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Abstract

This study investigates the asymmetric unemployment-output tradeoff in the Eurozone. Building upon the augmented Okun's law framework, the relationships between unemployment and output cannot be correctly specified in the static linear, static asymmetric and dynamic linear regressions. By contrast, the nonlinear autoregressive distributed lag (NARDL) model is well-specified and in this case indicates that the nature of Okun's law is asymmetric. For the Eurozone, the NARDL estimates demonstrate that labour markets quickly respond to cyclical outputs in a short period, while the adjustments towards new equilibrium become weak in the long run. Furthermore, the cross-sectional analysis of long run asymmetries indicates that government spending and trade balance are key factors affecting the asymmetric unemployment-output tradeoff. Thus, these results seem to suggest that, in spite of the fact that member states lack monetary sovereignty, flexible application of fiscal reforms or labour market reforms could help to reduce asymmetric effects.

JEL Codes: C22, E32, J64.

Keywords: unemployment-output tradeoff, nonlinear autoregressive distributed lag (NARDL), asymmetry determinants.

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1 Introduction

The Eurozone has documented discouraging economic performance since mid-1990s (Chamorel, 2006). Its annual growth rate of gross domestic product (GDP) averaged 1.55% during 1995-2014, which was comparatively lower than in the US (2.4%) and China (9.55%), as released by the World Bank. One of the main explanatory factors behind is the persistent hight unemployment. Unemployment rate in the region reached a peak of 12% in February 2013, while it had a historical low of 7.2% in March 2008. Compared with other major economies, unemployment rate is much higher in the euro area in 2013 than in the US (7.4%) and China (4.1%). This can be attributed to the lack of sufficient structural reforms in the labour market of this region, which indeed play a vital role in getting people into work. To construct a well-functioning labour market, labour supply-side policies and tax and benefit system reforms are widely proposed in the existing literature (Fernández-Villaverde et al., 2011; Anderson et al., 2014), including the tax and benefit system reforms. In practice, the European Commission and the Economic Policy Committee (EPC) have jointly launched a LABour market REForm (LABREF) database project, which allows cross-country analysis on the labour market measures, assists in the reform assessment, and enhances recommendations to member states.[1] This database becomes a valuable tool in designing policies that aim to reduce unemployment and boost growth. The Eurozone economies have implemented labour market reforms in order to minimise the output gaps between member states, though, the performances of these countries are still having a great discrepant.[2] These discrepancies might be due to the fact that there exists a huge disparity inside the Eurozone, with member states show big differences among themselves. However, structural reforms may also produce results different from expected since there might exist asymmetries in the unemployment-output relationship. The disparities in growth and labour markets might

[1]LABREF, see the databases and indicators in the economic and financial affairs of the European Commission.
[2]See the historical statistics of the Eurozone economies via the Eurostat: eceuropa.eu/eurostat.

suggest that structural reforms should be carried out in light of the nature of the unemployment-output relationship, since the long run and short run unemployment-output tradeoff could be asymmetric (Silvapulle et al., 2004; Belaire-Franch and Peiró, 2014). The existence of these asymmetries could explain why structural reforms that are effective in the short run might cause opposite or zero effects in the long run, and similarly, structural reforms which are expected having positive effects in the long run might cause negative or null effect in the short run. Consequently, identifying the correct inherent characteristics of the unemployment-output tradeoff along the whole time horizon is crucial to determine the optimal structural reforms.

The correlation between unemployment and output has been explored intensively in literature. The remarkable theory is the Okun's law, which essentially proposes a negative relationship between the unemployment and real output (Okun, 1962). It relates the level of activities in the labour market to the level of activities in the goods market over the economic cycle. The Okun's law has been widely used as a rule of thumb to estimate the potential output and ascertain the loss of output caused by the unemployment changes. A vast number of studies investigate the unemployment-output relationship in a linear framework and assume that the cyclical output has symmetrical effects on unemployment (Hamada and Kurosaka, 1984; Attfield and Silverstone, 1998; Christopoulos, 2004; Gabrisch and Buscher, 2006). However, when the fitness and stability of the Okun's law have been revisited and discussed by Sögner and Stiassny (2002); Perman and Tavera (2005), there is little evidence showing that the labour market should react to the business cycle in the symmetric pattern. In response to this issue, researchers are increasingly shifting their interests into the nonlinear modeling of the unemployment-output tradeoff (Lee, 2000; Harris and Silverstone, 2000; Altissimo and Violante, 2001; Vougas, 2003; Marinkov and Geldenhuys, 2007).

