I-approach to implying the regime probabilities. All models have three lags and are based again on a monthly data sample spanning the 1999M01-2016M03 period. All VAR systems that we consider were estimated equation-by-equation using a weighted least squares method, using as input for the weight calibration the R- or I-approach-based probabilities from the various gap measures. We consider three different versions concerning the content of y, to thereby address different, though related, aspects concerning the nonlinearity (convexity) whose existence we aim to examine again. The three versions are:

Model A: Containing Real GDP growth (natural log differences month-on-month, MoM), HICP inflation (MoM), short-term money market interest rate (STN).[25]

Model B: The same variables as in Model A containing in addition 1. A bank loan flow variable, capturing all new loans that are granted by banks in the euro area to nonfinancial private sector borrowers during a given month (included in the model as a month-on-month log difference), and 2. A corresponding bank loan interest rate, also for new business (included in the model in first differences);[26]; see Fig. 11 for the additional data series. Model B is based on a slightly shorter

[25] The results presented in this section are robust to replacing the STN by the ECB's policy interest rate; the policy rate correlates very strongly with the money market; only during the market turmoil following the outbreak of the global financial crisis in 2007 they decouple in levels for a while.

[26] Our choice of employing flow-based measures of volumes and interest rates instead of stock-based measures rests on economic grounds. The extent to which spending is financed by credit, consumption and investment in a given period will reflect the new lending that is extended in that period. Since GDP is a flow concept, the rate of growth of GDP should be related to the rate of growth in the flow of credit rather than to changes in the credit stock. See e.g. Biggs et al. (2009) who develop a theoretical model that clarifies this point and shows that consumption and investment flows are related to new lending rather than to the stock or changes in the stock of loans. Changes in the stocks of loans as a flow proxy are distorted by write-offs, changes in the valuation of securities and repos, and possible changes in the classification of loans to different loan segments. A pure loan flow measure shall be a superior measure to be related to real activity for these combined reasons.

sample period, starting only in Jan-2003, which is due to the shorter series for area aggregate loan flows and interest rates.

Model C: Including the euro effective exchange rate[27], euro area core inflation, import prices, export prices, nominal wages, and real GDP. All variables of Model C are included in first differences of natural log levels. See Fig. 12 for the additional data series.

All linear and regime switching VAR systems for all regime settings contain as well the US short-term interest rate as an exogenous control variable in the vector B. To reveal the linear and nonlinear models' dynamics we simulate and present sign-restricted impulse responses (SR-IRs).[28] The impulse responses are derived from the linear model as well as the regime-switching models. For the latter, we take the coefficient sets and covariance matrix estimates that are specific to the two regimes of the regime-switching version of the VAR and simulate the impulse responses assuming that the regime keep prevailing.[29]

3.3.1 RS-VAR Model A — Expansionary monetary policy shock

With Model A we simulate an expansionary monetary policy shock, amounting to -25 basis points (bps) to the short-term interest rate. Based on real GDP growth and the price inflation variable we imply a proxy for nominal GDP growth impulse responses as the sum of real GDP growth and inflation responses during the simulation. We impose a sign constraint on inflation and the off-model proxy for nominal GDP growth, which are both assumed to not fall over the first three months after the arrival of the shock in period 1. Importantly, we do not impose a constraint on real GDP growth as we want its response, both in terms of sign and magnitude, to not be predetermined and instead be implied by the relative strength of the responses of nominal GDP growth and inflation; thereby following the agnostic identification philosophy as promoted by Uhlig (2005).[30]

The results from the model using the HP-R approach to informing the regimes of the VAR along with the linear model-based IRs are presented in Fig. 13. The results from this along with all other eleven model settings are presented in Table 15. In the table, only the differences between point-in-time and cumulative responses between the two regimes are reported, not the actual responses. From Fig. 13 we can see that the inflation response on impact is about 3.5 times stronger under the expansion than under the recession regime (0.9pp versus 0.3pp). After the first year, the cumulative responses equal 1.6pp and 0.5pp respectively under the assumed expansion and recession regimes. With regard to real GDP, the responses are significantly positive for about half a year, mirroring the fact that the nominal GDP growth response is more positive than the inflation response. The real GDP response is more pronounced under the expansion than under the recession regime, equalling, on impact, 0.8pp and 0.2pp, while after the first year they equal a cumulative 1.5pp and 0.5pp, respectively. Concerning the differences of the responses when basing the IR analysis on the different regime approaches (Table 15), we can see that for the very majority (88%) of the cumulative responses of inflation, real GDP, and nominal GDP growth, the differences are negative (see the cumulative response columns, $H = 12$ and

[27] The euro effective exchange rate is defined vis-a-vis the EER-19 group of trading partners (AU, CA, DK, HK, JP, NO, SG, KR, SE, CH, GB, US, BG, CZ, HU, PL, RO, HR, and CN).

[28] As an entry point to the literature related to sign-restricted SVARs see Faust (1998), Canova and Nicolo (2002), and Uhlig (2005).

[29] See e.g. Ehrmann et al. (2001) who use the same regime-dependent impulse response simulation scheme. Other model settings are conceivable, whereby the regime process would be endogenous, for shocks to possibly imply, depending on their size, a transition between regimes.

[30] We shall note that the way the nominal GDP response is derived, via the use of the price inflation variable, is only a proxy because price inflation reflects import price effects, while GDP is a domestic concept, for which a deflator inflation variable would be the better choice to transform real into nominal and vice versa. We want to keep using the consumer basket-based price inflation measure, however, to be in line with its conventional use in a Phillips curve, as in the first part of the paper. Inflator deflation and consumer price inflation rates do correlate strongly, hence the approximation is acceptable in our view.

$H = 18$). The p-values reported in the last two columns of the table also confirm that the responses after 1 year and 1.5 years are in most cases very significant.

3.3.2 RS-VAR Model B — Extension to loan flows and loan interest rates

We conduct two different shock simulations with Model B. The first is an expansionary monetary policy shock again, applying a -25bps impulse to the euro area short-term interest rate. The sign constraints are now imposed on only the loan interest rate (-), the new business loan volumes (+), and the off-model proxy for nominal GDP growth (+) which is again computed as the sum of real GDP growth and inflation responses during the simulation. The constraints are set for the first three months after the arrival of the short-term interest rate shock in the first period. We do not impose any constraint on real GDP and in this case neither on inflation itself, as the combined constraints for nominal GDP to not fall and for bank loan supply conditions to improve, both induced by the expansionary monetary policy shock, shall suffice for identification. Compared to Model A, the sign restrictions applied for Model B are useful to sharpen the identification and examine the robustness of the results from Model A. They help better distinguish the shock scenario from a demand shock pattern, which under an expansionary monetary policy shock would imply that loan interest rates would fall, while under a demand side shock scenario would rise.

The responses from the model based on the EC-I regime probabilities are shown in Fig. 14 along with the summary of all twelve model settings in Table 16. Price inflation responds significantly positively under the expansion regime, with the cumulative sum of the point-in-time responses up to the 1-year horizon equalling 0.7pp. Under the recession regime, the inflation response is more muted, at an insignificant 0.2pp after 1 year. The linear model response falls in between, with a borderline significant 0.3pp effect after the first 12 months. The new business volume responses (NBVMoM) are, on impact in $T = 1$ quite close, equalling about 1pp and 0.96pp, but are more persistent under the expansion regime, for the responses after one year under the two regimes to equal 5.4pp and 2.3pp, respectively. The responses of new business interest rates (NBI) are quite comparable under the two regimes, starting from -0.2pp and -0.3pp under the expansion and recession in period 1 and then approaching cumulative effects after 1.5 years that remain slightly negative or close to zero. The nominal GDP responses are quite comparable in magnitude on impact, too (0.22pp and 0.24pp under expansion/recession), while again under the expansion regime the response is more persistently positive, for the cumulative effects after 1 year to have diverted visibly (1.6pp and 0.9pp). Table 16 confirms that the finding that price inflation reacts more strongly under the expansion than under the recession regime holds under all 10 model specifications presented in the table.[31] Also the real GDP responses are stronger under the expansion than under recession conditions in seven cases, in six cases of which the responses are significantly different with regard to cumulative responses after 18 months.

A second shock scenario based on Model B is one whereby the loan interest rate variable is shocked by -25bps, combined with the sign constraint for nominal loan volumes (+) and nominal GDP (+) to not fall for at least 3 months, for the shock to be an identified positive loan supply shock. Such a loan supply shock could have been the result of an expansionary monetary policy shock, though the motivation for having the direct loan supply shock is to be in a position to assess the effects of an *equally-sized* shock in terms of nominal loan interest rates in this case, to reveal whether nominal and real activity as well as inflation react differently under the two regimes, and thereby not make the finding of how the real economy reacts a function of the initial pass-through of monetary policy to

[31] Note that here the results for only 10, not 12, specifications are shown in because under the HP-I and the IMF-I approach the RS-VAR models were explosive under the expansion regime, which is supposedly related to the fact that the sample is shorter, starting only in Jan-2003 due to the inclusion of the loan flow and bank interest rate measures, rendering the expansion period shorter. The resulting responses from the linear models and under the recession regimes could have been presented but were excluded as they cannot be compared to the expansion regime-based IRs.

bank lending conditions. Inflation and real GDP growth are again not constrained themselves, nor is the short-term interest rate in this case.[32]

The results based on the EC-I version of the model are presented in Fig. 15 and the results of all specifications in Table 17. The profile and shape of the responses in Fig. 15 are similar to those resulting from the monetary policy shock scenario, while the magnitudes are a bit different. The inflation response on impact under the expansion regime is a bit stronger, for instance, now equalling 0.2pp on impact, and 1.1pp after 12 months. The inflation response under the recession regime again is more muted, equalling 0.1pp and 0.2pp on impact and after 1 year. The difference of the real GDP responses under the two regimes is more pronounced now, amounting to 1.4pp and 0.7pp after one year. The results in Table 17 confirm that the finding of more pronounced real and nominal growth and inflation responses is again clearly more sizable and significant under the expansion than under recession conditions. The response differentials of the new business volumes clearly confirm that it seems easier to stimulate nominal demand for loans and in the sequel production during times of expansion.

3.3.3 RS-VAR Model C — Extension to including the euro effective exchange rate

With Model C we aim to address the possibly state-dependent effects of euro effective exchange rate fluctuations on domestic euro area price dynamics. A euro exchange rate depreciation can affect domestic prices through various channels: 1) imported final consumer goods would become more expensive, thereby directly exerting upward pressure on HICP via the retail chain; 2) imported inputs to domestic intermediate and final goods production taking place in the euro area get more expensive and may for that reason imply indirect additional upward pressure on HICP; 3) upward price pressure may indirectly arise from the stimulating effect of the depreciation for exports. A number of theoretical models suggest that the exchange rate pass-through (to import prices or broader consumer price indices alike) may be time-varying. Time-variation has been linked to changing inflationary environments for instance[33]; or the size of the exchange rate shocks.[34] The size of the pass-through shall be related to the ability or incentive of importers to transfer their higher cost as a result of the currency depreciation to final consumers, which should be business-cycle dependent. During recession periods, a depreciation of local currency may not cause any significant price pressure because firms would lower their mark-ups to not loose market share. During an expansionary phase, on the other hand, firms would pass rising costs on to consumers.[35] [36]

There are three references in the literature that we are aware of that explicitly address the business-cycle dependence of exchange rate pass-through: 1) Goldfajn and Werlang (2000) employ a linear panel for 71 countries in which they include a cyclical measure of output; which confirms that pass-through effects are stronger during times of expansion than during weak growth periods; 2) Ben Cheikh (2012)

[32]The responses are very similar and the findings do not change when constraining also the short-term interest rate to not rise.

[33]See e.g. Taylor (2000) whose model suggest that agents keep their prices unchanged during low inflation regimes, during which exchange rate shocks are perceived to be transitory. They start raising prices in high inflation regimes, on the other hand.

[34]See Smets and Wouters (2002).

[35]See e.g. Froot and Rogoff (1995) and Rogoff (1996).

[36]A separate very significant strand in the literature addresses the fact that the exchange rate pass-through to import prices is incomplete, meaning that a 1% change in the exchange rate induces significantly less than 1% of a reaction of import prices in many countries. Three explanations have crystallised as being the major ones: 1) exporters price-to-market, i.e. they adjust their profit margins to offset foreign exchange rate changes in order to preserve market share; 2) some exporters set prices in local currency which do not fluctuate in response to exchange rate changes at least in the short run; 3) cross-border production means that inputs to the production process are prices in different currencies, thereby dampening the final goods' price response to particular bilateral exchange rate changes. The estimates that we present in this section confirm the basic finding that the exchange rate pass-through is less than unity; with the quantitative estimates being broadly in line with the ones that can be found in the literature.

uses nonlinear smooth transition regression models to reveal significant business cycle dependence for 6 out of 12 euro area countries; 3) Donayre and Panovska (2015) present a Bayesian threshold vector autoregressive model for Canada and Mexico, where the same nonlinear effect is found; i.e. pass-through estimates are larger during expansion than during recession regimes. An explicit reference to capacity constraint-type theory cannot be found as of yet in these papers about state-dependent exchange rate pass-through, although the underlying rationale does appear to be used at some points and can be read "between the lines". The capacity argument can be used to argue that export stimulus as a result of currency depreciation leads to less price inflation at times of recession, because exporting firms produce below their full capacity and can easily satisfy the additional demand; coupled with the argument that they do not wish to loose market share which they would if they lifted margins.

A -1% (depreciation) shock is applied to the euro effective exchange rate in Model C. A sign constraint is imposed on the responses of all price inflation variables (core consumer prices, wages, import and export prices), for them to not fall in response to the depreciation shock at least over three months after the arrival of the shock. A terms of trade (ToT) variable was constructed as an off-model variable which is defined as the difference of the export and import price responses. No sign constraints were imposed on the ToT nor on the real GDP growth variable. The simulation results are shown in Fig. 16, based on the model with the EC-R approach to calculating the regime probabilities. Table 18 summarizes the results from all twelve model specifications. In Fig. 16 we can see that the price inflation response again is by a large margin more positive under the expansion than under the recession regime (a significant 0.14pp vs an insignificant 0.02pp). For wages, too, the response is about 4 times as strong under the expansion regime. Concerning the import and export prices, we observe that the responses are quite similar on impact, not differing significantly across regimes, but then being more persistent under the expansion regime, for the responses after 1 year to be significantly larger under the expansion regime. Since the import price responses are more pronounced than the export price reaction, the terms of trade response is slightly negative, and slightly more negative under the recession regime, though overall comparable in terms of magnitude under both regimes. For nominal and real GDP, the net effects of the euro depreciation shock appear to be positive, suggesting that the export stimulus through the more competitive price of exports measured in foreign currency as well as possible substitution effects for the now more expensive import goods to be replaced by domestic production, to weigh positively on domestic production in the euro area. The effect, again, is very visible and significant from a statistical perspective, in that it is more positive under the expansion than under the recession regime.

The results in Table 18 confirm that in particular the business cycle dependence of price inflation responses to exchange rate shocks is robust across all twelve specifications, and significantly different across regimes with regard to the majority of point-in-time responses along the horizon, and for five specifications also with respect to cumulative responses. For wages, export and import price dynamics, the results are more mixed, though still overall leaning more often than not toward the finding that responses are stronger under the expansion regime. The responses of the terms of trade variable are quite mixed, reflecting that the relative magnitude of the responses of exports and imports are sometimes different across model specifications. Overall, the results suggest, in particular with respect to price inflation, that the consequence of an exchange rate shock is also business cycle dependent, with more upward pressure on prices being expected from unexpected currency depreciation at times of expansion than during recession phases.

4 Conclusions

The purpose of the paper was to revisit the idea that the Phillips curve may be inherently nonlinear. We have started by motivating the topic by augmenting the inflation forecast targeting model by Svensson (1997) with a convex Phillips curve to shape our understanding of the implications for the conduct of monetary policy in that framework. During boom times, preemptive policy, i.e. a timely normalization of interest rates should inflation forecasts point to re-appearing upward pressure on prices, is warranted to impede inflationary pressures before they occur. During recession times, relatively sharper expansionary measures to stimulate price inflation are required. Strong unconventional expansionary policy measures can thereby be rationalized once conventional, price-based instruments become ineffective when reaching the zero lower bound.

We provide comprehensive and robust empirical evidence in favour of the hypothesis that the euro area Phillips curve (as well as of numerous individual European countries) are characterized by a convex relationship between price inflation and economic slack. We have employed six different measures of economic slack, including statistical along with semi-structural measures developed by other international institutions (the EC and the IMF) as well as measures based on a Bayesian dynamic factor model, to thereby further corroborate the finding of convexity. Under a significant number of specifications the finding of convexity holds up. The potential error that policy makers would commit if assuming a linear curve while it is convex in reality can also be seen when it comes to forecasting, as illustrated in the paper: A linear model would over-predict inflation at times of weak growth, as over the past years following the global financial crisis, while the models featuring convexity result in conditional forecasts that are better centred around the realized inflation path.

In addition to the single equation analysis, we have set up some standard monetary structural VAR models, having augmenting them, however, by a regime-switching mechanism. An expansionary monetary policy shock (as well as a more direct positive bank credit supply shock) that we simulate turns out to have state-dependent consequences: it has less potential to induce price inflation at times of weak growth and stronger potential to do so during boom times. The regime-conditional impulse responses from a model that is further augmented by the euro effective exchange rate suggest that the consequence of an exchange rate shock is also business cycle dependent, with more upward pressure on prices being expected from unexpected currency depreciation at times of expansion than during recession phases.

An empirical assessment of the type we presented can be further extended by considering regime dependence on variables other than economic slack. The empirical relevance of other theories that imply nonlinearity, specifically for instance the costly adjustment model (Ball et al. (1988), Ball and Mankiw (1994)) or the signal extraction model (Lucas (1972), Lucas (1973)) can be assessed by conditioning the Phillips curve parameters on the level or variance of inflation, respectively. The predictive ability of different nonlinear model schemes can then be assessed to draw conclusions as to which of the theories are more relevant than others from an empirical perspective.

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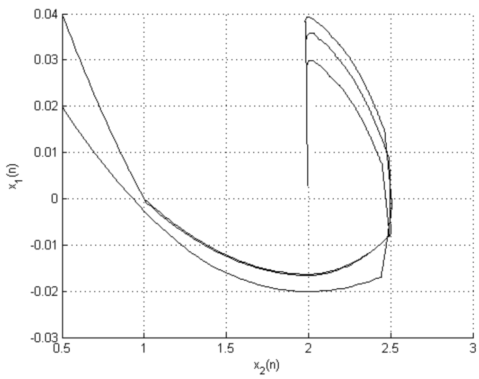
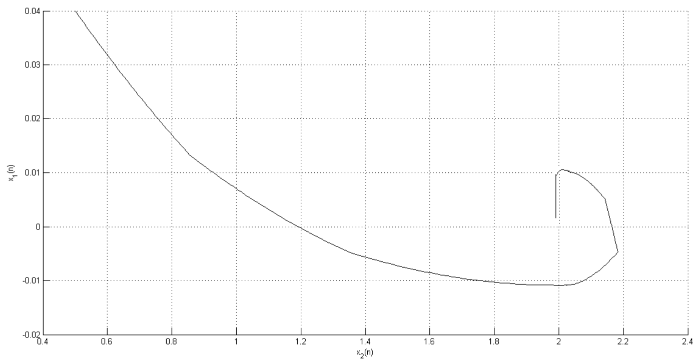
Figure 1: Potential output versus price inflation



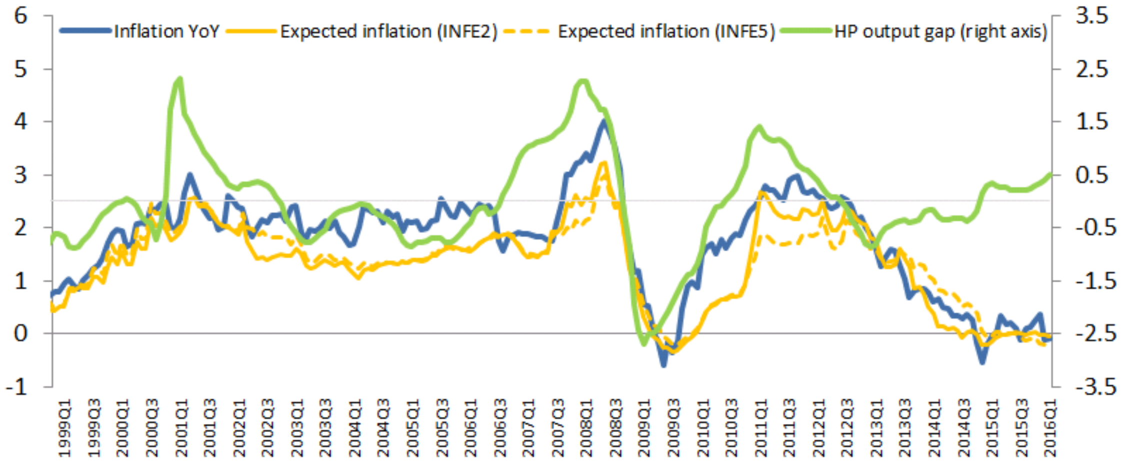
Note: Potential output is at 2 and the output gap zero at 2; for all three initial conditions the inflation rate (vertical axis) and output gap (horizontal axis) converge to a steady state; we observe small changes of the inflation rate in the region of a negative output gap (see region from 1.5 to 2) and a faster rising inflation rate in the region of positive output gaps.

Figure 2: Potential output versus price inflation — Nonlinear extension of Svensson model



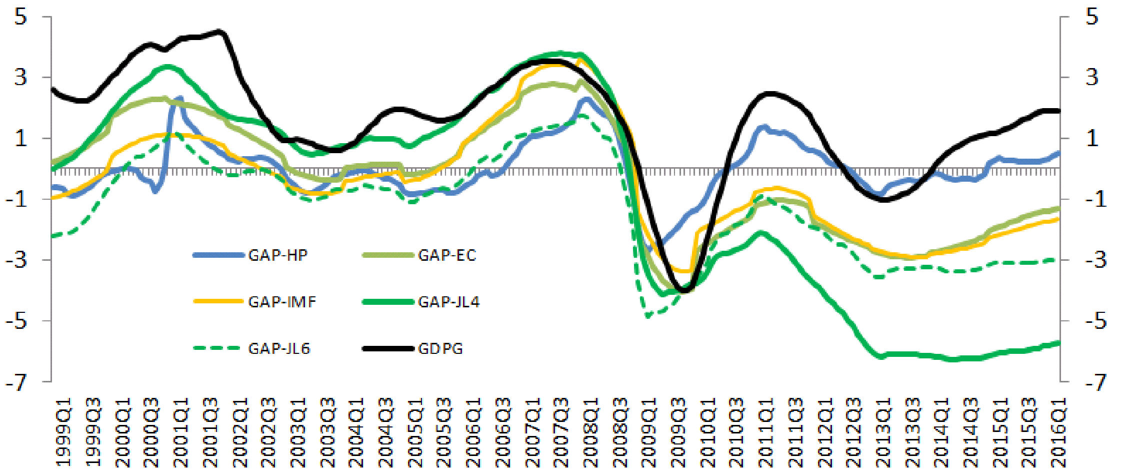
Note: The output gap is zero at 2, the potential output; the trajectory for the initial conditions $\pi(0) = 0.04$ and output $y(0) = 0.5$, inflation rate (vertical axis) and output gap (horizontal axis); in the region of a negative output gap, with $\alpha_2(y_t) = 0.05$, we observe a very small reaction of inflation rates to changes in the output gap, in the region of positive output gap, with $\alpha_2(y_t) = 0.12$, on the other hand, we see a strong response of inflation to the output gap.