Precisely, asymmetric unemployment-output relation refers to the changes in output might cause asymmetric changes in unemployment in the long run and short run, which could be positive or negative (ie, above or below the equilibrium relationship) (Harris and Silverstone, 2001; Silvapulle et al., 2004). In the existing regional unemployment-output relationship studies, the asymmetric effects have been found in the US (Silvapulle et al., 2004), New Zealand (Harris and Silverstone, 2000), South Africa (Marinkov and Geldenhuys, 2007) and OECD countries (Lee, 2000; Harris and Silverstone, 2001). There are some research focusing on the European countries (Perman and Tavera, 2005; Jardin and Stephan, 2010), but they did not test the long run and short run asymmetric effects in a nonlinear framework.

The objective of this paper is analyzing the asymmetries of the unemployment-output tradeoff in the euro area and identifying the possible determinants of these asymmetric effects. The interest on this region lies in the fact that it is constituted as a currency union but not as a fiscal union, which might cause discrepancies across member states in growth and labour market reforms. Concerning the research method, the nonlinear autoregressive distributed lag (NARDL) model has been utilized. The recent developments on this method have proved that it is competent and effective to test both the long run and short run asymmetries, irrespective of the integration order of the variables (Shin et al., 2014).

This study contributes to the literature mainly in four aspects. First, this paper identifies the asymmetric effects in the unemployment-output tradeoff in the euro area, which helps to understand the responsiveness of the activities in the labour markets to the activities in the good markets. Undeniably, this might play a considerable role in designing labour market reforms, talking into consideration that the potential asymmetries between unemployment and output affect the effectiveness of labour market reforms. Second, considering the heterogeneity of the unemployment-output correlation in this region, this study models the asymmetries separately for each country. The existence of high heterogeneity across member states suggests that labour market reforms should be in accordance with the country-specific long run and short run asymmetries. Third, we calculate the dynamic multipliers to obtain a measure of the cumulative effects of asymmetric output shocks on labour markets and thus, to depict the adjustments of labour markets in the disequilibrium unemployment-output relationship towards new long run equilibrium. This allows us to observe the impacts of positive and negative output shocks separately. Fourth, the cross-sectional analysis of asymmetry determinants indicates that government expenditure and trade situation are the key factors affecting the long run asymmetries. Therefore, these results suggest that, although member states lack the monetary sovereignty, appropriate application of fiscal reforms could also help to reduce the asymmetric effects.

The remaining parts of this study are organised as follows. Section 2 presents the empirical literature on the asymmetric unemployment-output relationship. Section 3 describes the econometric methods. The brief discussions of dataset are given in section 4. Section 5 summaries the results of unemployment-output tradeoff based on the linear and nonlinear framework. Finally, last section concludes the paper.