Figure 3: Euro area inflation, expected inflation, and output gap (1999M01-2016M03)



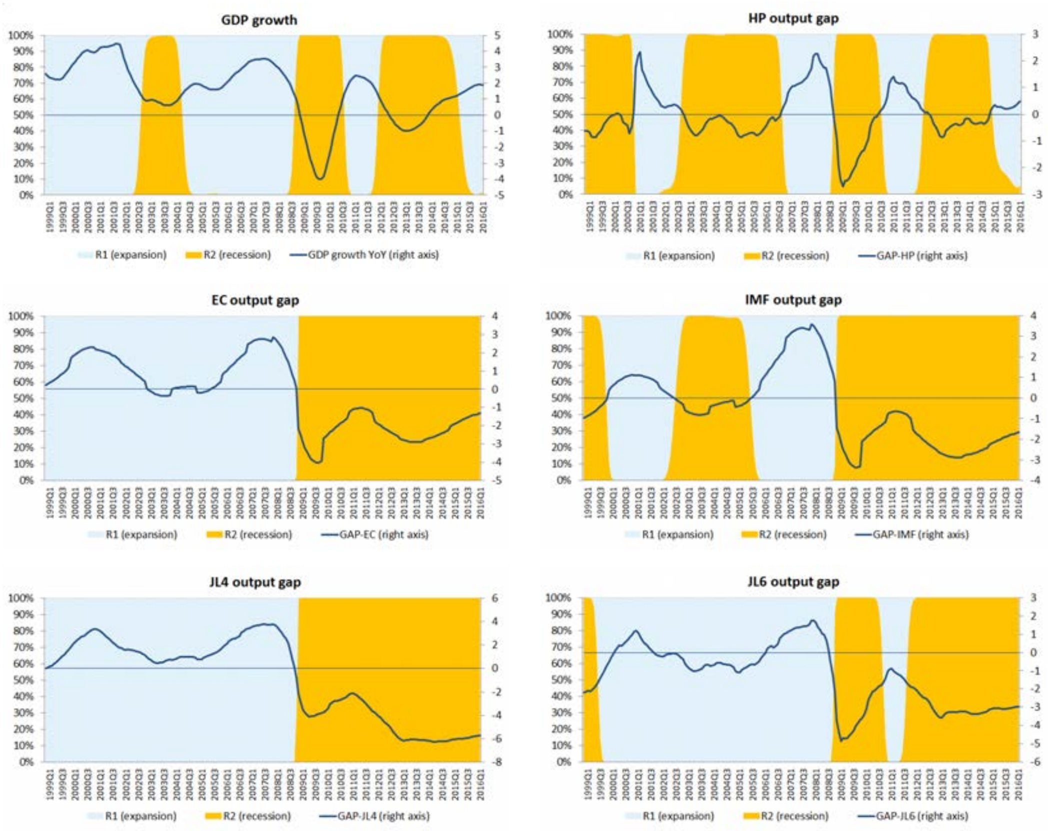
Note: The INFE2 and INFE5 expectation measures differ with respect to the window length based on which the underlying inflation perceptions were computed, which is set to 2 years and 5 years respectively for the INFE2 and INFE5 measure.

Figure 4: Euro area real GDP growth and different output gap measures (1999M01-2016M03)



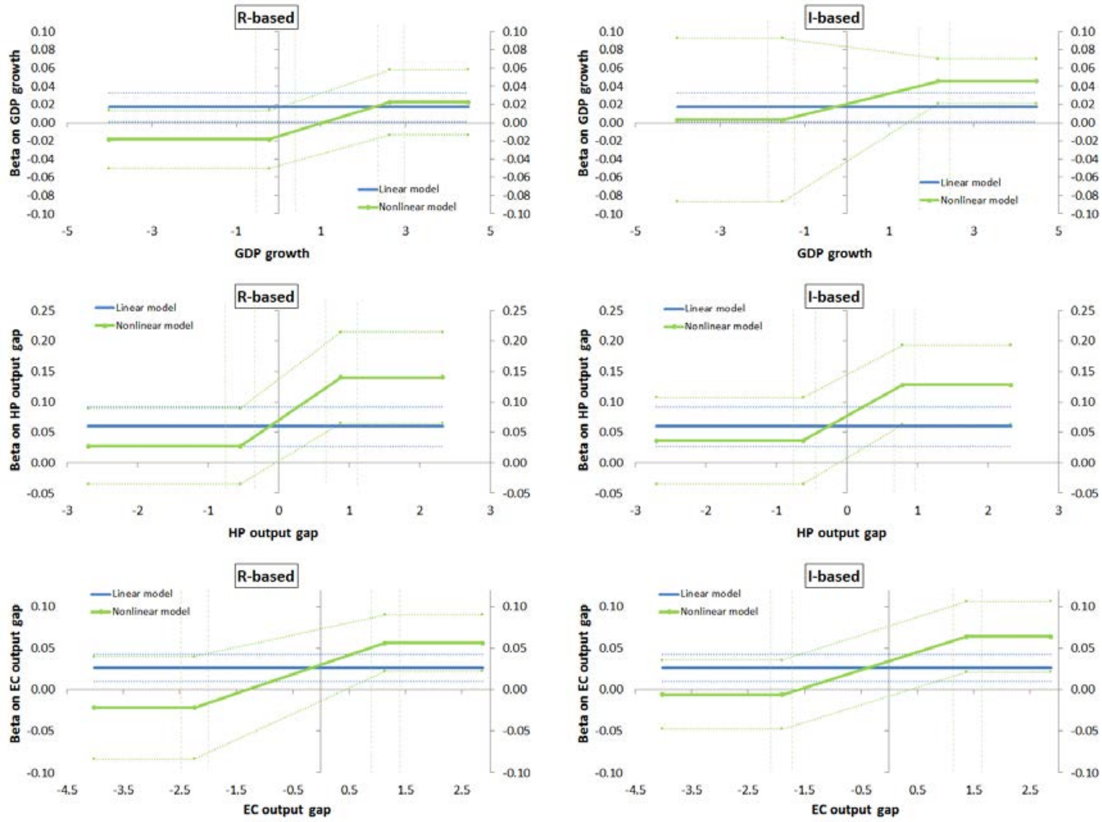
Note: The output gap measures include an HP-filtered gap (GAP-HP), the ones from the European Commission (GAP-EC) and the IMF (GAP-IMF), as well as two measures adopted from Jarocinski and Lenza (2016), referred to as GAP-JL4 and GAP-JL6. GDPG denotes real GDP growth YoY.

Figure 5: Smooth regime probabilities based on different real activity/output gap measures for the euro area



Note: The regime probabilities are inferred using a Markov-switching model based on the respective real activity/output gap measures. The sample for estimation and regime inference spans the period from 1999M01-2016M03. The regime probabilities are used as a basis for conducting all regime-conditional (that is, weighted least squares-type) regressions at the euro area level. In addition, a 0-1 indicator-based approach will be used which sets the recession/weak growth (expansion/strong growth) regime probability to 1 as soon as a measure turns negative (positive). See text for details.

Figure 6: Euro area Phillips curve — Linear vs. regime-switching parameter on output gap measures



Note: The charts visualise the parameter estimates of the real activity / output gap measures in the hybrid Phillips curve equations for the euro area. The horizontal bounds surrounding the linear and nonlinear parameter lines represent the 10th/90th percentiles of the coefficient distribution; reflecting coefficient uncertainty. The kinks at which the regime-switching coefficient estimates break are the regime-conditional means of the real activity measures, which result from the Markov-switching component of the models. They are surrounded by estimation uncertainty as well, which the dotted vertical lines reflect. The estimates that are visualised in this Figure are reported in tabular format in Table 2. The R- and I-based results involve the Markov-Switching probability-based weighting and the 0-1 indicator-based weighting based on the underlying slack measures, respectively. See text for further details.

Figure 6 (ctd): Euro area Phillips curve — Linear vs. regime-switching parameter on output gap measures

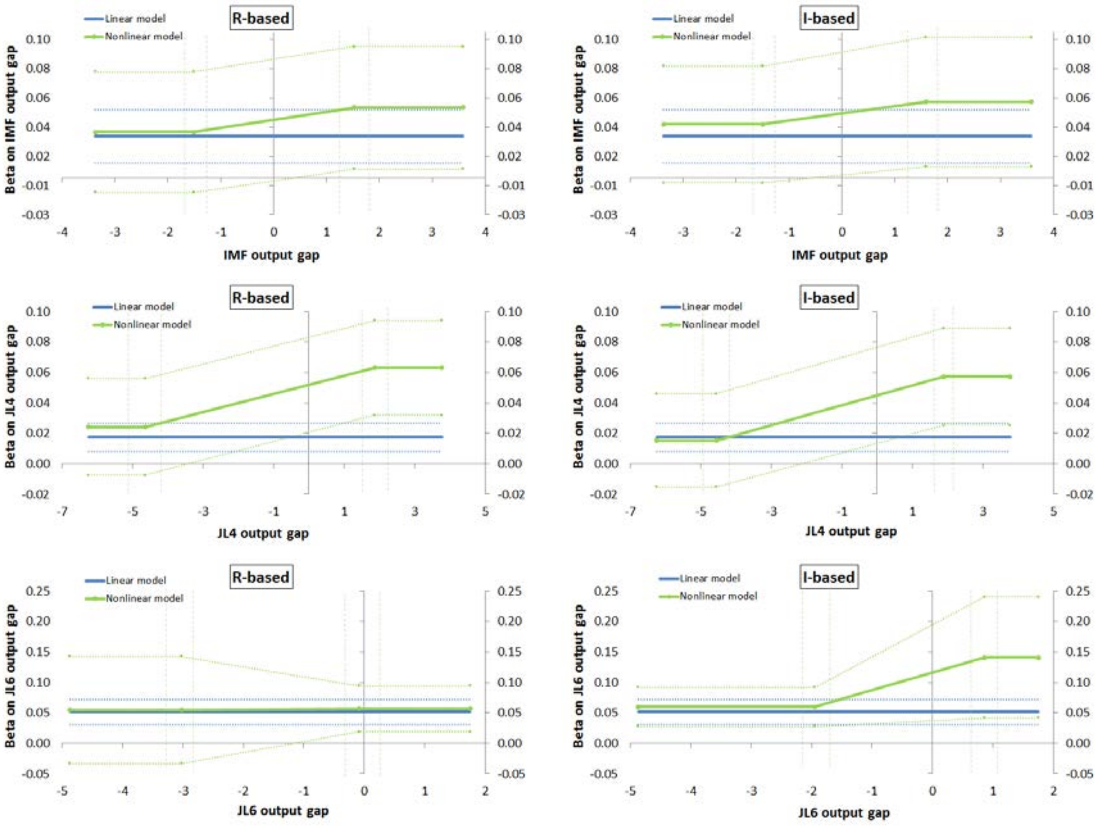


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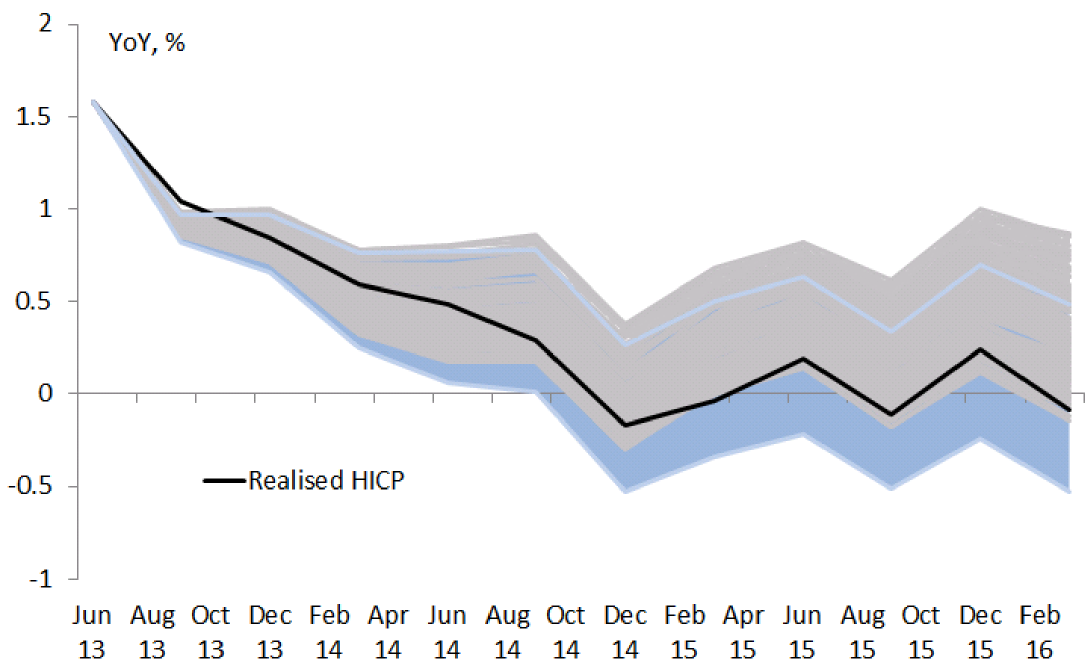
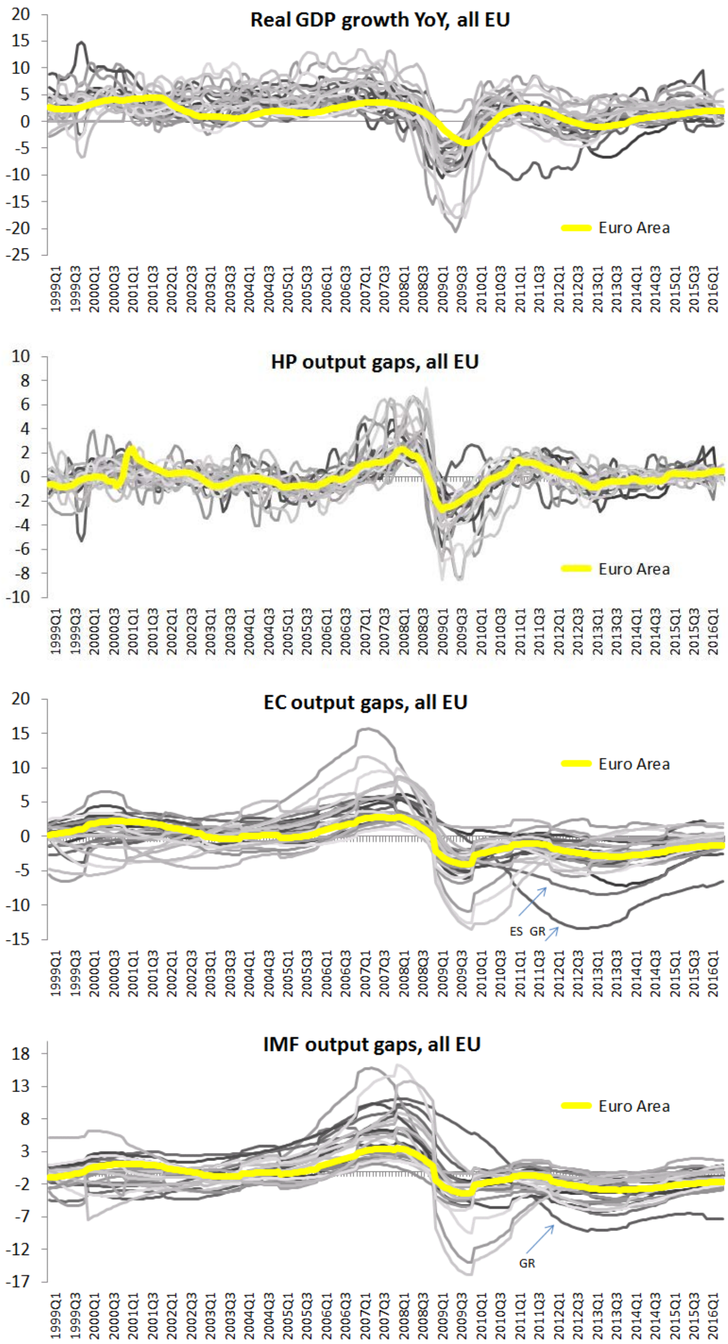
Figure 7: Conditional out-of-sample forecasts of euro area HICP inflation (2013M07-2016M03) using linear and regime-switching Phillips curve equations: Gray linear models, blue regime-switching models



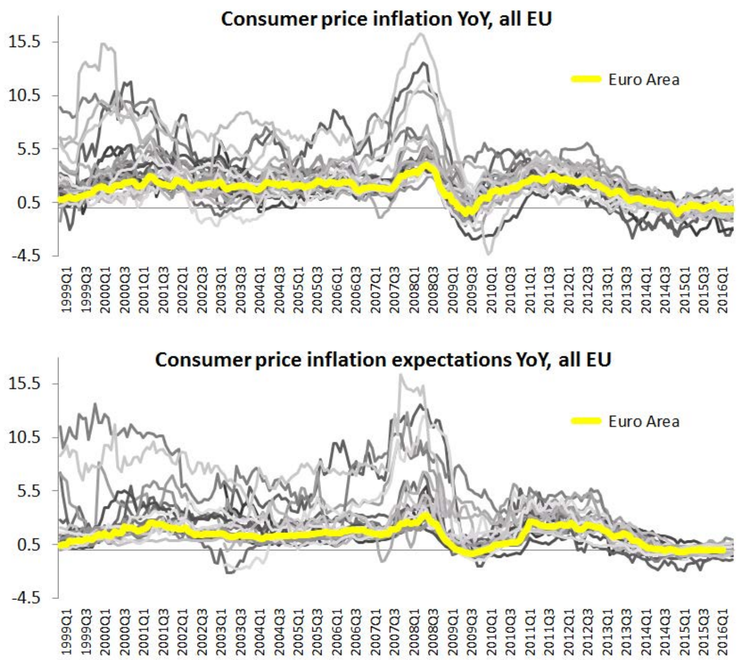
Note: The chart visualises the forecasts of HICP, conditional on realised history of the right hand-side variables of the underlying Phillips curve equations, over the 2013M07-2016M03 period (33 obs.) and is meant to highlight the upward bias of the linear models, and the better centred forecasts from the regime-switching models. The gray and blue areas depict the conditional forecasts resulting from all linear and regime-switching models, respectively. The suite of models underlying the area plots is generated by considering all combinations of equation structures made out of the different lag settings concerning the expectation variable (contemporaneous, lag by six and twelve months), the different output gap measures (6 in total), and the different regime indicator/proability (-I vs. -R) approaches that further multiply the number of equations in the regime-switching case. Hence, there are 6x3=18 linear and 12x3=36 nonlinear models producing the two fans in the chart. Additional coefficient uncertainty stemming from each underlying equation has not been accounted for.

Figure 8: Real GDP growth and output gap measures for the EU28 (1999M01-2016M03)



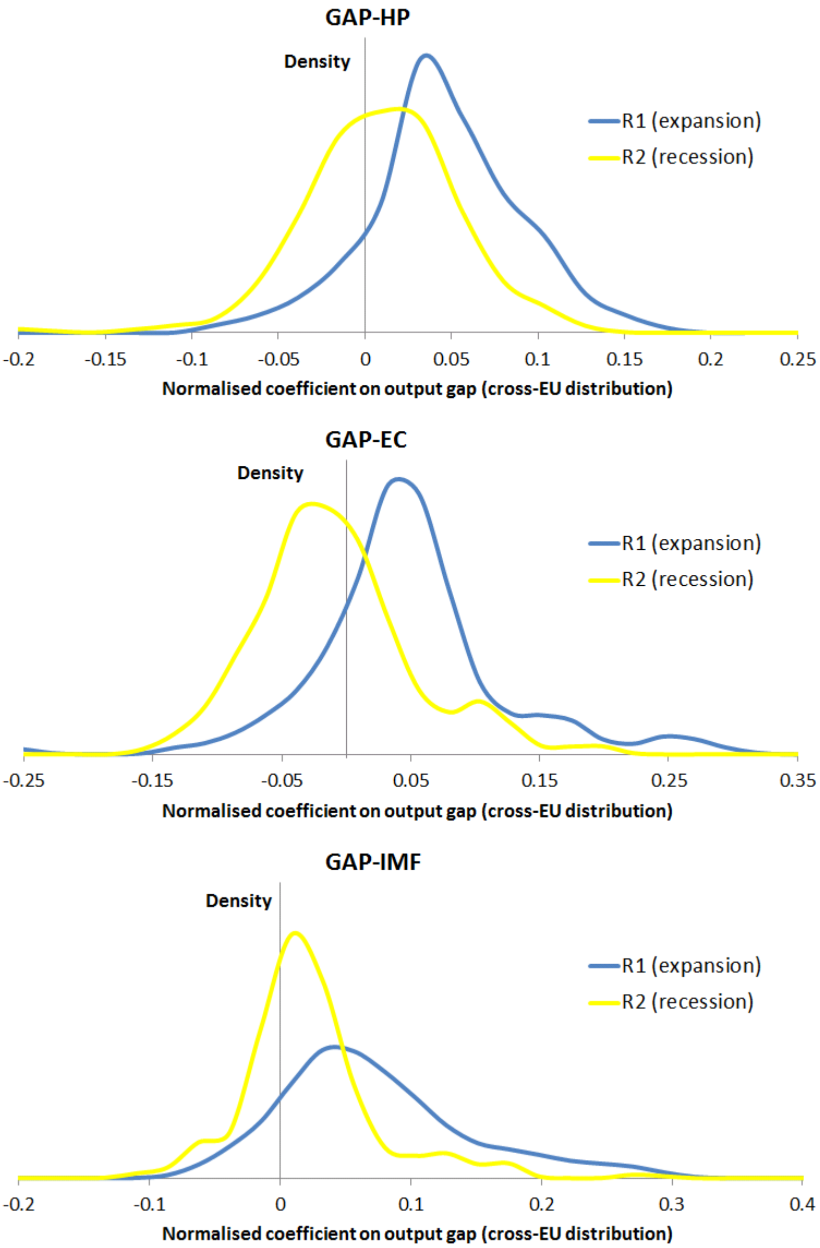
Note: The charts aim to provide a visual impression of how the collection of the 28 EU countries' real activity measures evolved over the 1999M01-2016M03 period. See text for further details.