2 Asymmetric Unemployment-Output Tradeoff: The Empirical Literature

The investigation of the unemployment-output tradeoff has important macroeconomic implications, in particular in determining the growth target. The empirical studies estimate the Okun's coefficient which reflects the responsiveness of the level of activities in the labour markets to the level of activities in the good markets. Thus, the coefficient can be also used to measure the cost of unemployment owing to the upswing or downswing of the output (Moosa, 1997). In practice, the stability of the Okun's coefficient has widely argued. This empirical finding establishes that the relationship between unemployment and output observed in the short run also remains in the long run. An earlier study on the relationship between output and employment suggests that the employment-output relationship is unstable, especially in the short run, which has become politically unpalatable since it makes the design of policies difficult (Wilson, 1960).[3] The investigation on this issue has been resumed after the postulated inverse unemployment-output relationship by Okun (1962). The robustness of the unemployment-output correlation has been evaluated by Lee (2000) using the postwar data for 16 OECD countries. The empirical findings provide evidence of asymmetric effects and structural breaks around 1970s, which support the instability of the relationship over time. Similar exercise has been done by Sögner and Stiassny (2002) based on the sample of 15 OECD economies. Using regime-switching approach, they failed to examine the asymmetries in the unemployment-output relationship. However, the Bayesian and Kalman filtering methods have identified the existence of structural instability caused by the labour demand or supply shocks. Since a common shock to the European union could cause different macroeconomic consequences across member states due to the heterogeneity of their macroeconomic indicators, Perman and Tavera (2005) explore evidence of the convergence of the Okun's coefficient in Europe. They find that European countries with centralised wage bargaining show the evidence of convergence of the Okun's coefficient both in the short and medium run.

One possible explanation of the unstable unemployment-output relationship could be the existence of asymmetric shocks, which shapes this relationship. In response to this issue, the academic attention is shifting into the asymmetric modelling of the unemployment-output trade-off. Using the asymmetric dynamic model, Silvapulle et al. (2004) present that the asymmetric unemployment-output correlation exists using the US postwar economy. The responsiveness of unemployment to cyclical output is proved to be strong when there is a shock from the negative output gap, in particular in the short run. The dynamic correlation of the US output-employment has also been explored by Altissimo and Violante (2001) in a nonlinear VAR model. The linear specification has been rejected in their study, but the regime dependent model demon-

[3]Due to lack of attention on this issue, it had not been widely developed, but the Okun's law was well received after two years.

strates that the asymmetries in the shocks were generated from recessions, which could be a possible interpretation for the divergence of the Okun's coefficient in the existing literature. In this vein, the study of Huang and Lin (2006) supports the nonlinear unemployment-output relationship by implementing the nonlinear inference approach in the US sample. In an asymmetric approach, Harris and Silverstone (2001) suggest that the short run adjustment of labour markets to the disequilibrium during the downturn of the economic cycle in the OECD countries (except Canada), while the existence of long run relationship between unemployment and output has been rejected in the US and New Zealand. Furthermore, there are some country-specific studies on the asymmetric unemployment-output correlation. In this regard, Harris and Silverstone (2000) conclude that the long run and short run correlation between unemployment and output are asymmetric in New Zealand. The asymmetric effects between cyclical output and cyclical unemployment in South Africa also have been identified (Marinkov and Geldenhuys, 2007).

The asymmetric unemployment-output tradeoff in Europe was empirically argued for the first time in the study of Jardin and Stephan (2010). They find that the unemployment reacts to output strongly when the economy is in a downswing, but the response tends to be weakened when the output reaches the bottom. Zanin and Marra (2012) adopt a penalized regression spline approach to model the time-varying effects in the unemployment-output correlation. They suggest that the inverse correlation in some Eurozone economies is spatially heterogeneous and time-varying, but the asymmetric effects have not been tested in the paper. Hutengs and Stadtmann (2013) examine the age effect in the unemployment-output tradeoff in the Eurozone. Their evidence show that the output shock leads to an asymmetric digestion and effect on the budgets. However, the potential asymmetric effects in the unemployment-output relationship are not investigated in these studies, which will be empirically explored in this paper. Our study is filling the gap of investigating asymmetric relationship between unemployment and output in this region, and further provides new insights into correcting the long run asymmetries.

3 Econometric Methods

In this section, the theoretical models for the unemployment-output tradeoff representing the Okun's law, the econometric approach and robust statistics for testing asymmetries are discussed. The framework for the unemployment-output relationship is based on the Okun's law (see, among others, Okun,1962; Harris and Silverstone, 2001; Silvapulle et al., 2004. The econometric strategy is mainly based on the nonlinear autoregressive distributed lag (NARDL) model.[4] General discussions on these models will be presented below.

3.1 The classical unemployment-output tradeoff framework

Unemployment rate and real output are commonly used to analyse the responsiveness of labour market to the cyclical output. Here, un_t and y_t designate the country-specific unemployment rate and the natural logarithm of real GDP, respectively. The standard specification for estimating the unemployment-output tradeoff has the following form:

$$\Delta un_t = \beta \Delta y_t + \varepsilon_t \tag{1}$$

Where Δun_t is the cyclical unemployment rate, Δy_t is the cyclical real output and ε_t is an error term. Parameter β is the Okun's coefficient. The simple static model represents the relationship between cyclical unemployment and cyclical output. To further look into the nature of the unemployment-output tradeoff, we need to test whether the two indicators are cointegrated or not. Even if the static model captures the long run relationship between unemployment and output, it is inadequate to account for short run dynamics (Silvapulle et al., 2004).

The long run equilibrium relationship between un_t and y_t could be examined in the conventional Engle and Granger (EG) cointegration approach (Engle and Granger, 1987). We add the

[4] For mode details, see the latest discussions about the NARDL (Shin et al., 2014).

constant and trend into the okun's law, it can be rewritten as:

$$un_t = \alpha + \beta_1 y_t + \beta_2 t + \varepsilon_t \tag{2}$$

If un_t and y_t are integrated $I(1)$, the long run cointegration relationship exists when $\varepsilon_t \sim I(0)$. The static model is usually weak in investigating the unemployment-output tradeoff since there is no any consideration for asymmetries.

3.2 The asymmetric dynamic unemployment-output tradeoff model

Given that the existing literature suggests that the unemployment-output relationship might be asymmetric (Harris and Silverstone, 2000; Altissimo and Violante, 2001; Silvapulle et al., 2004; Marinkov and Geldenhuys, 2007; Jardin and Stephan, 2010), these papers shed new light on investigating the asymmetric relationship between the proposed variables. The popular time series approach for testing asymmetries in all the above studies is the distributed lag model. Accordingly, following Shin et al. (2014), a nonlinear asymmetric cointegration technique to test both the long run and short run asymmetries in a coherent way is applied.[5] In particular, the NARDL introduces the short run and long run nonlinearities in the positive and negative partial sum decompositions of the independent variables. Let's start with the asymmetric long run regression of the unemployment-output tradeoff:

$$un_t = \beta^+ y_t^+ + \beta^- y_t^- + u_t \tag{3}$$

[5] See earlier version of the NARDL model: Shin, Yongcheol, Byungchul Yu, and Matthew Greenwood-Nimmo. Modelling asymmetric cointegration and dynamic multipliers in an ARDL framework. Mimeo: University of Leeds, 2009.

Where y_t is decomposed as a $k \times 1$ vector of regressors: $y_t = y_0 + y_t^+ + y_t^-$, y_t^+ and y_t^- are the partial sum process of the positive and negative changes in y_t.

$$y_t^+ = \sum_{j=1}^{t} \Delta y_j^+ = \sum_{j=1}^{t} max(\Delta y_j, 0), \quad y_t^- = \sum_{j=1}^{t} \Delta y_j^- = \sum_{j=1}^{t} min(\Delta y_j, 0) \tag{4}$$

and β^+ and β^- are the related asymmetric long run parameters. The stationary linear combination of the partial sum components could be defined as:

$$z_t = \beta_0^+ un_t^+ + \beta_0^- un_t^- + \beta_1^+ y_t^+ + \beta_1^- y_t^- \tag{5}$$

un_t and y_t are asymmetrically cointegrated only if z_t is stationary. The linear symmetric cointegration can only be obtained when $\beta_0^+ = \beta_0^-$ and $\beta_1^+ = \beta_1^-$. Nevertheless, the OLS estimator results in Equation (3) will be poorly estimated in finite samples, and the hypothesis test cannot be carried out without removing the serial correlation and endogeneity in the regressors. Thus we extend Equation (3) into the ARDL(p,q) model:

$$un_t = \sum_{j=1}^{p} \phi_j un_{t-j} + \sum_{j=0}^{q} (\theta_j^{+'} y_{t-j}^+ + \theta_j^{-'} y_{t-j}^-) + \varepsilon_t \tag{6}$$