Figure 9: Consumer price inflation and inflation expectations for the EU28 (1999M01-2016M03)



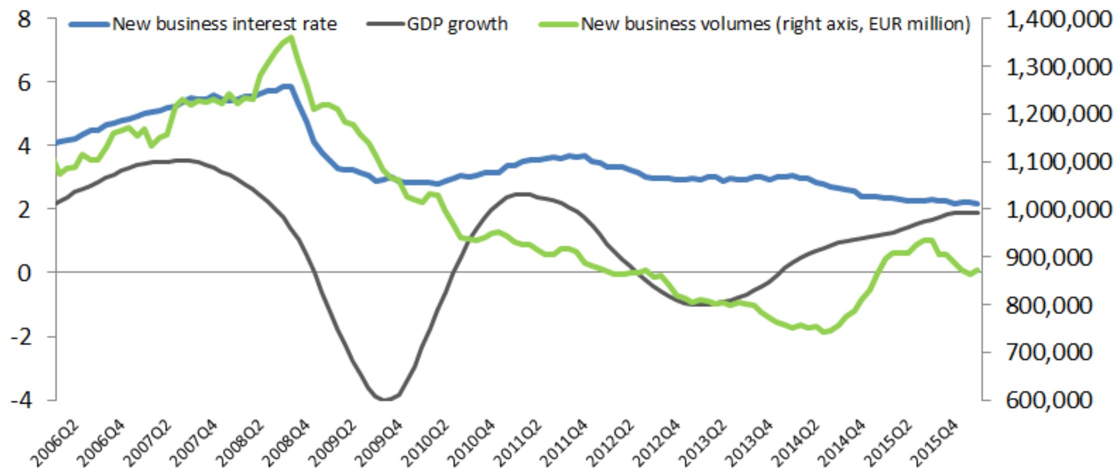
Note: The charts aim to provide a visual impression of how the collection of the 28 EU countries' consumer price inflation and inflation expectation measures have evolved over the 1999M01-2016M03 period. See text for further details.

Figure 10: Shift of cross-country distribution of Phillips curve parameter estimates on output gaps under expansion and recession regimes



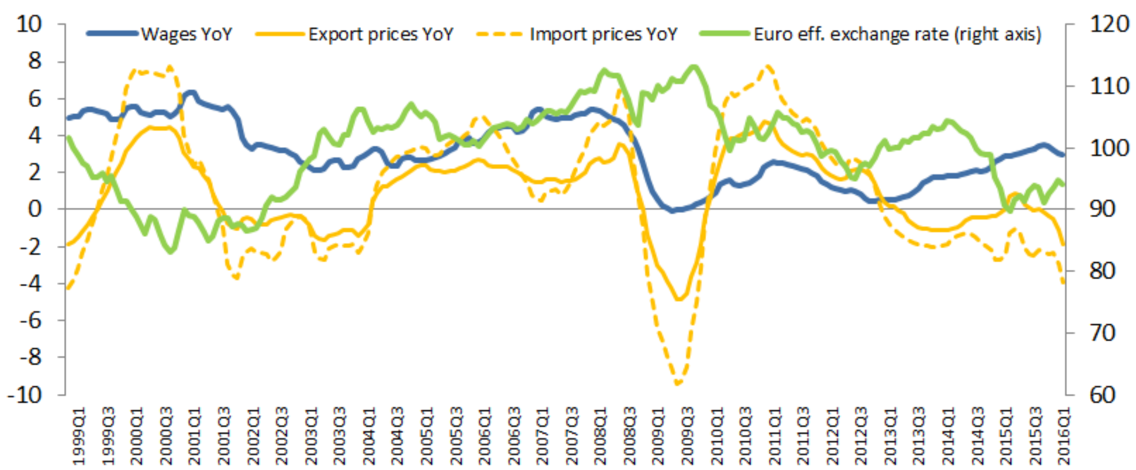
Note: The Kernel densities reflect the cross-country distribution of the normalised coefficients across the EU countries, as reported in Tables 5-10. For a given output gap measure, the cross-country distributions reflect the estimates from the three underlying schemes concerning the lag setting of inflation expectations, as well as the two different schemes regarding the regime-probability-based and the 0-1 output gap indicator-based weighting. See text for further details.

Figure 11: Euro area aggregate bank loan flows and loan interest rates (both new business) (2003M01-2016M03)



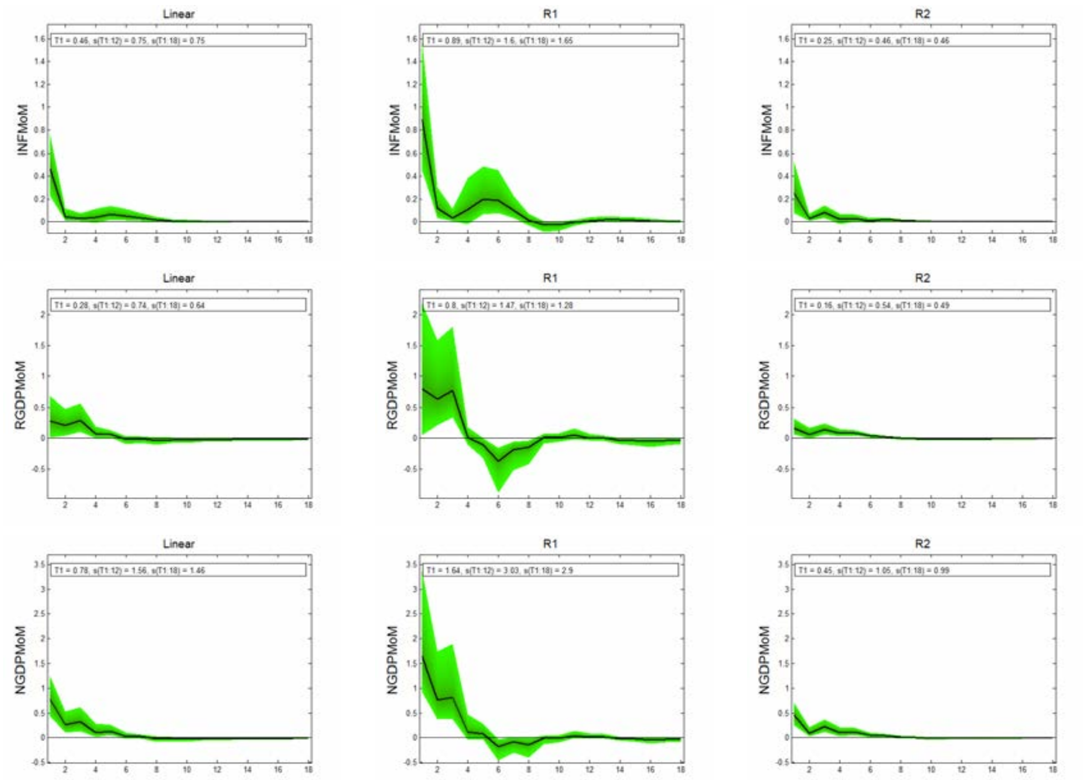
Note: The bank loan flow series reflect a 3-month moving sum of new business, i.e. newly granted loans, to the combined nonfinancial private sector of the euro area (derived from data provided through the MIR statistics from the ECB's Statistical Data Warehouse). The bank loan interest rate corresponds to the new business, too. A month-on-month log difference of the loan flow variable along with a first difference of the bank interest rate series are included, along with other euro area aggregate macro-financial variables, in the RS-VAR Model B. See text for details.

Figure 12: Euro effective exchange rate, and euro area import and export prices (1999M01-2016M03)



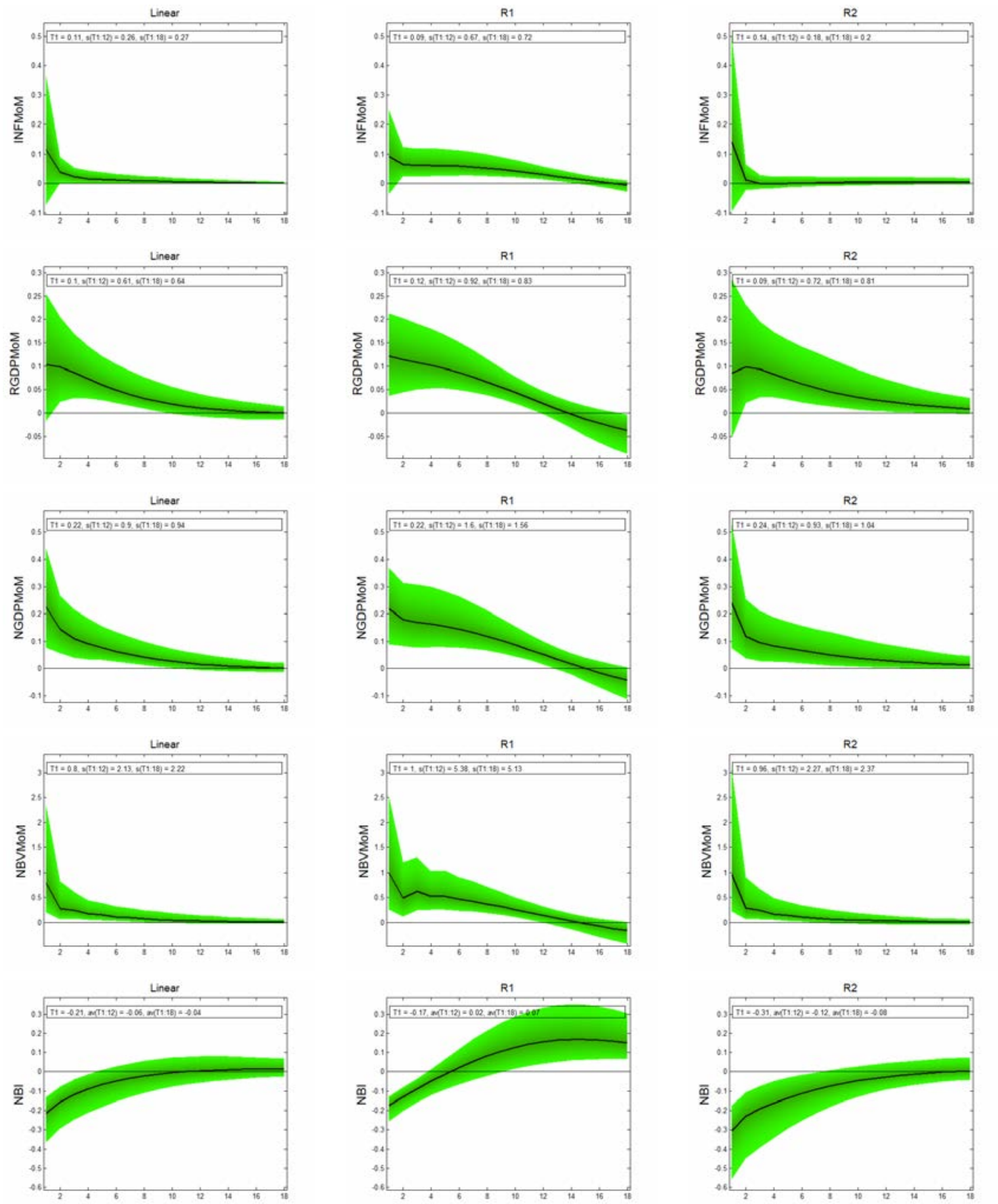
Note: The series presented in the chart are included in the RS-VAR Model C, along with core consumer price inflation and real GDP. The euro effective exchange rate is defined vis-a-vis the EER-19 group of trading partners (AU, CA, DK, HK, JP, NO, SG, KR, SE, CH, GB, US, BG, CZ, HU, PL, RO, HR, and CN). The effective exchange rate is included in the model in log differences month-on-month (shown here in levels). The import and export price deflator variables (shown here in year-on-year log differences), too, are included in month-on-month differences in the model.

Figure 13: Linear and regime-switching VAR — Model A — Sign-restricted impulse responses to expansionary monetary policy shock



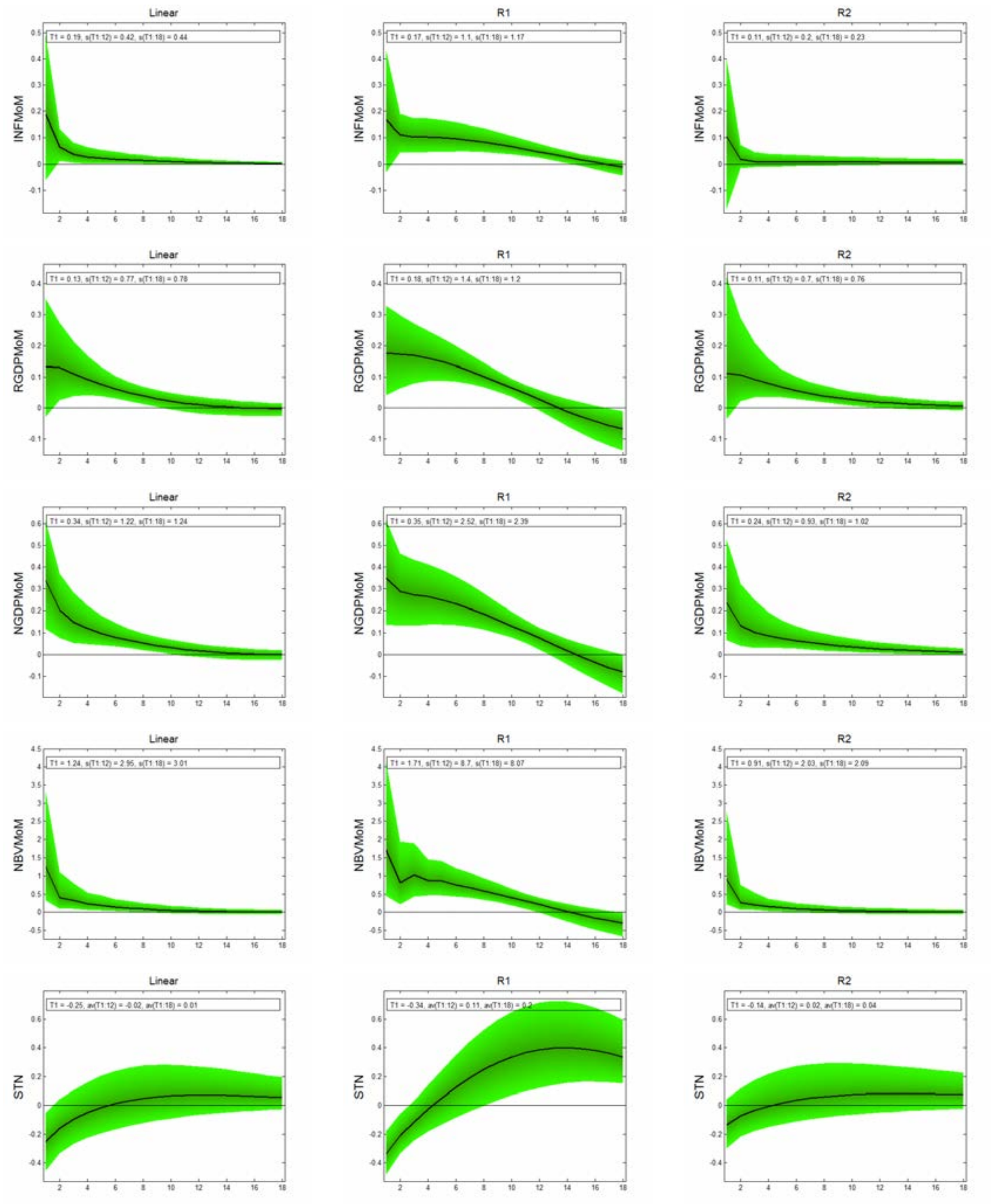
Note: The chart collection shows the sign-restricted impulse responses of Model A's variables up to an 18-month horizon, to a -25bps shock to the euro area short term interest rate. INFMoM: Euro area consumer price inflation month-on-month (MoM) log percent change. RGDPMoM: Real GDP growth MoM. NGDPMoM: nominal GDP growth, not included in the model as such but derived as the sum of the responses of real GDP growth and inflation (see text for some caveats). The upper/lower end of the green shaded area mark the 10th/90th percentiles of the response distributions. Cumulative responses are reported in the text boxes embedded in the charts. The model behind the responses corresponds to the HP-R model in Table 15.

Figure 14: Linear and regime-switching VAR — Model B — Sign-restricted impulse responses to expansionary monetary policy shock



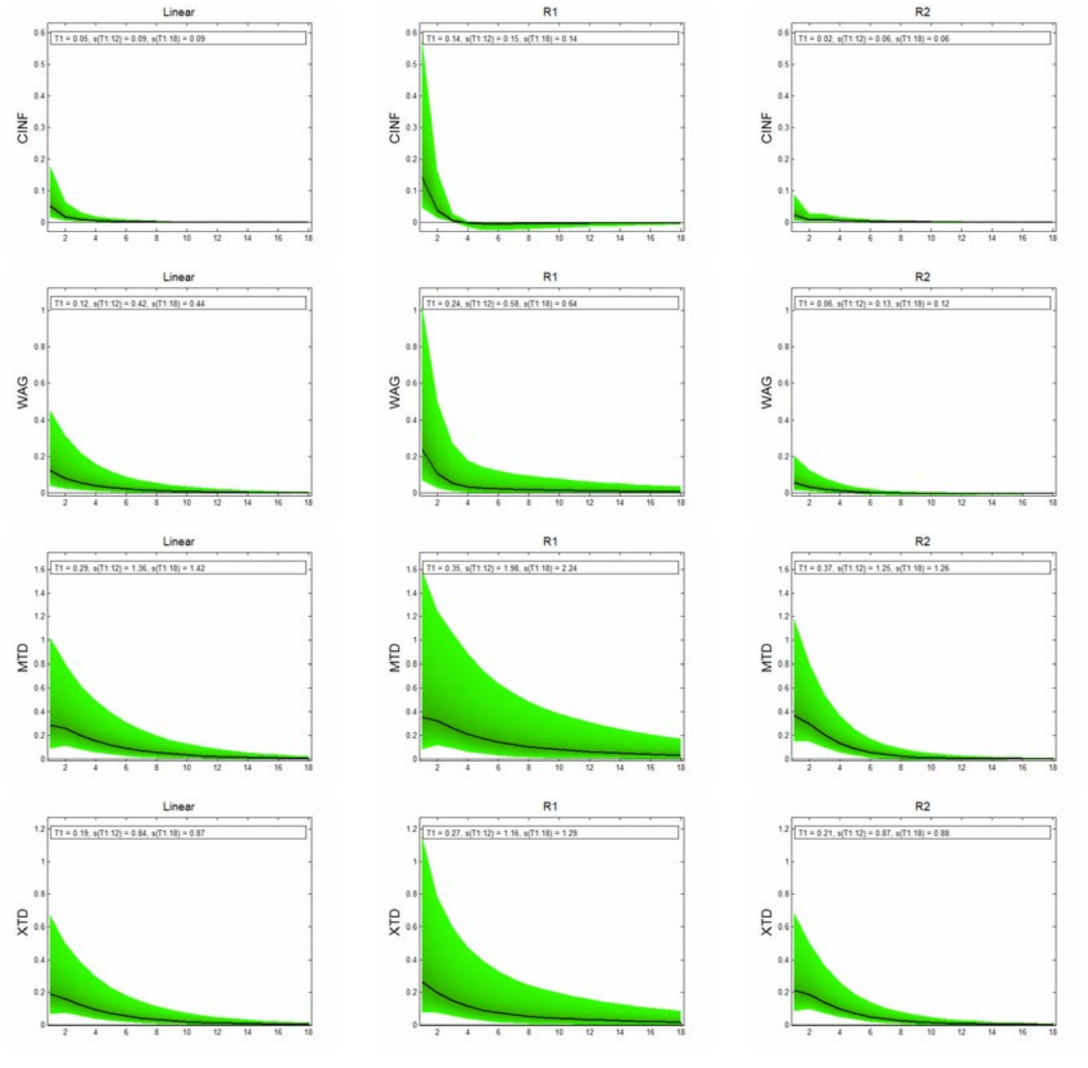
Note: The chart collection shows the sign-restricted impulse responses of Model B's variables up to an 18-month horizon, to a -25bps shock to the euro area short-term interest rate. NBVMoM and NBI denote bank loan volume growth and loan interest rates (both new business). The upper/lower end of the green shaded area mark the 10th/90th percentiles of the response distributions. Cumulative responses are reported in the text boxes embedded in the charts (for the new business interest rates the numbers in the box reflect averages). The model behind the responses corresponds to the EC-I model in Table 16.

Figure 15: Linear and regime-switching VAR — Model B — Sign-restricted impulse responses to positive credit supply shock



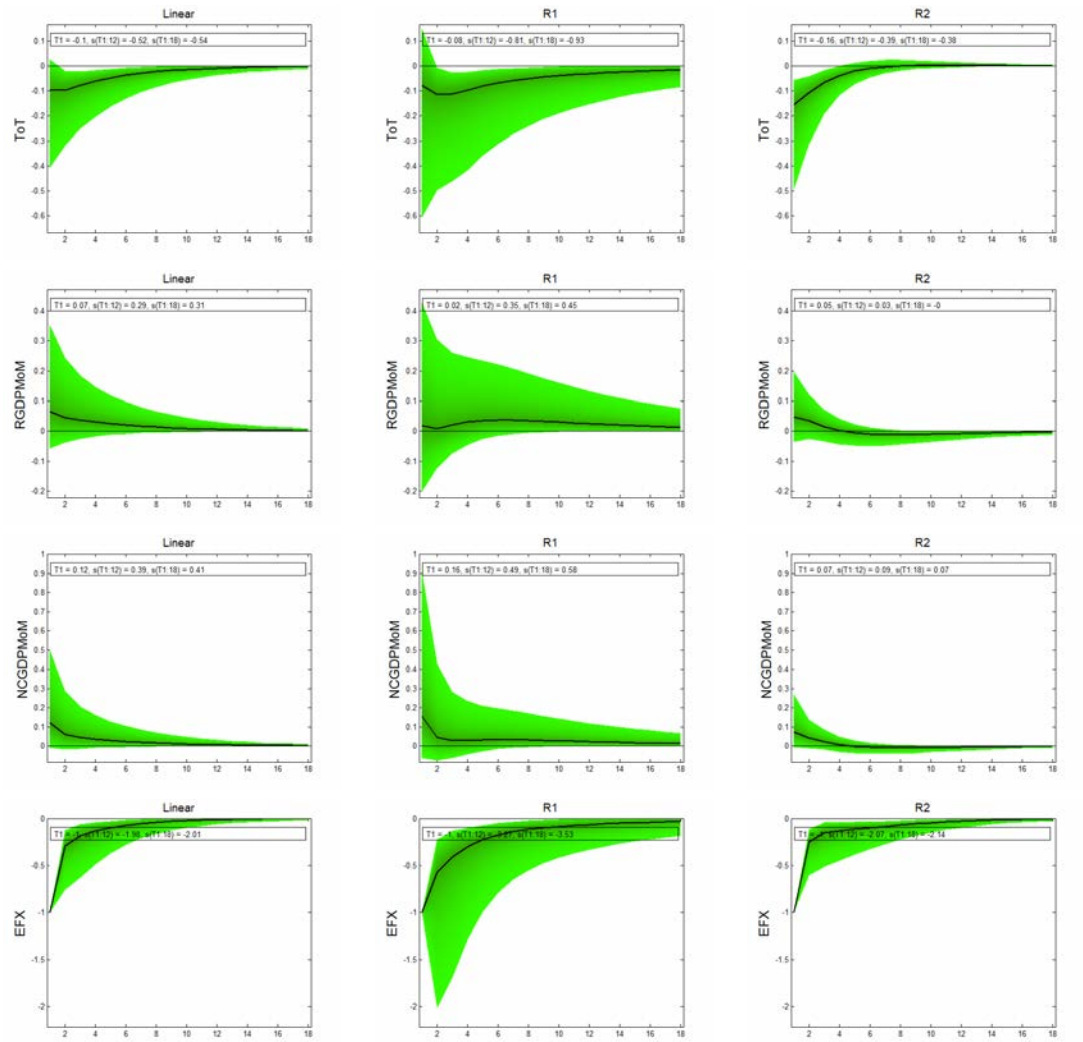
Note: The chart collection shows the sign-restricted impulse responses of Model B's variables up to an 18-month horizon, to a -25bps shock to the euro area loan interest rate. NBVMoM and NBI denote bank loan volume growth and loan interest rates (both new business). The upper/lower end of the green shaded area mark the 10th/90th percentiles of the response distributions. Cumulative responses are reported in the text boxes embedded in the charts (for the short-term interest rate the numbers in the box reflect averages). The model behind the responses corresponds to the EC-I model in Table 17.

Figure 16: Linear and regime-switching VAR — Model C — Sign-restricted impulse responses to euro effective exchange rate depreciation shock



Note: The chart collection shows the sign-restricted impulse responses of Model C's variables up to an 18-month horizon, to a -1 log percentage point shock to the euro effective exchange rate. CINF: Core euro area inflation month-on-month. WAG: Nominal wages month-on-month growth. MTD: import price deflator inflation month-on-month. XTD: export price deflator inflation month-on-month. The upper/lower end of the green shaded area mark the 10th/90th percentiles of the response distributions. Cumulative responses are reported in the text boxes embedded in the charts. The model behind the responses corresponds to the EC-R model in Table 18.

Figure 16 (ctd): Linear and regime-switching VAR — Model C — Sign-restricted impulse responses to euro effective exchange rate depreciation shock



Note: The chart collection shows the sign-restricted impulse responses of Model C's variables up to an 18-month horizon, to a -1 log percentage point shock to the euro effective exchange rate. ToT: Terms of trade, not as such contained in the model, with its response derived as the XTD minus MTD responses. NCGDPMoM: nominal GDP growth proxy, not contained in the model, derived as the sum of real GDP growth and core inflation responses (see text for caveats). EFX: Euro effective exchange rate. The upper/lower end of the green shaded area mark the 10th/90th percentiles of the response distributions. Cumulative responses are reported in the text boxes embedded in the charts. The model behind the responses corresponds to the EC-R model in Table 18.

Table 1: Literature overview (chronological) — Nonlinear Phillips curves

Author(s)	Year	Title	Country	Finding
Phillips, A.W.	1958	The relation between unemployment and the rate of change (	GB	Convexity
Lucas, R.E.	1973	Some international evidence on output-inflation trade-offs	18 countries	Convexity
Evans, P.	1986	Does the potency of monetary policy vary with capacity utiliza	US	Linearity
Ball, L. and N.G. Mankiw and D. Romer	1988	The New Keynesian economics and the output-inflation trade	US	Convexity
De Long, J.B. and L.H. Summers	1988	How does macroeconomic policy affect output?	US	Convexity
Cover , J.P.	1992	Asymmetric effects of positive and negative money supply sh	US	Convexity
Laxton, D. and D. Rose and R. Tetlow	1993	Is the Canadian Phillips curve nonlinear?	CA	Convexity
Clark, P. and D. Laxton and D. Rose	1995	Capacity constraints, inflation and the transmission mechanis	US	Convexity
Kandil, M.	1995	Asymmetric nominal flexibility and economic fluctuations	Many EU+non-EU	Convexity
Laxton, D. and G. Meredith and D. Rose	1995	Asymmetric effects of economic activity on inflation: Evidenc	G7	Convexity
Turner, D.	1995	Speed limit and asymmetric effects from the output gap in the	G7	Mixed evidence
Akerlof, G.A. and W.T. Dickens and G.L. Perry	1996	The macroeconomics of low inflation	US	Convexity
Clark, P. and D. Laxton and D. Rose	1996	Asymmetries in the US output-inflation nexus	US	Convexity
Karras, G.	1996	Are the output effects of monetary policy asymmetric? Evider	EU countries	Convexity
Clark, P. and D. Laxton	1997	Phillips curves, Phillips lines and the unemployment costs of	US	Convexity
Debelle, G. and D. Laxton	1997	Is the Phillips curve really a curve? Some evidence for Canada	CA, US, GB	Convexity
Eisner, R.	1997	New view of the NAIRU	US	Concavity
Gordon, R.J.	1997	The time-varying NAIRU and its implications for economic pol	US	Linearity
Stiglitz, J.	1997	Reflections on the natural rate hypothesis	US	Concavity
Demertzis, M. and A. Hallatt	1998	Asymmetric transmission mechanisms and the rise in Europea	EU countries	Convexity
Filardo, A.J.	1998	New evidence on the output cost of fighting inflation	US	Convexity
Laxton, D. and D. Rose and D. Tambakis	1999	The U.S. Phillips curve: The case for asymmetry	US	Convexity
Tambakis, D.N.	1999	Monetary policy with a nonlinear Phillips curve and asymmetr	US	Convexity
Weise, C.L.	1999	The asymmetric effects of monetary policy: A nonlinear vecto	US	Convexity
Nobay, A.R. and D.A. Peel	2000	Optimal monetary policy with a nonlinear Phillips curve	US	Convexity
Clark, P. and D. Laxton and D. Rose	2001	An evolution of alternative monetary policy rules in a model v	US	Convexity
Eliasson, A.C.	2001	Is the short-run Phillips curve nonlinear? Empirical evidence f	AU, SE, US	Mixed evidence
Isard, P. and D. Laxton and A.C. Eliasson	2001	Inflation targeting with NAIRU uncertainty and endogenous p	AU	Convexity
Mayes, D. and M. Viren	2002	Asymmetry and the problem of aggregation in the euro area	Euro area	Convexity
Barnes, M.L. and G.P. Olivei	2003	Inside and outside bounds: Threshold estimates of the Phillip	US	Convexity
Aguiar, A. and M.M.F. Martins	2005	Testing the significance and the non-linearity of the Phillips tr	Euro area	Linearity
Dolado, J.J. and R. Maria-Dolores and M. Nave	2005	Are monetary policy reaction functions asymmetric? The role	Euro area, US	EA convex, US linear
Fabiani, S. and M. Druant and I. Hernando and	2006	What firms' surveys tell us about price-setting behaviour in th	Euro area	Concavity
Telatar, E. and M. Hasanov	2006	The asymmetric effects of monetary shocks: The case of Turke	TR	Convexity
Baghli, M. and C. Cahn and H. Fraisse	2007	Is the inflation-output nexus asymmetric in the euro area?	Euro area	Convexity
De Veirman, E.	2007	Which nonlinearity in the Phillips curve? The absence of accel	JP	Convexity
Huh, H. and I. Jang	2007	Nonlinear Phillips curve, sacrifice ratio, and the natural rate o	GB, US	Convexity
Buchmann, M.	2009	Nonparametric hybrid Phillips curves based on subjective exp	Euro area	Convexity
Huh, H. and H.H. Lee and N. Lee	2009	Nonlinear Phillips curve, NAIRU and monetary policy rules	US	Mixed evidence
Musso, A. and L. Stracca and D. van Dijk	2009	Instability and nonlinearity in the euro area Phillips curve	Euro area	Linearity
Tambakis, D.N.	2009	Optimal monetary policy with a convex Phillips curve	7 EU/non-EU	Mixed evidence
Hasanov, M. and A. Arac and F. Telatar	2010	Nonlinearity and structural stability in the Phillips curve: Evid	TR	Convexity
Ball, L. and S. Mazumdar	2011	Inflation dynamics and the great recession	US	Convexity
Binder, M. and M. Gross	2013	Regime-switching global vector autoregressive models	Euro area	Convexity
Kumar, A. and P. Orrenius	2015	A closer look at the Phillips curve using state-level data	US	Convexity

Note: The table provides an overview of the empirical literature, in chronological order, which examines nonlinearity in the Phillips curve. The detailed references can be found in the bibliography.

Table 2: Euro area Phillips curve — Parameter estimates on real activity measures — Linear vs. regime-switching specifications

	Coefficient			Coef. Normalized				p-value			adj. R^2		p-value (LRT)
	Linear	**R1**	**R2**	**Linear**	**R1**	**R2**	**R2-R1**	**Linear**	**R1**	**R2**	**Linear**	**R**	
GDP-R	0.017	0.022	-0.018	0.033	0.024	-0.030	-0.054	0.083	0.304	0.348	0.942	0.945	0.010
GDP-I		0.046	0.003		0.057	0.005	-0.052		0.002	0.956		0.943	0.062
HP-R	0.060	0.140	0.027	0.059	0.085	0.020	-0.064	0.003	0.002	0.473	0.943	0.946	0.013
HP-I		0.128	0.036		0.077	0.027	-0.050		0.001	0.405		0.947	0.004
EC-R	0.026	0.056	-0.022	0.054	0.096	-0.026	-0.122	0.009	0.007	0.565	0.943	0.945	0.052
EC-I		0.064	-0.006		0.090	-0.006	-0.096		0.014	0.817		0.944	0.104
IMF-R	0.029	0.048	0.032	0.055	0.097	0.060	-0.037	0.011	0.059	0.209	0.943	0.943	0.251
IMF-I		0.052	0.037		0.099	0.039	-0.059		0.054	0.131		0.943	0.240
JL4-R	0.018	0.063	0.024	0.065	0.119	0.035	-0.085	0.002	0.001	0.210	0.944	0.946	0.017
JL4-I		0.057	0.015		0.108	0.024	-0.084		0.003	0.410		0.946	0.028
JL6-R	0.052	0.057	0.055	0.092	0.100	0.046	-0.054	0.000	0.015	0.307	0.945	0.945	0.479
JL6-I		0.141	0.060		0.108	0.086	-0.022		0.020	0.002		0.946	0.265

Note: The table reports the parameter estimates for the real activity measure in the euro area Phillips curve based on a linear and regime-switching equation structure. R1 and R2 denote the two regimes from the regime-switching specification. -R and -I attached to the gap measures in the first column denote the regime-switching mechanism, that is, either a Markov-Switching probability-based weighting or a 0-1 indicator-based weighting based on the underlying slack measures. The equation contains euro area HICP inflation as the dependent variable and as right hand-side variables an intercept, an autoregressive lag, an inflation expectation measure (lagged by 6 months) and a measure of slack (or GDP growth) as indicated in the first column. The normalised coefficients are the product of the coefficients and the ratio of the standard deviation (STD) of the independent and dependent variable; the underlying STDs under the regime-switching models are regime-conditional STD estimates for both inflation and the slack measure. The last column shows the p-values from a likelihood ratio test of the regime-switching against the linear specifications. 'R' in the adj. R^2 column denotes the regime switching model, i.e. it is an adj. R^2 resulting from the fit of the model overall (not regime-specific). The underlying monthly sample covers the period 1999M01-2016M03 (207 obs.). See text for further details.

Table 3: Euro area Phillips curve — Parameter estimates on real activity measures — Robustness test with alternative inflation expectation measure

	Coefficient			Coef. Normalized				p-value			adj. R^2		p-value (LRT)
	Linear	**R1**	**R2**	**Linear**	**R1**	**R2**	**R2-R1**	**Linear**	**R1**	**R2**	**Linear**	**R**	
GDP-R	0.021	0.026	-0.003	0.041	0.028	-0.006	-0.034	0.032	0.272	0.859	0.942	0.945	0.016
GDP-I		0.047	0.010		0.059	0.015	-0.044		0.002	0.858		0.944	0.048
HP-R	0.061	0.133	0.034	0.060	0.080	0.026	-0.055	0.002	0.003	0.359	0.943	0.946	0.010
HP-I		0.122	0.045		0.074	0.034	-0.040		0.002	0.284		0.947	0.003
EC-R	0.032	0.054	-0.030	0.065	0.091	-0.037	-0.128	0.001	0.009	0.416	0.944	0.945	0.068
EC-I		0.064	0.005		0.090	0.005	-0.086		0.014	0.848		0.944	0.184
IMF-R	0.033	0.045	0.038	0.063	0.091	0.072	-0.018	0.003	0.078	0.103	0.943	0.944	0.311
IMF-I		0.049	0.043		0.092	0.046	-0.046		0.075	0.060		0.944	0.302
JL4-R	0.021	0.062	0.021	0.078	0.117	0.030	-0.088	0.000	0.001	0.275	0.945	0.947	0.039
JL4-I		0.057	0.013		0.107	0.020	-0.087		0.003	0.487		0.946	0.046
JL6-R	0.057	0.064	0.041	0.103	0.112	0.034	-0.078	0.000	0.006	0.435	0.947	0.947	0.542
JL6-I		0.145	0.066		0.111	0.095	-0.016		0.017	0.000		0.947	0.294

Note: See Table 2 for a detailed explanation. The difference to Table 2 is that an alternative inflation expectation measure is used as a control variable — the INFE5 variable. See text for further details.

Table 4: Regime-conditional standard deviations of inflation and output gap measures

	INF		**GAPs**	
	R1	**R2**	**R1**	**R2**
GDP-R	0.86	0.90	0.92	1.48
GDP-I	0.91	0.85	1.13	1.29
HP-R	1.03	0.80	0.63	0.61
HP-I	1.04	0.78	0.63	0.59
EC-R	0.59	0.64	1.01	0.78
EC-I	0.64	1.01	0.90	1.05
IMF-R	0.57	0.58	1.14	1.09
IMF-I	0.58	0.94	1.09	1.00
JL4-R	0.59	1.04	1.12	1.48
JL4-I	0.58	1.04	1.10	1.59
JL6-R	0.51	0.93	0.89	0.77
JL6-I	0.65	0.92	0.50	1.32

Note: The table reports regime-conditional standard deviations (STDs) of year-on-year inflation and real activity measures, all expressed in log percentage points, over the 1999M1-2016M03 period. -R and -I attached to the gap measures in the first column denote the regime-switching mechanism, that is, either a Markov-Switching probability-based weighting or a 0-1 indicator-based weighting based on the underlying slack measures. See text for further details.

Table 5: Country-level Phillips curve estimates — Parameter estimates on real activity measures — Linear vs. regime-switching specifications — Based on GAPHP-R

INFE	Country	Coefficients Linear	Coefficients R1	Coefficients R2	Coef. Normalized Linear	Coef. Normalized R1	Coef. Normalized R2	p-values Linear	p-values R1	p-values R2	p (LRT)
lag-0	AT	0.076	0.159	0.051	0.074	0.111	0.045	0.006	0.019	0.17	0.52
	BE	0.203	0.299	0.193	0.136	0.117	0.11	0	0.002	0.002	0.50
	CY	0.055	0.252	0.067	0.030	0.048	0.032	0.23	0.20	0.43	0.15
	DE	0.043	0.09	0.034	0.063	0.089	0.046	0.039	0.008	0.051	0.033
	EE	0.042	0.062	0.06	0.045	0.042	0.054	0.006	0.007	0	0
	ES	0.043	0.14	0.078	0.020	0.041	0.023	0.25	0.1	0.39	0.60
	FI	0.019	0.051	-0.104	0.027	0.051	-0.176	0.20	0.009	0.36	0.012
	FR	0.076	0.129	0.089	0.057	0.069	0.055	0.017	0.004	0.007	0.004
	GR	0.057	0.144	0.028	0.035	0.042	0.014	0.022	0.054	0.52	0.45
	IE	0.037	-0.040	0.126	0.029	-0.028	0.055	0.035	0.17	0.002	0
	IT	0.063	0.152	0.045	0.063	0.101	0.033	0.001	0.12	0.074	0.44
	LT	0.048	0.134	0.041	0.043	0.059	0.041	0.001	0.52	0.019	0.33
	LV	0.067	0.067	0.154	0.044	0.031	0.076	0	0.006	0.021	0.11
	MT	0.118	0.166	0.05	0.106	0.094	0.031	0.011	0.061	0.66	0.84
	NL	0.025	0.044	0.008	0.017	0.019	0.005	0.31	0.43	0.84	0.91
	PL	0.160	0.181	0.227	0.052	0.029	0.058	0	0.014	0	0.31
	PT	0.115	0.072	0.275	0.072	0.030	0.117	0	0.14	0	0.092
	SI	0.023	0.06	-0.004	0.013	0.022	-0.002	0.33	0.16	0.95	0.36
	SK	0.018	0.181	0.009	0.008	0.024	0.007	0.39	0.047	0.68	0.27
	BG	-0.085	-0.213	-0.059	-0.028	-0.023	-0.038	0.075	0.16	0.50	0.57
	CZ	0.122	0.12	0.104	0.082	0.042	0.069	0	0.19	0.064	0.045
	GB	-0.006	0.009	0.078	-0.004	0.005	0.053	0.81	0.75	0.037	0.023
	HR	0.047	-0.009	0.072	0.034	-0.005	0.034	0.18	0.90	0.35	0.001
	HU	0.011	-0.038	-0.072	0.004	-0.01	-0.028	0.73	0.43	0.61	0.36
	RO	-0.007	0.023	-0.229	-0.001	0.029	-0.014	0.81	0.45	0.004	0.017
	SE	0.001	0.039	0.090	0.001	0.043	0.079	0.97	0.12	0.038	0.099
lag-6	AT	0.105	0.103	0.08	0.102	0.072	0.071	0	0.16	0.027	0.73
	BE	0.206	0.301	0.224	0.138	0.118	0.128	0	0.002	0.001	0.49
	CY	0.040	0.143	0.034	0.022	0.027	0.016	0.40	0.48	0.70	0.04
	DE	0.057	0.1	0.05	0.083	0.099	0.068	0.005	0.004	0.033	0.02
	EE	0.055	0.064	0.053	0.058	0.043	0.047	0.001	0.009	0	0
	ES	0.027	0.151	0.035	0.012	0.044	0.01	0.49	0.079	0.71	0.13
	FI	0.045	0.059	0.003	0.063	0.059	0.005	0.002	0.006	0.98	0.002
	FR	0.101	0.174	0.088	0.076	0.093	0.054	0.001	0	0.04	0
	GR	0.054	0.101	0.049	0.033	0.029	0.024	0.042	0.17	0.30	0.26
	IE	0.025	-0.042	0.105	0.020	-0.030	0.046	0.17	0.14	0.02	0.029
	IT	0.074	0.158	0.054	0.073	0.106	0.04	0	0.12	0.038	0.33
	LT	0.048	-0.067	0.045	0.043	-0.029	0.045	0.005	0.68	0.028	0.005
	LV	0.071	0.105	0.293	0.047	0.049	0.144	0	0	0	0
	MT	0.096	0.098	0.074	0.086	0.055	0.046	0.046	0.27	0.53	0.84
	NL	0.068	0.078	0.031	0.048	0.033	0.017	0.005	0.18	0.46	0.20
	PL	0.178	0.161	0.242	0.057	0.026	0.062	0	0.064	0.001	0.87
	PT	0.085	0.068	0.186	0.054	0.028	0.080	0.01	0.20	0.014	0.24
	SI	0.031	0.066	0.024	0.017	0.025	0.011	0.24	0.22	0.68	0.88
	SK	0.055	0.329	0.043	0.025	0.043	0.033	0.013	0.002	0.017	0.024
	BG	-0.032	-0.062	0.066	-0.010	-0.007	0.043	0.51	0.70	0.46	0.022
	CZ	0.103	0.237	0.064	0.069	0.082	0.043	0.002	0.005	0.26	0.18
	GB	0.045	0.048	0.098	0.034	0.028	0.066	0.053	0.11	0.023	0.003
	HR	0.016	0.064	-0.041	0.011	0.034	-0.019	0.72	0.48	0.66	0.79
	HU	0.011	0.042	-0.063	0.004	0.011	-0.024	0.75	0.38	0.66	0.049
	RO	-0.007	0.029	-0.204	-0.001	0.037	-0.013	0.82	0.43	0.019	0.088
	SE	0.026	0.073	0.094	0.039	0.081	0.083	0.13	0.002	0.038	0.024
lag-12	AT	0.090	0.12	0.062	0.088	0.084	0.056	0.002	0.083	0.11	0.69
	BE	0.196	0.317	0.198	0.132	0.125	0.113	0	0.002	0.002	0.20
	CY	0.048	0.201	0.09	0.026	0.038	0.043	0.35	0.32	0.31	0.20
	DE	0.049	0.096	0.035	0.072	0.095	0.047	0.02	0.006	0.14	0.005
	EE	0.033	0.067	0.007	0.035	0.045	0.006	0.042	0.005	0.76	0
	ES	0.029	0.155	0.016	0.013	0.045	0.005	0.51	0.073	0.87	0.20
	FI	0.032	0.052	-0.21	0.045	0.052	-0.354	0.059	0.024	0.087	0.003
	FR	0.073	0.149	0.088	0.055	0.08	0.053	0.027	0.001	0.054	0
	GR	0.059	0.136	0.034	0.037	0.039	0.017	0.024	0.07	0.52	0.83
	IE	0.019	-0.036	0.088	0.015	-0.025	0.039	0.32	0.20	0.058	0.14
	IT	0.067	0.137	0.049	0.066	0.092	0.037	0.002	0.18	0.082	0.75
	LT	0.042	0.157	0.021	0.038	0.069	0.021	0.015	0.23	0.35	0
	LV	0.042	0.116	0.032	0.028	0.054	0.016	0.019	0	0.67	0
	MT	0.110	0.117	0.09	0.099	0.066	0.056	0.023	0.22	0.45	0.90
	NL	0.059	0.078	0.024	0.042	0.033	0.013	0.016	0.19	0.58	0.54
	PL	0.185	0.179	0.293	0.060	0.029	0.075	0	0.049	0	0.28
	PT	0.061	0.046	0.127	0.038	0.019	0.054	0.098	0.42	0.15	0.098
	SI	0.035	0.095	0.025	0.019	0.036	0.012	0.21	0.11	0.68	0.33
	SK	0.042	0.277	0.033	0.019	0.036	0.025	0.058	0.01	0.10	0.075
	BG	-0.057	0.024	0.155	-0.019	0.003	0.100	0.24	0.88	0.11	0.001
	CZ	0.093	0.184	0.023	0.062	0.064	0.015	0.01	0.043	0.70	0.067
	GB	0.039	0.049	0.001	0.029	0.028	0.001	0.097	0.10	0.98	0
	HR	-0.015	0.09	-0.169	-0.011	0.049	-0.079	0.81	0.49	0.14	0.003
	HU	0.005	0.038	-0.082	0.002	0.01	-0.031	0.88	0.40	0.59	0.035
	RO	-0.014	0.001	-0.197	-0.002	0.001	-0.012	0.66	0.98	0.027	0.15
	SE	0.028	0.073	0.056	0.042	0.081	0.049	0.14	0.002	0.44	0.011

Note: The table reports country-level estimates of the parameters on the output gap measures in a hybrid Phillips curve specification. Gray cells are a visual support to finding lines in which coefficients are larger under R1 than under R2, and p-values below 10%. p (LRT) in the last column is the result from a likelihood ratio test of the regime-switching against the linear specification.