Where ϕ_j is the autoregressive parameter, θ_j^+ and θ_j^- are the asymmetric distributed-lagged parameters, and ε_t is the normal $i.i.d$ innovations. The error correction form of equation(6) can be written as:

$$\Delta un_t = \rho un_{t-1} + \theta^+ y_{t-1}^+ + \theta^- y_{t-1}^- + \sum_{j=1}^{p-1} \varphi_j \Delta un_{t-j} + \sum_{j=0}^{q-1} (\pi_j^+ \Delta y_{t-j}^+ + \pi_j^- \Delta y_{t-j}^-) + \varepsilon_t \tag{7}$$

Where ρ, θ^+ and θ^- are the long run coefficients, π^+ and π^- are the short run coefficients. $\beta^+ = -\theta^+/\rho$ and $\beta^- = -\theta^-/\rho$ are the asymmetric long run parameters. Shin et al. (2014) refer to Equation (7) as the NARDL model.

In order to observe the effects of the financial crises, two dummy variables are created for the 2008 world financial crisis and the euro crisis, respectively. If the date t is equal or greater than 2008q1, D_1 equals 1, otherwise $D_1 = 0$. Likewise, the dummy D_2 is set as 1 starting with 2009q4. The two dummy variables will be included in the above models to examine the effects of the financial crises.

3.3 Bounds testing and asymmetric dynamic multipliers

The NARDL model can be estimated by the OLS, which is said to be superior to the existing regime-switching models, since the examination of the long run asymmetry is easy to test: $\rho = \theta^+ = \theta^- = 0$. If the null could be rejected based on the bounds testing approach (Pesaran et al., 2001), it suggests the existence of long run asymmetry. The NARDL model is valid regardless of the integration orders of the regressors. The long run and short run symmetries can be examined by testing $\theta^+ = \theta^- = 0$ and $\pi^+ = \pi^- = 0$ (for all $i = 0, ..., q$), respectively. The two symmetry tests are based on the standard Wald tests.

The asymmetric dynamic multiplier effects of one unit change in y_t^+ and y_t^- individually on un_t can be derived from equation (7). They are defined as:

$$mh^+ = \sum_{j=0}^{h} \frac{\partial u_{t+j}}{\partial y_t^+} = \sum_{j=0}^{h} \lambda_j^+, \quad mh^- = \sum_{j=0}^{h} \frac{\partial u_{t+j}}{\partial y_t^-} = \sum_{j=0}^{h} \lambda_j^-, h = 0, 1, 2... \tag{8}$$

Where $h \to \infty$, $mh^+ \to \beta^+$ and $mh^- \to \beta^-$, where β^+ and β^- denote the asymmetric long run coefficients. The dynamic multipliers represent the transition between the initial equilibrium, short run disequilibrium after a shock, and the new long run equilibrium. It is a useful tool for analysing both the asymmetric short run adjustment and the asymmetric long run reaction. It is also quite helpful in observing the responsiveness of the labour market reforms to cyclical output.

3.4 Measuring the asymmetry determinants

Once we have obtained the long run positive and negative asymmetric coefficients, the next step in the analysis is identifying the main determinants that account for such asymmetries. This exercise would provide the knowledge that would allow to better design economic policies in each case. In order to have a measure of the size of the long run asymmetries, we calculate the difference between positive and negative asymmetric coefficients, denoted by LR_i^{asy}.

$$LR_i^{asy} = \hat{\beta}_i^{+} - \hat{\beta}_i^{-}, \qquad LR_i^{asy} = f(X, Y) \tag{9}$$