Table 6: Country-level Phillips curve estimates — Parameter estimates on real activity measures — Linear vs. regime-switching specifications — Based on GAPHP-I

INFE	Country	Coefficients Linear	Coefficients R1	Coefficients R2	Coef. Normalized Linear	Coef. Normalized R1	Coef. Normalized R2	p-values Linear	p-values R1	p-values R2	p (LRT)
lag-0	AT	0.076	0.123	0.041	0.074	0.08	0.036	0.006	0.029	0.38	0.41
	BE	0.203	0.314	0.18	0.136	0.123	0.098	0	0.002	0.006	0.66
	CY	0.055	0.213	0.247	0.030	0.061	0.103	0.23	0.078	0.034	0.074
	DE	0.043	0.167	0.051	0.063	0.147	0.071	0.039	0.001	0.093	0.033
	EE	0.042	0.09	0.042	0.045	0.058	0.043	0.006	0.003	0.12	0.025
	ES	0.043	0.108	0.098	0.020	0.033	0.028	0.25	0.15	0.35	0.80
	FI	0.019	0.069	-0.035	0.027	0.056	-0.052	0.20	0.037	0.21	0.075
	FR	0.076	0.132	0.072	0.057	0.063	0.045	0.017	0.026	0.21	0.50
	GR	0.057	0.12	0.012	0.035	0.037	0.006	0.022	0.039	0.83	0.66
	IE	0.037	-0.036	0.139	0.029	-0.022	0.059	0.035	0.28	0.001	0.002
	IT	0.063	0.101	0.073	0.063	0.059	0.059	0.001	0.028	0.021	0.44
	LT	0.048	0.103	0.065	0.043	0.057	0.066	0.001	0.015	0.042	0.55
	LV	0.067	0.2	0.108	0.044	0.076	0.071	0	0	0	0.004
	MT	0.118	0.2	0.073	0.106	0.107	0.041	0.011	0.058	0.50	0.93
	NL	0.025	0.059	0.029	0.017	0.025	0.015	0.31	0.25	0.55	0.91
	PL	0.160	0.176	0.281	0.052	0.030	0.066	0	0.008	0	0.36
	PT	0.115	0.127	0.270	0.072	0.045	0.117	0	0.039	0	0.045
	SI	0.023	0.047	-0.012	0.013	0.017	-0.005	0.33	0.31	0.85	0.48
	SK	0.018	-0.037	0.019	0.008	-0.021	0.005	0.39	0.25	0.60	0.002
	BG	-0.085	-0.271	-0.038	-0.028	-0.061	-0.013	0.075	0.036	0.63	0.27
	CZ	0.122	0.147	0.114	0.082	0.051	0.075	0	0.11	0.047	0.041
	GB	-0.006	0.006	-0.008	-0.004	0.003	-0.006	0.81	0.89	0.86	0.04
	HR	0.047	-0.104	0.046	0.034	-0.057	0.019	0.18	0.16	0.59	0.021
	HU	0.011	-0.093	0.053	0.004	-0.021	0.017	0.73	0.12	0.48	0.51
	RO	-0.007	0.113	-0.139	-0.001	0.016	-0.008	0.81	0.019	0.16	0.008
	SE	0.001	0.054	-0.021	0.001	0.053	-0.026	0.97	0.25	0.45	0.71
lag-6	AT	0.105	0.127	0.081	0.102	0.083	0.071	0	0.043	0.053	0.22
	BE	0.206	0.318	0.226	0.138	0.125	0.122	0	0.002	0.001	0.63
	CY	0.040	0.122	0.197	0.022	0.035	0.082	0.40	0.33	0.12	0.20
	DE	0.057	0.179	0.045	0.083	0.157	0.064	0.005	0.001	0.15	0.11
	EE	0.055	0.101	0.042	0.058	0.065	0.042	0.001	0.002	0.15	0.02
	ES	0.027	0.111	0.03	0.012	0.034	0.009	0.49	0.15	0.77	0.11
	FI	0.045	0.095	0.025	0.063	0.077	0.036	0.002	0.011	0.28	0.46
	FR	0.101	0.188	0.067	0.076	0.09	0.042	0.001	0.002	0.25	0.11
	GR	0.054	0.119	0.049	0.033	0.037	0.024	0.042	0.039	0.40	0.57
	IE	0.025	-0.038	0.118	0.020	-0.024	0.050	0.17	0.24	0.009	0.087
	IT	0.074	0.093	0.073	0.073	0.055	0.059	0	0.05	0.025	0.20
	LT	0.048	0.104	0.08	0.043	0.058	0.081	0.005	0.028	0.047	0.37
	LV	0.071	0.266	0.098	0.047	0.101	0.064	0	0	0.002	0
	MT	0.096	0.179	0.114	0.086	0.096	0.064	0.046	0.085	0.31	0.65
	NL	0.068	0.095	0.054	0.048	0.04	0.029	0.005	0.064	0.28	0.16
	PL	0.178	0.202	0.307	0.057	0.035	0.072	0	0.009	0	0.56
	PT	0.085	0.153	0.171	0.054	0.055	0.074	0.01	0.025	0.013	0.096
	SI	0.031	0.059	0.013	0.017	0.021	0.006	0.24	0.32	0.84	0.86
	SK	0.055	0.014	0.030	0.025	0.008	0.008	0.013	0.72	0.40	0.17
	BG	-0.032	-0.340	-0.033	-0.010	-0.077	-0.011	0.51	0.016	0.66	0.082
	CZ	0.103	0.267	0.074	0.069	0.092	0.049	0.002	0.001	0.20	0.14
	GB	0.045	0.081	0.023	0.034	0.039	0.016	0.053	0.058	0.62	0.13
	HR	0.016	0.04	-0.099	0.011	0.022	-0.042	0.72	0.63	0.33	0.74
	HU	0.011	0.011	0	0.004	0.003	0	0.75	0.84	1.00	0.089
	RO	-0.007	0.105	-0.082	-0.001	0.015	-0.005	0.82	0.057	0.43	0.18
	SE	0.026	0.094	-0.017	0.039	0.092	-0.021	0.13	0.038	0.55	0.13
lag-12	AT	0.090	0.118	0.055	0.088	0.077	0.048	0.002	0.057	0.21	0.30
	BE	0.196	0.343	0.201	0.132	0.135	0.109	0	0.001	0.003	0.48
	CY	0.048	0.115	0.207	0.026	0.033	0.086	0.35	0.39	0.11	0.71
	DE	0.049	0.182	0.031	0.072	0.16	0.044	0.02	0.001	0.37	0.054
	EE	0.033	0.103	-0.032	0.035	0.067	-0.032	0.042	0.001	0.30	0
	ES	0.029	0.114	-0.008	0.013	0.034	-0.002	0.51	0.14	0.94	0.19
	FI	0.032	0.077	0.014	0.045	0.062	0.021	0.059	0.046	0.55	0.30
	FR	0.073	0.169	0.011	0.055	0.081	0.007	0.027	0.007	0.86	0.049
	GR	0.059	0.125	0.032	0.037	0.038	0.016	0.024	0.042	0.63	0.87
	IE	0.019	-0.022	0.101	0.015	-0.014	0.043	0.32	0.50	0.03	0.14
	IT	0.067	0.081	0.067	0.066	0.048	0.054	0.002	0.099	0.042	0.48
	LT	0.042	0.185	0.025	0.038	0.102	0.025	0.015	0	0.64	0.01
	LV	0.042	0.292	-0.016	0.028	0.11	-0.011	0.019	0	0.62	0
	MT	0.110	0.177	0.127	0.099	0.095	0.071	0.023	0.13	0.26	0.96
	NL	0.059	0.086	0.045	0.042	0.036	0.024	0.016	0.11	0.36	0.31
	PL	0.185	0.205	0.363	0.060	0.035	0.085	0	0.007	0	0.15
	PT	0.061	0.13	0.11	0.038	0.047	0.048	0.098	0.06	0.16	0.022
	SI	0.035	0.089	0.008	0.019	0.032	0.003	0.21	0.17	0.90	0.32
	SK	0.042	0.011	0.031	0.019	0.006	0.009	0.058	0.78	0.35	0.26
	BG	-0.057	-0.319	-0.126	-0.019	-0.072	-0.043	0.24	0.02	0.16	0.13
	CZ	0.093	0.211	0.035	0.062	0.073	0.023	0.01	0.018	0.57	0.068
	GB	0.039	0.085	0.02	0.029	0.041	0.015	0.097	0.047	0.66	0.097
	HR	-0.015	-0.069	-0.226	-0.011	-0.038	-0.096	0.81	0.53	0.058	0.015
	HU	0.005	-0.019	-0.035	0.002	-0.004	-0.011	0.88	0.73	0.65	0.046
	RO	-0.014	0.147	-0.09	-0.002	0.021	-0.005	0.66	0.033	0.43	0.14
	SE	0.028	0.097	-0.032	0.042	0.095	-0.039	0.14	0.027	0.34	0.16

Note: The table reports country-level estimates of the parameters on the output gap measures in a hybrid Phillips curve specification. Gray cells are a visual support to finding lines in which coefficients are larger under R1 than under R2, and p-values below 10%. p (LRT) in the last column is the result from a likelihood ratio test of the regime-switching against the linear specification.

Table 7: Country-level Phillips curve estimates — Parameter estimates on real activity measures — Linear vs. regime-switching specifications — Based on GAPEC-R

INFE	Country	Coefficients			Coef. Normalized			p-values			p (LRT)
		Linear	R1	R2	Linear	R1	R2	Linear	R1	R2	
lag-0	AT	0.023	0.098	0	0.034	0.085	0	0.17	0.003	0.99	0.044
	BE	0.082	0.089	0.180	0.086	0.078	0.078	0.001	0.037	0	0.087
	CY	0.033	0.03	-0.012	0.058	0.038	-0.014	0.031	0.33	0.73	0.079
	DE	0.003	0.112	0.067	0.007	0.117	0.114	0.84	0	0.18	0
	EE	0.017	0.022	0.095	0.039	0.038	0.086	0.009	0.007	0	0
	ES	0.008	-0.058	-0.064	0.022	-0.056	-0.092	0.25	0.15	0.15	0.015
	FI	0.024	0.03	-0.012	0.054	0.042	-0.016	0.002	0.21	0.48	0.10
	FR	0.022	-0.017	0.012	0.044	-0.017	0.008	0.062	0.66	0.74	0.012
	GR	0.018	-0.038	0.041	0.055	-0.084	0.051	0.006	0.022	0.061	0.009
	IE	0.036	0.043	0.174	0.053	0.045	0.104	0.005	0.021	0.01	0.089
	IT	0.028	0.000	0.047	0.063	-0.001	0.039	0.002	0.99	0.002	0.13
	LT	0.028	0.086	0.03	0.048	0.079	0.048	0	0	0.17	0.004
	LV	0.012	0.002	0.073	0.017	0.002	0.048	0.10	0.89	0.43	0
	MT	0.152	0.289	0.206	0.159	0.142	0.131	0	0.013	0.052	0.33
	NL	0.010	0.062	0.022	0.015	0.036	0.016	0.41	0.23	0.12	0.063
	PL	0.019	0.101	-0.044	0.017	0.038	-0.031	0.12	0.009	0.081	0.017
	PT	0.043	0.059	0.063	0.071	0.071	0.067	0	0.067	0.004	0.62
	SI	0.014	0.238	-0.007	0.017	0.264	-0.005	0.20	0	0.71	0
	SK	0.012	-0.049	0.079	0.010	-0.112	0.022	0.26	0.10	0.04	0.082
	BG	-0.001	0.065	-0.06	0.000	0.034	-0.016	0.99	0.59	0.46	0.23
	CZ	0.042	0.068	0.046	0.060	0.041	0.039	0.002	0.31	0.14	0.004
	GB	0.001	0.006	-0.087	0.002	0.005	-0.116	0.91	0.84	0.006	0.001
	HR	0.015	0.078	0.032	0.031	0.152	0.021	0.37	0.015	0.45	0
	HU	-0.003	0.097	-0.032	-0.002	0.046	-0.016	0.84	0.26	0.17	0.29
	RO	0.010	0.014	-0.093	0.003	0.008	-0.013	0.50	0.79	0.041	0.044
	SE	0.009	0.016	-0.064	0.020	0.023	-0.11	0.42	0.48	0.004	0.003
lag-6	AT	0.046	0.043	0.076	0.067	0.037	0.075	0.01	0.29	0.13	0.93
	BE	0.083	0.062	0.296	0.087	0.054	0.128	0.001	0.16	0.021	0.59
	CY	0.037	0.03	0.028	0.065	0.039	0.031	0.015	0.33	0.44	0.25
	DE	0.028	0.117	0.077	0.057	0.122	0.131	0.056	0	0.12	0.007
	EE	0.020	0.029	0.487	0.045	0.050	0.444	0.006	0.001	0	0
	ES	0.019	-0.025	-0.037	0.049	-0.024	-0.053	0.011	0.61	0.057	0.001
	FI	0.026	0.066	0.015	0.058	0.091	0.021	0.008	0.026	0.37	0.55
	FR	0.032	0.054	0.05	0.064	0.054	0.033	0.009	0.20	0.43	0.34
	GR	0.020	-0.008	0.063	0.061	-0.017	0.078	0.003	0.63	0.025	0.003
	IE	0.037	0.054	0.057	0.055	0.057	0.034	0.002	0.004	0.34	0.005
	IT	0.027	0.010	0.056	0.060	0.016	0.047	0.004	0.73	0.20	0.06
	LT	0.023	0.083	0.052	0.040	0.077	0.083	0.01	0	0.059	0
	LV	0.034	0.052	0.321	0.048	0.051	0.210	0	0	0	0
	MT	0.063	0.172	0.018	0.066	0.085	0.011	0.16	0.16	0.86	0.34
	NL	0.034	0.121	0.044	0.051	0.07	0.031	0.003	0.037	0.14	0.27
	PL	0.022	0.1	-0.078	0.019	0.037	-0.054	0.12	0.023	0.02	0.001
	PT	0.026	0.027	0.024	0.043	0.033	0.025	0.036	0.46	0.31	1.00
	SI	0.011	0.202	-0.003	0.012	0.224	-0.002	0.35	0.006	0.88	0.002
	SK	0.009	-0.008	0.029	0.008	-0.018	0.008	0.48	0.83	0.56	0.69
	BG	0.113	0.355	-0.062	0.053	0.183	-0.017	0.011	0.001	0.37	0.001
	CZ	0.023	0.126	-0.022	0.033	0.077	-0.019	0.11	0.076	0.46	0.14
	GB	-0.006	0.014	-0.065	-0.011	0.011	-0.086	0.59	0.68	0.085	0.095
	HR	0.036	0.13	0.028	0.073	0.252	0.018	0.048	0.17	0.49	0.18
	HU	0.005	0.082	-0.023	0.004	0.039	-0.011	0.74	0.40	0.34	0.14
	RO	0.010	0.002	-0.069	0.004	0.001	-0.009	0.48	0.98	0.25	0.41
	SE	0.015	0.031	-0.036	0.035	0.044	-0.062	0.19	0.20	0.11	0.076
lag-12	AT	0.036	0.033	0.049	0.053	0.029	0.048	0.062	0.40	0.31	1.00
	BE	0.079	0.079	0.294	0.083	0.068	0.127	0.003	0.073	0.039	0.55
	CY	0.037	0.022	0.015	0.065	0.029	0.017	0.014	0.47	0.72	0.17
	DE	0.021	0.107	0.041	0.042	0.112	0.07	0.17	0.002	0.45	0.006
	EE	0.018	0.028	0.176	0.041	0.049	0.161	0.011	0.001	0.092	0
	ES	0.019	-0.072	-0.044	0.050	-0.070	-0.064	0.014	0.21	0.026	0
	FI	0.011	0.05	-0.01	0.024	0.07	-0.014	0.35	0.10	0.61	0.25
	FR	0.029	0.019	-0.048	0.059	0.019	-0.032	0.017	0.69	0.48	0.21
	GR	0.020	-0.015	0.119	0.061	-0.034	0.148	0.004	0.34	0.002	0
	IE	0.028	0.055	0.048	0.042	0.057	0.029	0.013	0.006	0.41	0.001
	IT	0.023	0.03	0.006	0.051	0.049	0.005	0.016	0.31	0.92	0.45
	LT	0.016	0.087	-0.012	0.028	0.08	-0.019	0.089	0	0.67	0
	LV	0.023	0.061	-0.05	0.033	0.06	-0.033	0.003	0	0.72	0
	MT	0.088	0.27	-0.009	0.092	0.133	-0.006	0.042	0.061	0.92	0.20
	NL	0.031	0.124	0.038	0.048	0.072	0.027	0.011	0.024	0.21	0.28
	PL	0.034	0.16	-0.084	0.030	0.06	-0.058	0.024	0.011	0.055	0.002
	PT	0.031	0.058	0.016	0.050	0.07	0.017	0.018	0.13	0.48	0.86
	SI	0.011	0.22	-0.001	0.012	0.244	-0.001	0.35	0.001	0.94	0
	SK	-0.001	-0.029	-0.018	-0.001	-0.068	-0.005	0.93	0.38	0.72	0.43
	BG	0.097	0.566	-0.188	0.046	0.291	-0.05	0.032	0	0.016	0
	CZ	0.022	0.136	-0.02	0.032	0.083	-0.017	0.13	0.041	0.52	0.016
	GB	-0.018	0.006	-0.045	-0.032	0.005	-0.059	0.16	0.87	0.18	0.04
	HR	0.016	-0.133	0.030	0.033	-0.257	0.020	0.46	0.14	0.45	0
	HU	0.005	0.009	-0.025	0.004	0.004	-0.012	0.75	0.93	0.29	0.034
	RO	0.012	-0.048	-0.079	0.004	-0.026	-0.011	0.44	0.56	0.21	0.31
	SE	0.016	0.027	-0.025	0.037	0.039	-0.044	0.23	0.27	0.33	0.065

Note: The table reports country-level estimates of the parameters on the output gap measures in a hybrid Phillips curve specification. Gray cells are a visual support to finding lines in which coefficients are larger under R1 than under R2, and p-values below 10%. p (LRT) in the last column is the result from a likelihood ratio test of the regime-switching against the linear specification.

Table 8: Country-level Phillips curve estimates — Parameter estimates on real activity measures — Linear vs. regime-switching specifications — Based on GAPEC-I

INFE	Country	Coefficients			Coef. Normalized			p-values			p (LRT)
		Linear	R1	R2	Linear	R1	R2	Linear	R1	R2	
	AT	0.023	0.113	0.003	0.034	0.095	0.003	0.17	0.001	0.95	0.03
	BE	0.082	0.105	0.322	0.086	0.088	0.150	0.001	0.022	0	0.12
	CY	0.033	0.04	0.003	0.058	0.049	0.004	0.031	0.22	0.92	0.088
	DE	0.003	0.197	-0.018	0.007	0.186	-0.034	0.84	0	0.41	0.003
	EE	0.017	0.022	0.037	0.039	0.036	0.059	0.009	0.022	0.13	0.26
	ES	0.008	0.014	0.001	0.022	0.014	0.001	0.25	0.73	0.97	0.17
	FI	0.024	0.045	-0.015	0.054	0.065	-0.02	0.002	0.033	0.41	0.16
	FR	0.022	-0.015	0.056	0.044	-0.015	0.037	0.062	0.72	0.46	0.008
	GR	0.018	-0.009	0.072	0.055	-0.019	0.116	0.006	0.60	0	0
	IE	0.036	0.023	0.025	0.053	0.021	0.023	0.005	0.27	0.52	0.92
	IT	0.028	-0.041	0.046	0.063	-0.067	0.048	0.002	0.18	0.065	0.28
	LT	0.028	0.092	0.01	0.048	0.08	0.016	0	0	0.57	0.018
	LV	0.012	0.003	0.022	0.017	0.003	0.036	0.10	0.85	0.05	0.12
lag-0	MT	0.152	0.310	0.367	0.159	0.171	0.214	0	0.002	0.003	0.054
	NL	0.010	0.063	0.049	0.015	0.037	0.035	0.41	0.21	0.091	0.068
	PL	0.019	0.096	-0.054	0.017	0.036	-0.038	0.12	0.007	0.048	0.015
	PT	0.043	0.047	0.062	0.071	0.058	0.065	0	0.13	0.006	0.73
	SI	0.014	0.056	-0.017	0.017	0.056	-0.011	0.20	0.005	0.59	0.003
	SK	0.012	-0.030	0.080	0.010	-0.072	0.021	0.26	0.15	0.056	0.12
	BG	-0.001	0.068	-0.233	0.000	0.035	-0.056	0.99	0.52	0.026	0.02
	CZ	0.042	0.015	0.054	0.060	0.016	0.043	0.002	0.54	0.23	0.59
	GB	0.001	-0.042	-0.053	0.002	-0.031	-0.074	0.91	0.34	0.024	0.016
	HR	0.015	0.062	0.021	0.031	0.117	0.014	0.37	0.07	0.62	0
	HU	-0.003	0.056	-0.043	-0.002	0.036	-0.018	0.84	0.088	0.18	0.26
	RO	0.010	0.017	-0.051	0.003	0.01	-0.006	0.50	0.71	0.48	0.091
	SE	0.009	-0.041	-0.036	0.020	-0.054	-0.063	0.42	0.14	0.067	0.002
	AT	0.046	0.050	0.080	0.067	0.042	0.079	0.01	0.22	0.11	0.96
	BE	0.083	0.066	0.264	0.087	0.055	0.123	0.001	0.17	0.014	0.61
	CY	0.037	0.034	0.038	0.065	0.042	0.046	0.015	0.33	0.27	0.28
	DE	0.028	0.168	-0.007	0.057	0.159	-0.012	0.056	0.002	0.75	0.03
	EE	0.020	0.033	0.032	0.045	0.055	0.051	0.006	0	0.25	0.094
	ES	0.019	0.057	-0.023	0.049	0.059	-0.031	0.011	0.21	0.30	0.043
	FI	0.026	0.071	0.02	0.058	0.104	0.026	0.008	0.006	0.27	0.39
	FR	0.032	0.059	0.067	0.064	0.059	0.044	0.009	0.16	0.29	0.31
	GR	0.020	0.004	0.079	0.061	0.008	0.127	0.003	0.83	0	0.006
	IE	0.037	0.034	0.063	0.055	0.032	0.057	0.002	0.096	0.11	0.052
	IT	0.027	-0.010	0.010	0.060	-0.017	0.010	0.004	0.73	0.82	0.20
	LT	0.023	0.093	0.019	0.040	0.082	0.032	0.01	0	0.34	0.004
	LV	0.034	0.051	0.023	0.048	0.039	0.037	0	0.002	0.11	0
lag-6	MT	0.063	0.231	0.094	0.066	0.128	0.055	0.16	0.028	0.40	0.15
	NL	0.034	0.124	0.049	0.051	0.073	0.035	0.003	0.027	0.10	0.25
	PL	0.022	0.101	-0.1	0.019	0.038	-0.071	0.12	0.011	0.008	0.001
	PT	0.026	0.019	0.020	0.043	0.024	0.021	0.036	0.59	0.41	0.98
	SI	0.011	0.023	-0.006	0.012	0.023	-0.004	0.35	0.37	0.85	0.96
	SK	0.009	-0.014	0.011	0.008	-0.033	0.003	0.48	0.57	0.83	0.69
	BG	0.113	0.312	-0.158	0.053	0.163	-0.038	0.011	0.001	0.033	0
	CZ	0.023	0.05	0.001	0.033	0.055	0.001	0.11	0.028	0.99	0.47
	GB	-0.006	-0.056	-0.045	-0.011	-0.042	-0.064	0.59	0.26	0.077	0.075
	HR	0.036	0.087	0.018	0.073	0.163	0.012	0.048	0.40	0.65	0.20
	HU	0.005	0.051	-0.031	0.004	0.033	-0.013	0.74	0.13	0.36	0.031
	RO	0.010	-0.007	-0.121	0.004	-0.004	-0.013	0.48	0.89	0.091	0.21
	SE	0.015	-0.005	-0.021	0.035	-0.006	-0.036	0.19	0.86	0.30	0.013
	AT	0.036	0.039	0.056	0.053	0.033	0.055	0.062	0.33	0.25	0.97
	BE	0.079	0.088	0.252	0.083	0.074	0.117	0.003	0.061	0.024	0.52
	CY	0.037	0.020	0.025	0.065	0.025	0.030	0.014	0.57	0.54	0.25
	DE	0.021	0.164	-0.017	0.042	0.155	-0.032	0.17	0.003	0.42	0.031
	EE	0.018	0.033	-0.015	0.041	0.054	-0.024	0.011	0	0.54	0.002
	ES	0.019	0.027	-0.03	0.050	0.028	-0.042	0.014	0.62	0.19	0.027
	FI	0.011	0.051	-0.006	0.024	0.074	-0.007	0.35	0.055	0.78	0.19
	FR	0.029	0.025	-0.028	0.059	0.026	-0.018	0.017	0.59	0.69	0.21
	GR	0.020	0.004	0.087	0.061	0.008	0.139	0.004	0.83	0	0
	IE	0.028	0.034	0.064	0.042	0.031	0.058	0.013	0.13	0.085	0.003
	IT	0.023	0.014	-0.065	0.051	0.022	-0.068	0.016	0.65	0.20	0.30
	LT	0.016	0.099	-0.026	0.028	0.087	-0.044	0.089	0	0.19	0
	LV	0.023	0.071	-0.028	0.033	0.054	-0.045	0.003	0.001	0.053	0
lag-12	MT	0.088	0.323	0.048	0.092	0.179	0.028	0.042	0.004	0.63	0.11
	NL	0.031	0.128	0.043	0.048	0.076	0.03	0.011	0.015	0.16	0.23
	PL	0.034	0.146	-0.138	0.030	0.055	-0.097	0.024	0.005	0.008	0.001
	PT	0.031	0.046	0.013	0.050	0.056	0.013	0.018	0.22	0.58	0.82
	SI	0.011	0.024	-0.017	0.012	0.024	-0.011	0.35	0.39	0.56	0.90
	SK	-0.001	-0.052	-0.081	-0.001	-0.126	-0.021	0.93	0.096	0.15	0.11
	BG	0.097	0.497	-0.295	0.046	0.259	-0.07	0.032	0	0.001	0
	CZ	0.022	0.047	0	0.032	0.051	0	0.13	0.037	0.99	0.42
	GB	-0.018	-0.052	-0.047	-0.032	-0.039	-0.066	0.16	0.30	0.05	0.062
	HR	0.016	-0.152	0.021	0.033	-0.286	0.014	0.46	0.088	0.59	0
	HU	0.005	0.054	-0.041	0.004	0.035	-0.017	0.75	0.10	0.24	0.09
	RO	0.012	-0.037	-0.154	0.004	-0.021	-0.017	0.44	0.53	0.047	0.12
	SE	0.016	-0.007	-0.016	0.037	-0.01	-0.028	0.23	0.81	0.48	0.013

Note: The table reports country-level estimates of the parameters on the output gap measures in a hybrid Phillips curve specification. Gray cells are a visual support to finding lines in which coefficients are larger under R1 than under R2, and p-values below 10%. p (LRT) in the last column is the result from a likelihood ratio test of the regime-switching against the linear specification.

Table 9: Country-level Phillips curve estimates — Parameter estimates on real activity measures — Linear vs. regime-switching specifications — Based on GAPIMF-R

INFE	Country	Coefficients Linear	R1	R2	Coef. Normalized Linear	R1	R2	p-values Linear	R1	R2	p (LRT)
lag-0	AT	0.016	0.048	-0.05	0.030	0.075	-0.05	0.22	0.013	0.31	0.043
	BE	0.109	0.098	0.128	0.099	0.079	0.051	0.001	0.03	0.052	0.64
	CY	0.044	0.078	0.073	0.042	0.056	0.037	0.14	0.36	0.22	0.46
	DE	0.001	0.083	0.046	0.003	0.095	0.062	0.94	0.004	0.46	0.006
	EE	0.015	0.03	0.004	0.037	0.044	0.007	0.015	0.094	0.70	0.073
	ES	0.008	-0.015	0.033	0.021	-0.027	0.039	0.32	0.52	0.013	0.019
	FI	0.018	0.024	-0.001	0.047	0.041	-0.001	0.008	0.059	0.98	0.54
	FR	0.028	-0.004	0.028	0.044	-0.004	0.021	0.076	0.93	0.28	0.017
	GR	0.013	-0.009	0.070	0.040	-0.028	0.099	0.039	0.52	0.005	0.004
	IE	0.003	0.018	-0.023	0.008	0.034	-0.013	0.61	0.08	0.61	0.093
	IT	0.048	0.009	0.034	0.092	0.021	0.022	0	0.60	0.092	0.041
	LT	0.032	0.081	0.026	0.063	0.117	0.037	0	0	0.064	0.11
	LV	0.019	0.025	0.049	0.025	0.016	0.041	0.03	0.25	0.37	0.002
	MT	0.158	0.187	0.158	0.714	1.623	0.165	0	1.00	0	1.00
	NL	0.009	-0.050	0.020	0.013	-0.041	0.012	0.46	0.13	0.31	0.066
	PL	0.111	0.278	0.122	0.087	0.214	0.041	0	0.012	0.012	0.02
	PT	0.040	0.194	0.047	0.065	0.12	0.058	0.001	0.001	0.009	0.22
	SI	0.018	0.21	0.012	0.021	0.278	0.007	0.098	0.001	0.58	0.001
	SK	0.017	-0.005	0.101	0.010	-0.006	0.025	0.24	0.95	0.007	0.15
	BG	-0.023	-0.036	0.049	-0.022	-0.037	0.018	0.40	0.58	0.47	0.18
	CZ	0.017	0.043	0.005	0.040	0.045	0.007	0.036	0.38	0.76	0
	GB	0.012	0.042	-0.112	0.017	0.043	-0.071	0.33	0.064	0.18	0.004
	HR	0.009	0.113	-0.006	0.020	0.185	-0.006	0.53	0.012	0.88	0
	HU	0.001	0.058	-0.009	0.001	0.045	-0.005	0.91	0.24	0.74	0.76
	RO	0.022	0.016	0.017	0.008	0.028	0.002	0.079	0.35	0.85	0.78
	SE	0.005	-0.006	-0.009	0.014	-0.01	-0.016	0.58	0.80	0.61	0.16
lag-6	AT	0.030	0.016	0.022	0.057	0.025	0.022	0.024	0.46	0.64	0.84
	BE	0.119	0.085	0.111	0.109	0.069	0.044	0	0.062	0.15	0.81
	CY	0.051	0.139	0.065	0.048	0.1	0.033	0.083	0.028	0.28	0.019
	DE	0.027	0.089	0.063	0.053	0.102	0.085	0.075	0.003	0.31	0.062
	EE	0.018	0.029	0.002	0.044	0.043	0.003	0.006	0.28	0.88	0.16
	ES	0.022	0.048	0.019	0.055	0.089	0.023	0.007	0.026	0.46	0.26
	FI	0.017	0.021	0.062	0.045	0.036	0.053	0.035	0.18	0.10	0.71
	FR	0.043	0.072	0.045	0.068	0.069	0.034	0.006	0.097	0.14	0.30
	GR	0.014	0.020	0.098	0.043	0.063	0.140	0.03	0.066	0	0
	IE	0.004	0.011	-0.047	0.010	0.021	-0.027	0.52	0.31	0.29	0.081
	IT	0.040	0.012	0.029	0.077	0.026	0.019	0.001	0.53	0.28	0.07
	LT	0.030	0.063	0.002	0.059	0.091	0.003	0.001	0.006	0.91	0.069
	LV	0.040	0.092	0.196	0.053	0.057	0.165	0	0	0	0
	MT	0.072	0.096	0.072	0.323	0.836	0.075	0.12	1.00	0.12	1.00
	NL	0.029	0.047	0.032	0.042	0.038	0.019	0.015	0.12	0.43	0.73
	PL	0.111	0.17	0.138	0.087	0.131	0.047	0	0.19	0.012	0.32
	PT	0.025	0.183	0.024	0.040	0.114	0.03	0.045	0.047	0.20	0.65
	SI	0.014	0.166	0.024	0.017	0.22	0.014	0.20	0.02	0.28	0.002
	SK	0.024	0.134	0.083	0.015	0.173	0.021	0.15	0.004	0.095	0.07
	BG	0.065	0.185	0.008	0.062	0.187	0.003	0.018	0.001	0.90	0.001
	CZ	0.011	0.099	-0.021	0.025	0.104	-0.027	0.20	0.04	0.24	0.011
	GB	0.001	0.061	-0.02	0.001	0.061	-0.012	0.97	0.023	0.82	0.18
	HR	0.027	0.121	0.003	0.056	0.198	0.003	0.089	0.42	0.94	0.19
	HU	0.012	0.071	0.016	0.015	0.054	0.008	0.22	0.13	0.53	0.02
	RO	0.018	0.015	-0.005	0.007	0.027	-0.001	0.17	0.47	0.96	0.89
	SE	0.011	0.021	-0.005	0.030	0.036	-0.008	0.26	0.42	0.81	0.63
lag-12	AT	0.024	0.019	0.002	0.046	0.029	0.002	0.077	0.38	0.96	0.97
	BE	0.114	0.088	0.074	0.104	0.071	0.03	0	0.058	0.37	0.91
	CY	0.047	0.084	0.111	0.044	0.06	0.056	0.11	0.35	0.077	0.15
	DE	0.021	0.088	0.004	0.040	0.1	0.006	0.18	0.004	0.95	0.013
	EE	0.016	0.045	-0.007	0.039	0.066	-0.011	0.012	0.036	0.52	0.052
	ES	0.024	0.069	0.03	0.060	0.128	0.036	0.006	0.004	0.21	0.054
	FI	0.005	0.009	0.020	0.014	0.015	0.017	0.58	0.59	0.72	0.49
	FR	0.038	0.038	0.026	0.059	0.036	0.02	0.019	0.44	0.68	0.45
	GR	0.014	0.013	0.124	0.044	0.040	0.177	0.033	0.29	0	0
	IE	0.006	0.015	-0.028	0.013	0.029	-0.016	0.38	0.15	0.51	0.054
	IT	0.033	0.014	0.007	0.062	0.032	0.005	0.008	0.46	0.83	0.31
	LT	0.028	0.069	-0.039	0.054	0.1	-0.054	0.002	0	0.057	0
	LV	0.018	0.099	-0.016	0.024	0.062	-0.013	0.08	0	0.87	0
	MT	0.095	0.162	0.095	0.431	1.403	0.099	0.03	1.00	0.028	1.00
	NL	0.024	0.046	0.023	0.035	0.038	0.014	0.049	0.13	0.56	0.94
	PL	0.115	0.203	0.133	0.090	0.156	0.045	0	0.12	0.018	0.25
	PT	0.027	0.171	0.021	0.043	0.106	0.026	0.03	0.046	0.24	0.64
	SI	0.012	0.2	0.013	0.014	0.265	0.008	0.30	0.002	0.54	0
	SK	0.008	0.052	0.034	0.005	0.068	0.008	0.63	0.54	0.55	0.42
	BG	0.085	0.24	0.089	0.082	0.243	0.032	0.004	0	0.16	0
	CZ	0.010	0.097	-0.025	0.023	0.103	-0.032	0.25	0.033	0.20	0
	GB	-0.014	0.058	-0.005	-0.019	0.058	-0.003	0.37	0.045	0.94	0.019
	HR	0.007	-0.303	0.002	0.015	-0.498	0.002	0.71	0.005	0.97	0
	HU	0.010	0.044	0.02	0.012	0.034	0.01	0.31	0.33	0.43	0.011
	RO	0.017	0.006	0.003	0.007	0.01	0	0.22	0.82	0.98	0.91
	SE	0.011	0.02	-0.005	0.029	0.035	-0.008	0.31	0.46	0.84	0.63

Note: The table reports country-level estimates of the parameters on the output gap measures in a hybrid Phillips curve specification. Gray cells are a visual support to finding lines in which coefficients are larger under R1 than under R2, and *p*-values below 10%. *p* (LRT) in the last column is the result from a likelihood ratio test of the regime-switching against the linear specification.

Table 10: Country-level Phillips curve estimates — Parameter estimates on real activity measures — Linear vs. regime-switching specifications — Based on GAPIMF-I

INFE	Country	Coefficients Linear	Coefficients R1	Coefficients R2	Coef. Normalized Linear	Coef. Normalized R1	Coef. Normalized R2	p-values Linear	p-values R1	p-values R2	p (LRT)
lag-0	AT	0.016	0.046	-0.056	0.030	0.039	-0.06	0.22	0.039	0.23	0.031
	BE	0.109	0.122	0.234	0.099	0.107	0.130	0.001	0.021	0.006	0.57
	CY	0.044	0.525	0.061	0.042	0.913	0.037	0.14	0	0.23	0.038
	DE	0.001	0.151	-0.022	0.003	0.164	-0.037	0.94	0.001	0.35	0.008
	EE	0.015	0.016	0.003	0.037	0.048	0.005	0.015	0.24	0.82	0.19
	ES	0.008	-0.016	0.066	0.021	-0.014	0.079	0.32	0.49	0.011	0.013
	FI	0.018	0.025	0.011	0.047	0.029	0.013	0.008	0.094	0.67	0.65
	FR	0.028	-0.013	0.011	0.044	-0.016	0.010	0.076	0.80	0.74	0.12
	GR	0.013	-0.015	0.066	0.040	-0.032	0.093	0.039	0.25	0.009	0.005
	IE	0.003	-0.004	-0.048	0.008	-0.005	-0.059	0.61	0.72	0.042	0.035
	IT	0.048	0.086	0.102	0.092	0.162	0.132	0	0.013	0	0.002
	LT	0.032	0.068	0.011	0.063	0.069	0.013	0	0	0.53	0.12
	LV	0.019	0.086	0.022	0.025	0.124	0.041	0.03	0.053	0.012	0.10
	MT	0.158	0.165	0.390	0.714	0.094	0.278	0	0.049	0.003	0.21
	NL	0.009	-0.059	0.026	0.013	-0.340	0.030	0.46	0.59	0.089	0.28
	PL	0.111	0.222	0.179	0.087	0.076	0.052	0	0	0.003	0.058
	PT	0.040	0.195	0.053	0.065	0.238	0.063	0.001	0	0.004	0.088
	SI	0.018	0.047	0.019	0.021	0.093	0.01	0.098	0.15	0.40	0.49
	SK	0.017	-0.019	0.115	0.010	-0.048	0.026	0.24	0.61	0.005	0.08
	BG	-0.023	-0.028	0.009	-0.022	-0.015	0.003	0.40	0.64	0.91	0.41
	CZ	0.017	0.037	0.049	0.040	0.047	0.042	0.036	0.044	0.081	0
	GB	0.012	-0.029	-0.086	0.017	-0.023	-0.067	0.33	0.41	0.007	0.002
	HR	0.009	0.116	-0.017	0.020	0.222	-0.015	0.53	0.008	0.66	0
	HU	0.001	0.013	-0.028	0.001	0.012	-0.013	0.91	0.67	0.32	0.88
	RO	0.022	0.019	-0.016	0.008	0.014	-0.002	0.079	0.22	0.88	0.52
	SE	0.005	-0.004	-0.009	0.014	-0.005	-0.015	0.58	0.86	0.66	0.15
lag-6	AT	0.030	0.023	0.039	0.057	0.019	0.042	0.024	0.36	0.37	0.99
	BE	0.119	0.093	0.223	0.109	0.082	0.124	0	0.089	0.014	0.84
	CY	0.051	0.386	0.052	0.048	0.672	0.031	0.083	0.001	0.33	0.005
	DE	0.027	0.141	-0.009	0.053	0.153	-0.016	0.075	0.002	0.67	0.039
	EE	0.018	0.039	0.003	0.044	0.115	0.006	0.006	0.009	0.76	0.35
	ES	0.022	0.05	0.025	0.055	0.044	0.03	0.007	0.022	0.33	0.20
	FI	0.017	0.033	0.036	0.045	0.039	0.043	0.035	0.07	0.17	0.76
	FR	0.043	0.061	0.029	0.068	0.076	0.026	0.006	0.22	0.47	0.56
	GR	0.014	0.014	0.095	0.043	0.029	0.133	0.03	0.21	0	0
	IE	0.004	-0.003	-0.049	0.010	-0.003	-0.061	0.52	0.81	0.019	0.001
	IT	0.040	0.099	0.084	0.077	0.186	0.11	0.001	0.017	0	0.014
	LT	0.030	0.073	-0.003	0.059	0.074	-0.003	0.001	0	0.90	0.046
	LV	0.040	0.13	0.015	0.053	0.188	0.029	0	0.001	0.16	0
	MT	0.072	0.089	0.076	0.323	0.051	0.054	0.12	0.29	0.53	0.50
	NL	0.029	-0.060	0.047	0.042	-0.345	0.056	0.015	0.60	0.003	0.16
	PL	0.111	0.17	0.144	0.087	0.058	0.042	0	0.017	0.037	0.25
	PT	0.025	0.154	0.032	0.040	0.188	0.038	0.045	0.036	0.10	0.48
	SI	0.014	0.04	0.021	0.017	0.078	0.011	0.20	0.29	0.38	0.27
	SK	0.024	0.029	0.115	0.015	0.074	0.026	0.15	0.34	0.031	0.044
	BG	0.065	0.166	0	0.062	0.09	0	0.018	0.003	1.00	0.007
	CZ	0.011	0.06	0.002	0.025	0.075	0.002	0.20	0.004	0.94	0.055
	GB	0.001	-0.059	-0.108	0.001	-0.048	-0.084	0.97	0.12	0.003	0.001
	HR	0.027	0.084	-0.01	0.056	0.16	-0.009	0.089	0.61	0.79	0.15
	HU	0.012	0.016	-0.008	0.015	0.016	-0.004	0.22	0.59	0.78	0.054
	RO	0.018	0.018	-0.06	0.007	0.014	-0.008	0.17	0.33	0.58	0.64
	SE	0.011	0.027	-0.002	0.030	0.037	-0.003	0.26	0.26	0.92	0.81
lag-12	AT	0.024	0.04	0.023	0.046	0.034	0.025	0.077	0.12	0.57	0.62
	BE	0.114	0.106	0.214	0.104	0.093	0.119	0	0.053	0.017	0.90
	CY	0.047	0.314	0.085	0.044	0.546	0.051	0.11	0.023	0.12	0.004
	DE	0.021	0.145	-0.026	0.040	0.157	-0.043	0.18	0.001	0.27	0.016
	EE	0.016	0.043	-0.006	0.039	0.126	-0.01	0.012	0.003	0.60	0.072
	ES	0.024	0.071	0.033	0.060	0.062	0.039	0.006	0.003	0.16	0.049
	FI	0.005	0.022	-0.007	0.014	0.026	-0.008	0.58	0.27	0.85	0.62
	FR	0.038	0.028	0.001	0.059	0.035	0.001	0.019	0.61	0.98	0.65
	GR	0.014	0.009	0.123	0.044	0.019	0.172	0.033	0.45	0	0
	IE	0.006	0.008	-0.034	0.013	0.009	-0.042	0.38	0.48	0.12	0
	IT	0.033	0.063	0.061	0.062	0.119	0.08	0.008	0.15	0.005	0.18
	LT	0.028	0.089	-0.049	0.054	0.09	-0.056	0.002	0	0.023	0
	LV	0.018	0.188	-0.023	0.024	0.272	-0.043	0.08	0	0.036	0
	MT	0.095	0.129	0.043	0.431	0.074	0.031	0.03	0.18	0.70	0.25
	NL	0.024	-0.073	0.042	0.035	-0.419	0.050	0.049	0.55	0.011	0.17
	PL	0.115	0.216	0.134	0.090	0.073	0.039	0	0.004	0.068	0.094
	PT	0.027	0.213	0.026	0.043	0.261	0.032	0.03	0.004	0.15	0.32
	SI	0.012	0.052	0.019	0.014	0.102	0.01	0.30	0.21	0.42	0.092
	SK	0.008	0.053	0.083	0.005	0.133	0.019	0.63	0.053	0.19	0.12
	BG	0.085	0.239	0.101	0.082	0.13	0.032	0.004	0	0.21	0
	CZ	0.010	0.067	0.02	0.023	0.084	0.017	0.25	0.001	0.53	0.009
	GB	-0.014	-0.06	-0.14	-0.019	-0.049	-0.108	0.37	0.12	0	0
	HR	0.007	-0.380	-0.012	0.015	-0.727	-0.011	0.71	0	0.74	0
	HU	0.010	0.013	-0.004	0.012	0.013	-0.002	0.31	0.65	0.88	0.007
	RO	0.017	0.013	-0.01	0.007	0.01	-0.001	0.22	0.56	0.94	0.49
	SE	0.011	0.029	0	0.029	0.039	-0.001	0.31	0.25	0.99	0.73

Note: The table reports country-level estimates of the parameters on the output gap measures in a hybrid Phillips curve specification. Gray cells are a visual support to finding lines in which coefficients are larger under R1 than under R2, and p-values below 10%. p (LRT) in the last column is the result from a likelihood ratio test of the regime-switching against the linear specification.