Where $\hat{\beta}_i^{+}$ and $\hat{\beta}_i^{-}$ are the estimated long run asymmetric coefficients from Equation (7). X and Y are the labour market variables and country-level variables (for instance, labour cost, minimum wage, tax rate and inflation rate), respectively. We explain the cross-section variation in the degree of long run asymmetries by fitting multivariate regressions, which could demonstrate how those macroeconomic indicators affect the asymmetric unemployment-output relationship.[6]

4 The Data

Unemployment rates are collected from the Eurostat. Real GDP for the Eurozone economies are available on the Datastream.[7] The period of time considered for this study varies across countries, which depends on the availability of the data set.[8] All series have been seasonally adjusted. Figure 1 represents the unemployment rates and real outputs for the Eurozone economies. Intuitively, there might be a negative correlation in the economies of Cyprus, Estonia, Finland,

[6]In the existing literature, the typically considered factors are labour cost, minimum wage, tax rate, government spending and foreign trade (Symons and Layard, 1984; Blundell et al., 1987).

[7]The GDP at market prices and the consumer price index of Spain are obtained from the OECD statistics. The real GDP is defined as the nominal GDP adjusting for inflation.

[8]Those countries admitted after 2012 have been excluded from the sample, including Latvia and Lithuania.

Greece, Italy, Slovenia and Spain. Other countries do not exhibit simple unemployment-output tradeoffs. For all of the 17 Eurozone countries, the 2008 world financial crisis had severe shocks to their outputs and unemployment rates. The financial crisis has yielded a decrease in outputs and a rise in unemployment rates. Nevertheless, the duration of the shocks appear to be quite different among these countries. For instance, Germany experienced a surged unemployment rate, which had been cracked down in a short period. While other economies were immersed in the long term recession.

Insert Figure 1 here.

The Eurozone economies have launched variety of structural reforms in response to the cyclical outputs. During the recession periods, the priority of reforms in the region is getting people into work. In order to establish a well-functioning labour markets, structural reforms on the labour markets are mainly focused on the supply-side measures, such as tax reduction and increasing benefits, which might give incentives to the unemployed people and encourage them returning to work. Additionally, the labour market reform (LABREF) database project managed by the European Commission and the Economic Policy Committee (EPC) provides a consistent and policy associated representation of different reforms strategies being pursued by member states.[9] Thus, the LABREF database is helpful for member states since it provides a common space to share and evaluate their labour market reforms.

The commonly selected labour demand and supply factors in the existing literature are wage, government spending, tax rate and trade (Symons and Layard, 1984; Blundell et al., 1987). Subject to availability, the data for measuring asymmetry determinants at the macro level include tax rate, minimum wage (per month), labour cost index, government deficit/surplus (% of GDP), industrial production index, CPI, imports (% of GDP) and exports (% of GDP). These variables are available on the Eurostat.

[9] The LABREF database includes the measures of labour market reforms in the EU dating back to 2000, but this study will only discuss the reforms of some countries in the euro area.

5 Empirical Analysis and Results

This section discusses the static and dynamic estimates of the unemployment-output tradeoff in the Eurozone. In order to be consistent with the conventional framework for estimating the unemployment-output relationship, this study starts with the static linear and asymmetric estimates, which are carried out using the Engle-Granger (EG) two-step cointegration approach. To further construct a reference point, the dynamic linear modelling of the unemployment-output tradeoff is represented. Further, the nonlinear asymmetric distributed lag approach is applied to test the correlation between unemployment and output. Finally, the cross-sectional analysis of asymmetric unemployment-output tradeoff determinants is carried out to explain the variations in the long run asymmetries.