Table 11: Country-level Phillips curve estimates — Aggregate euro area and EU parameters on real activity measures

			Coefficients			Coef. normalised			p-value		
			Linear	**R1**	**R2**	**Linear**	**R1**	**R2**	**Linear**	**R1**	**R2**
HP-R	INFE-0	EA	0.052	0.095	0.073	0.051	0.058	0.055	0.01	0.03	0.05
		W-EA	0.064	0.121	0.067	0.055	0.071	0.040	0.07	0.07	0.15
		W-EU	0.049	0.095	0.065	0.042	0.057	0.042	0.24	0.20	0.13
	INFE-6	EA	0.060	0.140	0.027	0.059	0.085	0.020	0.00	0.00	0.47
		W-EA	0.077	0.135	0.074	0.069	0.079	0.051	0.06	0.06	0.15
		W-EU	0.068	0.116	0.074	0.060	0.069	0.053	0.08	0.08	0.13
	INFE-12	EA	0.053	0.127	0.008	0.053	0.077	0.006	0.01	0.01	0.84
		W-EA	0.067	0.128	0.060	0.059	0.074	0.036	0.08	0.07	0.21
		W-EU	0.059	0.110	0.045	0.051	0.065	0.028	0.10	0.09	0.36
HP-I	INFE-0	EA	0.052	0.087	0.096	0.051	0.053	0.072	0.01	0.03	0.02
		W-EA	0.064	0.133	0.079	0.055	0.079	0.052	0.07	0.05	0.18
		W-EU	0.049	0.104	0.057	0.042	0.062	0.038	0.24	0.21	0.31
	INFE-6	EA	0.060	0.128	0.036	0.059	0.077	0.027	0.00	0.00	0.40
		W-EA	0.077	0.151	0.075	0.069	0.088	0.052	0.06	0.04	0.21
		W-EU	0.068	0.135	0.059	0.060	0.078	0.042	0.08	0.05	0.30
	INFE-12	EA	0.053	0.118	0.006	0.053	0.071	0.005	0.01	0.00	0.89
		W-EA	0.067	0.147	0.052	0.059	0.086	0.035	0.08	0.06	0.44
		W-EU	0.059	0.131	0.040	0.051	0.076	0.027	0.10	0.06	0.48
EC-R	INFE-0	EA	0.021	-0.039	0.036	0.042	-0.066	0.027	0.04	0.16	0.31
		W-EA	0.018	0.039	0.035	0.033	0.035	0.037	0.31	0.33	0.27
		W-EU	0.015	0.033	0.008	0.027	0.029	0.004	0.43	0.43	0.21
	INFE-6	EA	0.026	0.056	-0.022	0.054	0.096	-0.016	0.01	0.01	0.57
		W-EA	0.030	0.062	0.055	0.057	0.059	0.057	0.03	0.26	0.20
		W-EU	0.023	0.054	0.027	0.043	0.050	0.025	0.15	0.34	0.18
	INFE-12	EA	0.023	0.046	-0.132	0.046	0.078	-0.098	0.03	0.03	0.02
		W-EA	0.026	0.054	0.013	0.049	0.050	0.016	0.07	0.24	0.44
		W-EU	0.018	0.045	-0.001	0.033	0.041	0.000	0.10	0.36	0.38
EC-I	INFE-0	EA	0.021	-0.032	0.029	0.042	-0.045	0.030	0.04	0.35	0.24
		W-EA	0.018	0.066	0.030	0.033	0.053	0.015	0.31	0.28	0.38
		W-EU	0.015	0.042	0.011	0.027	0.034	-0.003	0.43	0.29	0.30
	INFE-6	EA	0.026	0.064	-0.006	0.054	0.090	-0.006	0.01	0.01	0.82
		W-EA	0.030	0.082	0.026	0.057	0.073	0.015	0.03	0.21	0.46
		W-EU	0.023	0.054	0.009	0.043	0.049	-0.002	0.15	0.25	0.39
	INFE-12	EA	0.023	0.050	-0.020	0.046	0.071	-0.021	0.03	0.06	0.47
		W-EA	0.026	0.077	-0.013	0.049	0.069	-0.020	0.07	0.32	0.36
		W-EU	0.018	0.050	-0.021	0.033	0.045	-0.028	0.10	0.33	0.31
IMF-R	INFE-0	EA	0.024	0.009	0.066	0.047	0.019	0.069	0.03	0.69	0.00
		W-EA	0.026	0.041	0.039	0.039	0.044	0.035	0.36	0.36	0.27
		W-EU	0.022	0.039	0.009	0.033	0.042	0.013	0.36	0.32	0.28
	INFE-6	EA	0.029	0.048	0.032	0.055	0.097	0.033	0.01	0.06	0.21
		W-EA	0.038	0.066	0.049	0.061	0.074	0.045	0.04	0.15	0.27
		W-EU	0.030	0.064	0.033	0.048	0.071	0.031	0.22	0.14	0.40
	INFE-12	EA	0.026	0.056	0.024	0.049	0.112	0.025	0.02	0.03	0.40
		W-EA	0.033	0.062	0.023	0.053	0.072	0.017	0.09	0.21	0.67
		W-EU	0.024	0.059	0.016	0.038	0.067	0.012	0.15	0.19	0.72
IMF-I	INFE-0	EA	0.024	0.017	0.069	0.047	0.032	0.074	0.03	0.49	0.00
		W-EA	0.026	0.067	0.037	0.039	0.059	0.029	0.36	0.28	0.28
		W-EU	0.022	0.047	0.012	0.033	0.042	0.010	0.36	0.32	0.25
	INFE-6	EA	0.029	0.052	0.037	0.055	0.099	0.039	0.01	0.05	0.13
		W-EA	0.038	0.085	0.040	0.061	0.083	0.035	0.04	0.13	0.34
		W-EU	0.030	0.056	0.010	0.048	0.057	0.011	0.22	0.14	0.32
	INFE-12	EA	0.026	0.062	0.027	0.049	0.116	0.029	0.02	0.02	0.32
		W-EA	0.033	0.079	0.025	0.053	0.066	0.016	0.09	0.21	0.34
		W-EU	0.024	0.050	-0.006	0.038	0.041	-0.007	0.15	0.20	0.31

Note: The table reports the parameter estimates from the linear and regime-switching specifications for the euro area (EA) along with the weighted aggregates from the underlying euro area countries (W-EA) and the 26 EU country estimates (W-EU). The first column indicates the real activity measure that is used as a dependent variable as well as a regime-informing variable. -R and -I attached to the gap measures in the first column denote the regime-switching mechanism, that is, either a Markov-Switching probability-based weighting or a 0-1 indicator-based weighting based on the underlying slack measures. INF-0, INF-6, and INF-12 in the second column indicate the lag displacement of the inflation expectation variable. See text for further details.

Table 12: Percentages of countries for which Phillips curve coefficient on real activity measure under recession regime is less than under expansion regime

	HP-R	**HP-I**	**EC-R**	**EC-I**	**IMF-R**	**IMF-I**
Coefficients	74.4%	75.6%	69.2%	62.8%	74.4%	73.1%
Coef. Normalized	69.2%	66.7%	67.9%	66.7%	82.1%	76.9%

Note: The table reports the percentage of cases (countries) in which the recession regime-conditional coefficient on the real activity measure is less than under the expansion regime-conditional estimate. The percentages cover all EU countries as well as the three model specifications for each country with respect to the lag setting of the inflation expectation variable. See text for further details.

Table 13: Cross-country ranking reflecting degree of convexity in the country-level Phillips curves

	Av.	Rank*	HP-R lag-0	HP-R lag-6	HP-R lag-12	HP-I lag-0	HP-I lag-6	HP-I lag-12	EC-R lag-0	EC-R lag-6	EC-R lag-12	EC-I lag-0	EC-I lag-6	EC-I lag-12	IMF-R lag-0	IMF-R lag-6	IMF-R lag-12	IMF-I lag-0	IMF-I lag-6	IMF-I lag-12
AT	14.2	**16**	3	16	12	5	15	12	5	22	21	3	24	21	5	23	18	5	23	22
BE	19.2	**25**	17	19	19	7	17	14	19	23	22	23	25	23	15	19	16	20	24	23
CY	14.8	**18**	13	12	22	22	24	25	9	17	18	10	20	20	17	11	23	1	1	1
DE	7.5	**1**	5	9	5	3	2	3	17	19	15	1	2	2	14	21	7	3	3	4
EE	13.8	**14**	18	18	9	11	10	4	23	26	24	18	17	9	13	16	10	11	6	6
ES	13.1	**12**	9	8	8	14	9	10	11	12	19	13	5	10	25	12	8	23	20	19
FI	9.9	**3**	1	2	1	1	6	9	8	9	8	5	6	8	11	24	24	16	22	17
FR	14.6	**17**	15	6	14	10	4	6	20	14	12	22	15	14	20	17	21	21	13	18
GR	20.9	**26**	7	15	16	6	14	17	26	24	25	26	26	25	26	25	25	24	25	24
IE	18.6	**24**	25	25	25	26	26	26	24	13	16	16	21	22	10	13	14	9	12	12
IT	14.9	**20**	2	1	3	16	20	22	21	21	14	25	22	7	19	22	17	12	9	15
LT	10.1	**4**	11	24	6	17	22	5	12	18	6	8	9	5	7	7	4	8	8	5
LV	14.0	**15**	23	26	10	15	7	2	22	25	7	20	19	6	21	26	11	6	4	2
MT	10.4	**6**	4	14	21	4	8	16	15	8	3	21	7	4	1	1	1	25	21	13
NL	17.0	**22**	16	10	17	12	16	18	14	11	13	15	11	13	23	20	20	26	26	25
PL	12.7	**11**	20	20	24	20	23	24	6	7	4	6	4	3	4	8	6	14	19	16
PT	14.9	**20**	26	23	23	24	21	20	16	16	11	17	18	15	8	9	9	4	5	3
SI	7.8	**2**	8	11	15	9	13	11	1	2	2	7	13	16	2	2	2	7	11	9
SK	18.1	**23**	12	13	20	19	19	21	25	20	23	24	23	24	22	5	13	22	14	7
BG	12.1	**9**	14	22	26	23	25	23	10	3	1	4	1	1	24	4	3	19	7	8
CZ	10.4	**7**	19	5	4	18	5	8	18	6	5	19	8	12	12	6	5	18	10	10
GB	12.3	**10**	24	21	13	13	11	13	4	5	10	11	14	17	6	10	12	10	16	11
HR	10.3	**5**	22	3	2	25	3	7	3	1	26	2	3	26	3	3	26	2	2	26
HU	13.3	**13**	10	7	7	21	18	19	7	10	17	9	10	11	9	14	19	13	18	20
RO	14.8	**19**	6	4	18	8	12	15	13	15	20	12	16	19	16	18	22	15	17	21
SE	11.4	**8**	21	17	11	2	1	1	2	4	9	14	12	18	18	15	15	17	15	14

Note: The table reports the ranks based on the difference between the normalised coefficient estimates under the two regimes, as presented in Tables 5- 10. A lower rank (toward 1) means that the difference is more negative, i.e. the degree of convexity in the Phillips curve more pronounced. The column Av. shows the average of the ranks over the 18 columns. The Rank* reflects an overall ranking in descending order based on the average of the rank in the Av. column. See text for further details.

Table 14: P-values from LL ratio test of regime-switching vs. linear Phillips curve specification across countries and real activity measures

	Count< .1		HP-R			HP-I			EC-R			EC-I			IMF-R			IMF-I		
			lag-0	lag-6	lag-12	lag-0	lag-6	lag-12	lag-0	lag-6	lag-12	lag-0	lag-6	lag-12	lag-0	lag-6	lag-12	lag-0	lag-6	lag-12
AT	4	22%	0.52	0.73	0.69	0.41	0.22	0.30	0.04	0.93	1.00	0.03	0.96	0.97	0.04	0.84	0.97	0.03	0.99	0.62
BE	1	6%	0.50	0.49	0.20	0.66	0.63	0.48	0.09	0.59	0.55	0.12	0.61	0.52	0.64	0.81	0.91	0.57	0.84	0.90
CY	8	44%	0.15	0.04	0.20	0.07	0.20	0.71	0.08	0.25	0.17	0.09	0.28	0.25	0.46	0.02	0.15	0.04	0	0
DE	17	94%	0.03	0.02	0.01	0.03	0.11	0.05	0	0.01	0.01	0	0.03	0.03	0.01	0.06	0.01	0.01	0.04	0.02
EE	14	78%	0	0	0	0.03	0.02	0	0	0	0	0.26	0.09	0	0.07	0.16	0.05	0.19	0.35	0.07
ES	9	50%	0.60	0.13	0.20	0.80	0.11	0.19	0.01	0	0	0.17	0.04	0.03	0.02	0.26	0.05	0.01	0.20	0.05
FI	4	22%	0.01	0	0	0.07	0.46	0.30	0.10	0.55	0.25	0.16	0.39	0.19	0.54	0.71	0.49	0.65	0.76	0.62
FR	7	39%	0	0	0	0.50	0.11	0.05	0.01	0.34	0.21	0.01	0.31	0.21	0.02	0.30	0.45	0.12	0.56	0.65
GR	12	67%	0.45	0.26	0.83	0.66	0.57	0.87	0.01	0	0	0	0.01	0	0	0	0	0.01	0	0
IE	15	83%	0	0.03	0.14	0	0.09	0.14	0.09	0.01	0	0.92	0.05	0	0.09	0.08	0.05	0.03	0	0
IT	5	28%	0.44	0.33	0.75	0.44	0.20	0.48	0.13	0.06	0.45	0.28	0.20	0.30	0.04	0.07	0.31	0	0.01	0.18
LT	13	72%	0.33	0.01	0	0.55	0.37	0.01	0	0	0	0.02	0	0	0.11	0.07	0	0.12	0.05	0
LV	15	83%	0.11	0	0	0	0	0	0	0	0	0.12	0	0	0	0	0	0.10	0	0
MT	1	6%	0.84	0.84	0.90	0.93	0.65	0.96	0.33	0.34	0.20	0.05	0.15	0.11	1.00	1.00	1.00	0.21	0.50	0.25
NL	3	17%	0.91	0.20	0.54	0.91	0.16	0.31	0.06	0.27	0.28	0.07	0.25	0.23	0.07	0.73	0.94	0.28	0.16	0.17
PL	9	50%	0.31	0.87	0.28	0.36	0.56	0.15	0.02	0	0	0.01	0	0	0.02	0.32	0.25	0.06	0.25	0.09
PT	6	33%	0.09	0.24	0.1	0.05	0.1	0.02	0.62	1.00	0.86	0.73	0.98	0.82	0.22	0.65	0.64	0.09	0.48	0.32
SI	8	44%	0.36	0.88	0.33	0.48	0.86	0.32	0	0	0	0	0.96	0.90	0	0	0	0.49	0.27	0.09
SK	7	39%	0.27	0.02	0.08	0	0.17	0.26	0.08	0.69	0.43	0.12	0.69	0.11	0.15	0.07	0.42	0.08	0.04	0.12
BG	12	67%	0.57	0.02	0	0.27	0.08	0.13	0.23	0	0	0.02	0	0	0.18	0	0	0.41	0.01	0
CZ	12	67%	0.04	0.18	0.07	0.04	0.14	0.07	0	0.14	0.02	0.59	0.47	0.42	0	0.01	0	0	0.06	0.01
GB	16	89%	0.02	0	0	0.04	0.13	0.1	0	0.1	0.04	0.02	0.07	0.06	0	0.18	0.02	0	0	0
HR	12	67%	0	0.79	0	0.02	0.74	0.02	0	0.18	0	0	0.20	0	0	0.19	0	0	0.15	0
HU	11	61%	0.36	0.05	0.03	0.51	0.09	0.05	0.29	0.14	0.03	0.26	0.03	0.09	0.76	0.02	0.01	0.88	0.05	0.01
RO	5	28%	0.02	0.09	0.15	0.01	0.18	0.14	0.04	0.41	0.31	0.09	0.21	0.12	0.78	0.89	0.91	0.52	0.64	0.49
SE	9	50%	0.1	0.02	0.01	0.71	0.13	0.16	0	0.08	0.06	0	0.01	0.01	0.16	0.63	0.63	0.15	0.81	0.73

Note: The table reports the p-values of a likelihood (LL) ratio test based on the regime-switching vs. the linear Phillips curve specifications across countries and real activity measures. The count in the columns on the left side of the table reflects how many of the p-values in each row are less than 10%. The percentage expresses this count as a ratio to 18 (the number of columns). See text for further details.

Table 15: RS-VAR Model A — Sign-restricted impulse responses to expansionary monetary policy shock — Differences between Regime 1 (expansion) and Regime 2 (recession) responses

			Responses: Regime2 - Regime1					*p*-values: Regime1<>Regime2				
			PiT			Cumulative		PiT			Cumulative	
			H=1	H=12	H=18	H=12	H=18	H=1	H=12	H=18	H=12	H=18
INF	GDP	R	-0.84	-0.01	0	-1.3	-1.35	0	0	0	0	0
		I	0.33	-0.03	0.00	-0.16	-0.18	0.17	0	0	0.30	0.30
	HP	R	-0.64	-0.01	0.00	-1.14	-1.2	0	0	0	0.01	0.01
		I	-1.01	-0.01	0.00	-1.71	-1.82	0.01	0	0	0	0
	EC	R	0.17	0	0.01	-0.36	-0.27	0.14	0	0	0.26	0.15
		I	0.10	-0.02	0.04	-0.72	-0.58	0.24	0.02	0	0.01	0.01
	IMF	R	0.13	-0.02	0.05	-0.86	-0.7	0.04	0	0	0.01	0.01
		I	0.14	-0.03	0.05	-0.99	-0.85	0.13	0	0	0.15	0.18
	JL4	R	0.22	0.00	0.01	-0.16	-0.1	0.62	0.02	0.04	0.09	0.15
		I	0.35	0.01	0.00	0.10	0.12	0.03	0.01	0	0.11	0.15
	JL6	R	0	0.01	0.01	-0.21	-0.17	0	0	0	0.02	0.02
		I	-1.38	-0.05	0.01	-1.52	-1.6	0	0	0	0	0
RGDP	GDP	R	-0.71	-0.03	0.02	-1.11	-0.99	0	0	0	0	0
		I	0.56	0.03	0.05	-0.13	0.21	0.12	0	0	0.34	0.94
	HP	R	-0.63	-0.02	0.03	-0.92	-0.79	0.01	0	0	0.01	0.01
		I	-1.15	-0.09	0.04	-1.99	-1.83	0	0	0	0.01	0.01
	EC	R	0.06	0.07	0.04	-0.05	0.30	0.58	0	0	0.33	0.77
		I	0.11	0.07	0.07	-0.3	0.19	0.01	0.01	0	0.06	0.02
	IMF	R	-0.31	0.04	0.06	-0.87	-0.48	0	0.01	0	0	0.01
		I	-0.31	0.04	0.06	-0.89	-0.48	0.02	0	0	0.03	0.05
	JL4	R	-0.03	0.05	0.03	-0.25	0.02	0	0.02	0.03	0.01	0.01
		I	-0.19	0.02	0.02	-0.36	-0.22	0.02	0	0	0.03	0.04
	JL6	R	-0.59	-0.01	0.02	-1.25	-1.15	0.01	0	0	0.01	0.01
		I	-1.9	-0.14	0.00	-2.27	-2.16	0	0	0	0	0
NGDP	GDP	R	-1.51	-0.04	0.02	-2.37	-2.3	0	0	0	0	0
		I	0.83	0	0.06	-0.37	-0.07	0.25	0.36	0	0.36	0.45
	HP	R	-1.18	-0.03	0.03	-1.98	-1.91	0.01	0	0	0.01	0.01
		I	-2.19	-0.1	0.03	-3.8	-3.75	0	0	0	0	0
	EC	R	0.31	0.07	0.06	-0.32	0.12	0.75	0	0	0.40	0.71
		I	0.28	0.06	0.11	-0.92	-0.28	0.01	0.01	0	0.04	0.06
	IMF	R	-0.12	0.03	0.11	-1.6	-1.04	0	0	0	0	0
		I	-0.14	0.01	0.12	-1.8	-1.26	0.12	0	0	0.03	0.04
	JL4	R	0.28	0.05	0.05	-0.33	0.01	0.04	0.01	0	0.08	0.18
		I	0.28	0.02	0.03	-0.15	0.02	0.05	0	0	0.03	0.07
	JL6	R	-0.56	0.00	0.03	-1.45	-1.3	0.01	0	0	0.01	0.01
		I	-3.32	-0.2	0.00	-3.89	-3.87	0	0	0	0	0

Note: The table reports the differences between the Regime 2 (recession) and Regime 1 (expansion) responses at three points along the simulation horizon, either point-in-time (PiT) or reflecting cumulative responses. The first column indicates the model variable whose response is reported in the table. The second and third column indicate the real activity/gap measure (either using the -R or the I-approach) that was used to define the regimes of the VAR. The *p*-values reflect the extent to which the PiT and cumulative responses under the two regimes were different. As a visual support, response differences that are negative as well as *p*-values below 10% are marked in gray.