5.1 Static Estimation of the Unemployment-Output Tradeoff

Table 1 and Table 2 report the static linear and asymmetric estimates of the unemployment-output tradeoff, respectively. A deterministic time trend has been included in each single regression to remove the trending behaviour of unemployment rate (un_t). The cointegration test of the unemployment-output relationship is based on the EG-two step cointegration method. In Table 1, majority of those statistics are statistically significant at the 5% level, but severe serial correlation and ARCH effects exist in the residuals. The static linear estimates represent that the world financial crisis in 2008 and the euro crisis in late 2009 have significant impacts on the responsiveness of the unemployment to the changes in output, except in Malta, which could be due to its economic particularities in this region. Though EG residual-based Augmented Dickey Fuller (ADF) test indicates that there is a long run equilibrium linkage between unemployment and output in Austria, Greece, Malta, Netherland, Slovakia and Slovenia. These models are not correctly specified as indicated by the diagnostic tests. This implies that the static linear cointegration approach is not valid for exploring the unemployment-output tradeoff in the

Eurozone.

Insert Table 1 and 2 here.

Considering the potential nonlinear properties of output shocks, the static asymmetric estimation of the unemployment-output relationship is represented in Table 2. The equal positive and negative asymmetric effects have been rejected for all economies in the Eurozone, except Ireland. This indicates that the spillovers from the changes in real outputs to unemployment rates are asymmetrical. Only a few of EG statistics are significant at the 5% level, such as Germany, Greece and Malta, which suggests the existence of the cointegration relation, but these models suffer from serial correlation and heteroscedasticity. And also, the χ^2_{RESET} statistics indicate that the nonlinear combination of the independent variables may have power in explaining the dependent variable. This means that the potential long run relationship between unemployment and output estimated by the static asymmetric regression might be unreliable. Interestingly, the inclusion of the positive and negative asymmetric output shocks reduce the effects of two dummies,[10] which suggests that the unemployment-output tradeoff is more likely to be affected by the cumulative asymmetric effects, rather than the spillovers from the financial crises.

5.2 Dynamic Linear Estimation of the Unemployment-Output Tradeoff

The above section has discussed the static modelling of the unemployment-output tradeoff, but the results show that those models are misspecified. An intuition for improving this is the extension of dynamic modelling. Based on Equation (7), the dynamic linear model form can be obtained by imposing restrictions on the long run and short run asymmetric parameters: $\theta^+ = \theta^-$, $\pi_t^+ = \pi_t^-$.[11] Table 3 reports the dynamic linear estimation of the relationship between unemployment and output. As demonstrated in the table, a long run cointegration relationship exists in France, Luxembourg, Netherland, Portugal, and Slovakia. The F_{PSS} bounds tests have

[10] Compared with the static linear estimates, some of the dummy variables become insignificant in Table 2.

[11] The dynamic linear estimation of the unemployment-output is valid irrespective the integration order of the variables, saying *I(0)*, *I(1)* or mutually cointegrated, so this study did not test the stationarity of these series.

been rejected in these economies, and the dynamic linear models are also correctly specified. Although the long run unemployment-output tradeoffs have been found in Belgium, Estonia, Finland, Germany, Greece, Ireland, Italy, Malta, Slovenia, and Spain, these models are severely misspecified, which could be due to the asymmetric effects of output shocks on unemployment. Among the identified unemployment-output relations, only the long run coefficients (L_y) are negative and statistically significant in Estonia, Finland, Italy, Slovakia, Slovenia and Spain, which is generally consistent with the Okun's law. While the long run coefficients are positive in Austria, Germany, Greece, Luxembourg, and Malta (without taking into account of the significance of the long run coefficients), which are inconsistent with the conventional negative Okun's coefficient. For 7 out 17 countries the non-zero long run coefficients (L_y) have been rejected, including Austria, Belgium, Cyprus, France, Germany, Greece, and Ireland, which implies that the long run cointegration relationship between unemployment and output in these economies might not exist, while the short run dynamics might exist. Quite a few long run coefficients are larger than the previous findings in magnitude (Okun, 1962; Sögner and Stiassny, 2002; Silvapulle et al., 2004; Perman and Tavera, 2005; Huang and Lin, 2006), such as Austria and Italy, which could be due to the failure to accurately capture the long run correlation.

Insert Table 3 here.