Table 16: RS-VAR Model B — Sign-restricted impulse responses to expansionary monetary policy shock — Differences between Regime 1 (expansion) and Regime 2 (recession) responses

			Responses: Regime2 - Regime1					*p*-values: Regime1<>Regime2				
				PiT		Cumulative			PiT		Cumulative	
			H=1	H=12	H=18	H=12	H=18	H=1	H=12	H=18	H=12	H=18
INF	GDP	R	-0.11	0.01	0.01	-0.11	-0.05	0.09	0.23	0.14	0.14	0.16
		I	-0.03	-0.03	-0.01	-0.44	-0.54	0.28	0	0	0	0
	HP	R	-0.06	0.00	0.00	-0.15	-0.13	0.01	0.39	0.66	0.04	0.06
	EC	R	0.09	-0.01	0.02	-0.55	-0.5	0.02	0.06	0.13	0.19	0.14
		I	0.05	-0.03	0.01	-0.49	-0.52	0.02	0.33	0.16	0.44	0.37
	IMF	R	0.05	-0.06	-0.03	-0.63	-0.89	0	0.02	0.07	0.02	0.02
	JL4	R	0.15	-0.01	0.02	-0.45	-0.4	0.20	0.32	0.03	0.42	0.44
		I	0.11	-0.01	0.01	-0.4	-0.37	0.03	0.01	0.01	0.05	0.05
	JL6	R	0.19	-0.01	0.01	-0.37	-0.34	0.02	0	0	0	0
		I	-0.81	0.08	0.05	-0.61	-0.28	0.01	0.01	0	0.01	0.02
RGDP	GDP	R	-0.28	-0.01	-0.02	-0.75	-0.83	0.01	0.16	0.11	0.1	0.11
		I	0.08	-0.03	0.02	-0.67	-0.65	0.31	0	0	0	0
	HP	R	-0.24	-0.04	-0.03	-1.21	-1.39	0.04	0.12	0.09	0.13	0.12
	EC	R	-0.11	0.07	0.07	0.40	0.84	0.01	0.01	0.05	0.06	0.03
		I	-0.04	0.00	0.05	-0.2	-0.02	0.06	0.03	0.35	0.19	0.08
	IMF	R	-0.06	-0.03	0.02	-0.45	-0.47	0	0	0.07	0	0
	JL4	R	-0.16	0.07	0.06	0.22	0.63	0.04	0.30	0.01	0.75	0.64
		I	-0.25	0.04	0.03	-0.16	0.07	0.01	0.03	0.03	0.06	0.12
	JL6	R	-0.29	0.05	0.05	-0.21	0.10	0	0.03	0	0	0.01
		I	-0.29	-0.01	-0.03	-2.05	-2.21	0.01	0	0	0	0
NGDP	GDP	R	-0.41	0.00	-0.01	-0.85	-0.87	0.02	0.52	0.21	0.1	0.12
		I	0.02	-0.06	0.01	-1.14	-1.23	0.65	0	0.01	0	0
	HP	R	-0.31	-0.03	-0.02	-1.35	-1.51	0.02	0.15	0.12	0.1	0.11
	EC	R	0.00	0.06	0.09	-0.11	0.38	0.06	0.02	0.03	0.07	0.08
		I	0.02	-0.02	0.06	-0.67	-0.52	0.07	0.05	0.27	0.22	0.15
	IMF	R	0	-0.08	-0.02	-1.05	-1.33	0	0	0.02	0	0
	JL4	R	-0.02	0.05	0.09	-0.23	0.23	0	0	0	0	0
		I	-0.16	0.03	0.05	-0.57	-0.31	0	0	0	0	0
	JL6	R	-0.12	0.05	0.06	-0.59	-0.26	0	0.02	0	0	0
		I	-1.12	0.06	0.01	-2.68	-2.55	0	0.03	0	0	0.01
NBV	GDP	R	-0.31	-0.03	-0.01	-0.7	-0.81	0.09	0.06	0.22	0.14	0.14
		I	-0.17	-0.05	0.08	-1.92	-1.71	0.24	0.01	0	0	0
	HP	R	-0.4	-0.01	0.00	-0.58	-0.6	0.08	0.46	1.00	0.30	0.37
	EC	R	0.07	-0.03	0.16	-2.5	-1.92	0.22	0.32	0.34	0.27	0.29
		I	-0.03	-0.11	0.17	-3.12	-2.76	0.09	0.08	0.86	0.42	0.37
	IMF	R	-0.1	-0.35	-0.11	-4.41	-5.72	0	0.01	0	0	0
	JL4	R	0.24	-0.02	0.13	-2.03	-1.54	0.24	0.19	0.45	0.27	0.28
		I	0.25	-0.02	0.03	-1.53	-1.46	0.09	0.01	0.02	0.03	0.03
	JL6	R	0.73	0.08	0.07	0.80	1.27	0.21	0.16	0.26	0.32	0.27
		I	-3.64	0.34	0.20	-1.04	0.37	0	0.01	0.02	0.02	0.04
NBI	GDP	R	-0.01	0.15	0.12	1.28	2.07	0.17	0.12	0.12	0.36	0.29
		I	0.05	-0.16	-0.16	-0.59	-1.62	0.47	0	0	0	0
	HP	R	0.04	0.12	0.10	1.20	1.84	0.35	0.11	0.14	0.61	0.54
	EC	R	-0.28	-0.24	-0.12	-3.27	-4.31	0.02	0.15	0.21	0.02	0.04
		I	-0.13	-0.18	-0.15	-1.71	-2.72	0.01	0.45	0.42	0.02	0.08
	IMF	R	-0.12	-0.24	-0.32	-1.73	-3.47	0	0.03	0.05	0	0
	JL4	R	-0.26	-0.22	-0.1	-3	-3.92	0.26	0.13	0.02	0.38	0.41
		I	-0.21	-0.12	-0.04	-2	-2.43	0.01	0.01	0.01	0.13	0.13
	JL6	R	-0.23	-0.15	-0.08	-2.3	-2.96	0	0	0.01	0.01	0.02
		I	0.17	0.64	0.49	7.26	10.56	0.12	0.10	0.13	0.17	0.20

Note: The table reports the differences between the Regime 2 (recession) and Regime 1 (expansion) responses at three points along the simulation horizon, either point-in-time (PiT) or reflecting cumulative responses. The first column indicates the model variable whose response is reported in the table. The second and third column indicate the real activity/gap measure (either using the -R or the I-approach) that was used to define the regimes of the VAR. The *p*-values reflect the extent to which the PiT and cumulative responses under the two regimes were different. As a visual support, response differences that are negative as well as *p*-values below 10% are marked in gray.

Table 17: RS-VAR Model B — Sign-restricted impulse responses to positive credit supply shock — Differences between Regime 1 (expansion) and Regime 2 (recession) responses

			Responses: Regime2 - Regime1					p-values: Regime1<>Regime2				
			PiT			Cumulative		PiT			Cumulative	
			H=1	H=12	H=18	H=12	H=18	H=1	H=12	H=18	H=12	H=18
INF	GDP	R	-0.15	0.01	0.01	-0.13	-0.07	0	0.05	0.03	0	0
		I	0.07	-0.03	-0.01	-0.4	-0.5	0.22	0.01	0.01	0.03	0.05
	HP	R	-0.02	0	0	-0.11	-0.11	0	0	0	0	0
	EC	R	-0.07	-0.01	0.03	-0.71	-0.61	0.02	0.12	0.24	0.13	0.18
		I	-0.06	-0.04	0.02	-0.9	-0.94	0	0.09	0.17	0	0
	IMF	R	-0.08	-0.09	-0.05	-1.15	-1.55	0.08	0.02	0.01	0.06	0.09
	JL4	R	-0.04	-0.01	0.03	-0.67	-0.58	0.29	0.41	0.44	0.38	0.40
		I	-0.04	0	0.02	-0.59	-0.52	0.44	0.31	0.38	0.26	0.36
	JL6	R	0.06	0	0.01	-0.45	-0.42	0.55	0.23	0.29	0.21	0.28
		I	-0.82	0.08	0.05	-0.95	-0.63	0.01	0	0	0.01	0.01
RGDP	GDP	R	-0.24	-0.01	-0.01	-0.61	-0.65	0.04	0.02	0.01	0.05	0.04
		I	-0.17	0.00	0.07	-0.82	-0.56	0.12	0.01	0.02	0.04	0.04
	HP	R	-0.19	-0.02	0	-0.92	-0.97	0.03	0.01	0	0.04	0.04
	EC	R	-0.17	0.04	0.06	-0.32	0.02	0	0	0	0.02	0.04
		I	-0.07	-0.01	0.07	-0.7	-0.44	0	0.06	0	0	0
	IMF	R	-0.07	-0.05	0.03	-0.95	-0.99	0.25	0	0.37	0.09	0.09
	JL4	R	-0.19	0.03	0.05	-0.45	-0.15	0.04	0	0	0.43	0.43
		I	-0.28	0.02	0.02	-0.68	-0.55	0.36	0	0	0.16	0.16
	JL6	R	-0.3	0.02	0.03	-0.75	-0.56	0.30	0.26	0	0.44	0.47
		I	-0.1	-0.01	-0.03	-2.1	-2.26	0.01	0	0	0.01	0.01
NGDP	GDP	R	-0.4	0.01	0.00	-0.73	-0.7	0	0.07	0.04	0.09	0.1
		I	-0.12	-0.03	0.06	-1.24	-1.09	0.17	0.01	0.02	0.04	0.03
	HP	R	-0.21	-0.02	0	-1.02	-1.06	0	0.09	0	0.05	0.05
	EC	R	-0.24	0.03	0.09	-1.04	-0.6	0.08	0.07	0	0.04	0.03
		I	-0.11	-0.05	0.09	-1.59	-1.37	0	0	0.07	0.01	0.02
	IMF	R	-0.14	-0.14	-0.02	-2.08	-2.52	0.01	0	0.23	0.17	0.14
	JL4	R	-0.23	0.02	0.08	-1.14	-0.75	0	0	0	0	0
		I	-0.33	0.01	0.04	-1.3	-1.1	0	0	0	0	0
	JL6	R	-0.25	0.02	0.04	-1.22	-1	0.31	0.68	0.01	0.27	0.31
		I	-0.92	0.06	0.01	-3.08	-2.93	0	0	0	0	0
NBV	GDP	R	-0.64	-0.09	-0.03	-2.41	-2.71	0.05	0.01	0	0.05	0.05
		I	-0.01	-0.06	0.12	-2.63	-2.33	0.06	0.04	0.02	0.02	0.02
	HP	R	-0.15	-0.08	-0.04	-1.17	-1.51	0.02	0.01	0	0.05	0.06
	EC	R	-1.1	-0.08	0.19	-6.19	-5.58	0.02	0.15	0.02	0.11	0.12
		I	-0.8	-0.19	0.30	-6.67	-5.98	0	0.15	0.12	0	0
	IMF	R	-0.71	-0.58	-0.15	-8.66	-10.71	0.05	0.1	0.02	0.31	0.33
	JL4	R	-1.03	-0.08	0.16	-5.86	-5.36	0.19	0.05	0.04	0.29	0.30
		I	-0.95	-0.08	0.03	-5.03	-5.07	0.23	0.08	0.05	0.21	0.23
	JL6	R	-0.43	0.03	0.05	-2.07	-1.78	0.17	0.73	0.35	0.16	0.22
		I	-3.82	0.38	0.24	-1.21	0.40	0	0.02	0.02	0.01	0.14
STN	GDP	R	-0.01	0.25	0.19	2.22	3.53	0.01	0.01	0	0.12	0.11
		I	0.37	-0.24	-0.25	0.48	-1.1	0.08	0.01	0.05	0.04	0.04
	HP	R	-0.07	0.09	0.04	0.69	1.04	0.01	0	0	0.09	0.08
	EC	R	0.24	-0.11	0	-0.14	-0.47	0.27	0.09	0.07	0.08	0.08
		I	0.20	-0.31	-0.26	-1.1	-2.9	0	0.02	0.02	0.01	0.02
	IMF	R	0.21	-0.41	-0.63	-1.12	-4.46	0.95	0.46	0.85	0.26	0.67
	JL4	R	0.23	-0.09	-0.01	0.02	-0.26	0.36	0.77	0.92	0.44	0.29
		I	0.21	0.07	0.09	1.18	1.67	0.50	0.33	0.25	0.45	0.33
	JL6	R	0.16	0.04	0.04	1.02	1.26	0.91	0.27	0.45	0.25	0.25
		I	-0.35	0.91	0.68	9.05	13.66	0.05	0.02	0.02	0.04	0.03

Note: The table reports the differences between the Regime 2 (recession) and Regime 1 (expansion) responses at three points along the simulation horizon, either point-in-time (PiT) or reflecting cumulative responses. The first column indicates the model variable whose response is reported in the table. The second and third column indicate the real activity/gap measure (either using the -R or the I-approach) that was used to define the regimes of the VAR. The p-values reflect the extent to which the PiT and cumulative responses under the two regimes were different. As a visual support, response differences that are negative as well as p-values below 10% are marked in gray.

Table 18: RS-VAR Model C — Sign-restricted impulse responses to negative effective euro exchange rate shock — Differences between Regime 1 (expansion) and Regime 2 (recession) responses

			Responses: Regime2 - Regime1					p-values: Regime1<>Regime2				
				PiT		Cumulative			PiT		Cumulative	
			H=1	H=12	H=18	H=12	H=18	H=1	H=12	H=18	H=12	H=18
CINF	GDP	R	0	0.00	0.00	0	0	0.18	0.36	0	0.23	0.24
		I	-0.04	0.00	0.00	-0.02	-0.02	0.05	0.58	0	0.06	0.07
	HP	R	-0.02	-0.01	0	-0.15	-0.17	0.03	0	0	0.02	0.03
		I	0	0	0	-0.11	-0.12	0.18	0.04	0.05	0.18	0.21
	EC	R	-0.12	0.00	0.00	-0.09	-0.08	0.01	0	0	0.02	0.02
		I	-0.13	0.01	0.00	-0.09	-0.07	0.05	0.04	0.02	0.11	0.14
	IMF	R	-0.05	0.00	0.00	-0.03	-0.02	0.05	0	0.01	0.22	0.24
		I	-0.05	0.00	0.00	-0.02	-0.01	0.04	0.59	0.64	0.01	0.01
	JL4	R	-0.12	0.00	0.00	-0.09	-0.08	0.16	0.1	0.04	0.34	0.36
		I	-0.1	0.00	0.00	-0.08	-0.08	0.16	0.17	0.65	0.17	0.17
	JL6	R	-0.1	0.00	0.00	-0.1	-0.1	0.03	0.32	0.42	0.08	0.09
		I	0.01	0.00	0.00	0.01	0.02	0.15	0.13	0.18	0.33	0.31
WAG	GDP	R	0.08	-0.01	0	0.11	0.09	0.48	0.23	0.10	0.99	0.97
		I	0.05	-0.03	-0.01	-0.41	-0.51	0.34	0.08	0.08	0.16	0.14
	HP	R	0.08	0.01	0.00	0.25	0.27	0.11	0.11	0.15	0.12	0.16
		I	0.11	0.01	0.01	0.35	0.40	0.17	0.51	0.46	0.56	0.59
	EC	R	-0.18	-0.01	-0.01	-0.45	-0.51	0.01	0.02	0.02	0.03	0.05
		I	-0.03	-0.02	-0.01	-0.33	-0.43	0.09	0.05	0.04	0.12	0.11
	IMF	R	0.00	-0.01	-0.01	-0.12	-0.18	0.16	0.02	0.01	0.07	0.06
		I	0.01	-0.02	-0.01	-0.11	-0.18	0.08	0.01	0.01	0.12	0.20
	JL4	R	-0.2	-0.01	-0.01	-0.44	-0.49	0.10	0.10	0.04	0.28	0.27
		I	-0.21	-0.01	0	-0.33	-0.36	0.04	0.07	0.03	0.06	0.07
	JL6	R	-0.16	0	0	-0.28	-0.31	0.02	0.24	0.26	0.04	0.04
		I	-0.06	-0.01	0	-0.09	-0.11	0.08	0	0	0.03	0.04
MTD	GDP	R	0.20	-0.01	-0.01	0.31	0.25	0.49	0.28	0.13	0.94	0.99
		I	0.36	-0.03	-0.02	0.06	-0.08	0.48	0.11	0.09	0.33	0.14
	HP	R	-0.01	0.04	0.02	0.39	0.54	0.03	0.23	0.12	0.24	0.30
		I	0.01	0.07	0.03	1.00	1.28	0.46	0.17	0.18	0.58	0.54
	EC	R	0.02	-0.06	-0.03	-0.73	-0.97	0.06	0.01	0	0.15	0.1
		I	0.17	-0.06	-0.04	-0.23	-0.54	0.53	0.03	0.01	0.28	0.28
	IMF	R	0.18	-0.05	-0.03	-0.21	-0.46	0.31	0.02	0.04	0.07	0.06
		I	0.22	-0.06	-0.04	-0.2	-0.51	0.05	0.21	0.25	0.05	0.06
	JL4	R	0.05	-0.05	-0.03	-0.48	-0.71	0.44	0.07	0.03	0.34	0.31
		I	0.04	-0.02	-0.01	-0.04	-0.15	0.23	0.14	0.20	0.13	0.13
	JL6	R	0	0.00	0	0.28	0.26	0.05	0.63	0.25	0.34	0.48
		I	-0.07	0.01	0.00	0.04	0.08	0.02	0	0	0.05	0.05
XTD	GDP	R	0	0	0	0.16	0.14	0.20	0.35	0.16	0.57	0.76
		I	0.28	-0.01	-0.01	0.50	0.45	0.44	0.19	0.16	0.34	0.34
	HP	R	-0.08	0.02	0.01	0.07	0.15	0.03	0.43	0.02	0.11	0.15
		I	-0.06	0.04	0.02	0.38	0.51	0.17	0.16	0.14	0.41	0.45
	EC	R	-0.05	-0.02	-0.01	-0.29	-0.4	0.02	0.01	0.01	0.07	0.12
		I	0.08	-0.03	-0.02	0.06	-0.08	0.47	0.07	0.02	0.80	0.32
	IMF	R	0.01	-0.02	-0.02	-0.02	-0.14	0.20	0.02	0.03	0.07	0.12
		I	0.03	-0.03	-0.02	-0.01	-0.14	0	0.34	0.26	0.03	0.05
	JL4	R	-0.03	-0.02	-0.01	-0.17	-0.27	0.21	0.09	0.04	0.24	0.35
		I	-0.05	-0.01	-0.01	0.01	-0.04	0.09	0.07	0.38	0.13	0.05
	JL6	R	-0.05	0.01	0	0.20	0.21	0.04	0.99	0.20	0.25	0.35
		I	-0.08	0.01	0.00	0.20	0.23	0	0	0	0.04	0.04
ToT	GDP	R	-0.19	0.01	0.00	-0.14	-0.11	0.38	0.52	0.24	0.34	0.36
		I	-0.07	0.02	0.01	0.44	0.53	0.36	0.08	0.07	0.24	0.23
	HP	R	-0.06	-0.02	-0.01	-0.29	-0.36	0.15	0.05	0	0.20	0.35
		I	-0.05	-0.04	-0.02	-0.59	-0.73	0.20	0.11	0.11	0.17	0.16
	EC	R	-0.08	0.03	0.02	0.41	0.55	0.1	0.02	0.01	0.1	0.06
		I	-0.1	0.04	0.02	0.29	0.46	0.38	0.06	0.05	0.64	0.57
	IMF	R	-0.17	0.03	0.02	0.20	0.33	0.14	0.08	0.10	0.20	0.15
		I	-0.18	0.04	0.02	0.22	0.38	0	0.61	0.59	0.23	0.27
	JL4	R	-0.09	0.03	0.01	0.30	0.42	0.38	0.21	0.06	0.72	0.64
		I	-0.09	0.02	0.01	0.04	0.09	0.31	0.98	0.1	0.58	0.60
	JL6	R	-0.06	0.00	0.00	-0.1	-0.08	0.13	0.24	0.84	0.34	0.36
		I	-0.01	0	0	0.16	0.15	0	0	0	0.11	0.10
RGDP	GDP	R	0.15	-0.01	0	0.49	0.46	0.97	0.37	0.21	0.92	0.92
		I	0.14	-0.04	-0.02	-0.5	-0.64	0.75	0.04	0.03	0.09	0.08
	HP	R	0.07	0.04	0.02	0.95	1.11	0.40	0.17	0.1	0.98	0.98
		I	0.09	0.05	0.02	1.03	1.23	0.71	0.83	0.92	0.91	0.92
	EC	R	0.03	-0.03	-0.02	-0.32	-0.45	0.1	0.02	0.01	0.01	0.01
		I	0.08	-0.04	-0.02	-0.34	-0.53	0.40	0.06	0.04	0.17	0.15
	IMF	R	0.05	-0.03	-0.01	-0.03	-0.14	0.39	0.08	0	0.08	0.07
		I	0.06	-0.03	-0.02	-0.01	-0.13	0.30	0.02	0.03	0.13	0.12
	JL4	R	0.06	-0.03	-0.02	-0.21	-0.33	0.37	0.11	0.03	0.25	0.23
		I	0.12	-0.02	-0.01	0.16	0.10	0.41	0.15	0.18	0.51	0.57
	JL6	R	0.07	-0.01	0	0.29	0.26	0.08	0.36	0.22	0.25	0.24
		I	-0.04	-0.01	0	0.12	0.08	0.15	0.17	0.18	0.15	0.15

Note: The first column indicates the model variable whose response is reported in the table. The second and third column indicate the real activity/gap measure (either using the -R or the I-approach) that was used to define the regimes of the VAR. The p-values reflect the extent to which the PiT and cumulative responses under the two regimes were different. As a visual support, response differences that are negative as well as p-values below 10% are marked in gray.

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