Interestingly, the test of structural changes during crises periods has been rejected in many economies.[12] In the Eurozone, only four countries have structural changes during the great recession, namely Germany, Ireland, Malta, and Spain. And four economies receive shocks since the outbreak of the euro crisis in late 2009, which are Cyprus, Greece, Italy, and Slovenia. It is apparent that the dynamic linear approach has improved the model accuracy compared with the static models. Nevertheless, the diagnostic statistics and incorrect long run coefficients in

[12]This study includes two dummies (D_1 and D_2) in the dynamic linear estimation of the unemployment-output relationship. Those insignificant short run parameters (including the dummies) are excluded from the final estimation.

some countries indicate that these models are still severely misspecified.

5.3 NARDL Modelling of the Unemployment-Output Tradeoff

The static linear estimates in above sections imply that the correlation between unemployment and output might be asymmetric. Table 4 reports the dynamic asymmetric estimation of the unemployment-output tradeoff. For 12 out 17 economies, the null hypothesis that the long run coefficients are equal to zero ($\rho = \theta = 0$) have been rejected, which indicates the existence of long run correlation between unemployment and output.[13] Among these correctly specified models, the null of long run symmetric output effects have been rejected in Austria, Belgium, Estonia, Italy, Malta, Slovakia, and Slovenia, whereas the null of short run symmetries are accepted (except Belgium).[14] It means that the responsiveness of unemployment to cyclical output shocks in these countries are asymmetric in the long run but symmetric in the short run. Without taking the model specifications into consideration, long run symmetries and short run asymmetries exist in Germany, Ireland, and Portugal; short run asymmetry has been found in Finland; and Greece has both long run and short run asymmetries. For other countries, both the long run and short run relationship between unemployment and output are symmetric, namely Cyprus, France, Luxembourg, and Netherland. Among them, only France does not show any misspecification in the dynamic asymmetric estimation. It implies that the long run and short run unemployment-output tradeoff are symmetric in France.

The estimated long run coefficients L_{y^+} and L_{y^-} are -16.70 and -292.70 for Belgium, -20.59 and -36.84 for Estonia, -43.09 and -77.42 for Italy, respectively.[15] Then we can conclude that an economic upturn of 5.99% reduces unemployment by 1% in Belgium, while the downturn of

[13]The F_{PSS} statistics are significant in Austria, Belgium, Estonia, Finland, France, Germany, Greece, Italy, Malta, Slovakia, Slovenia and Spain, but the robustness tests demonstrate that four models are misspecified, namely in the economy of Finland, Germany, Greece and Spain.

[14]In Belgium, both the null hypotheses of long run and short run symmetric effects have been rejected.

[15]In this context, only the correctly identified models which have long run asymmetry and significant long run coefficients will be discussed.

just 0.28% in the economy increases unemployment by 1%. In Estonia, on one hand, an increase of 4.86% in the output reduces unemployment by 1%, on the other hand, a downturn of 2.7% implies the opposite. Similarly, 2.32% growth in the Italian economy reduces its unemployment by 1%, but 1.29% drop in the economy increases unemployment by 1%. The associated values are -11.23 and -19.57 for Malta, -29.55 and -95.80 for Slovakia, -8.23 and -41.90 for Slovenia, respectively. Therefore the values convert into an economic upturn of 8.90% and a downturn of 5.11% in Malta, an expansion of 3.38% and a reduction of 1.04% in Slovakia, a rise of 12.15% and a decline of 2.38% in Slovenia, respectively. For Austria, only the negative long run coefficient is significant, which suggests that an economic downturn of 1.27% increases unemployment by 1%. In the case of Belgium, both the long run and short run asymmetric effects have been identified.[16]

Insert Table 4 here.

In Table 4, regardless of the model specifications, only 5 countries receive significant shocks from the 2008 world financial crisis (D_1) and 5 economies significantly suffer from euro crisis (D_2). Actually, the aftermath of two crises have significant effects on the Eurozone economies. The discrepancies between empirical results (no significant shocks from the financial crises) and the realities (these countries suffered from financial crises) could be due to the asymmetric effects in the unemployment-output tradeoff. The labour market responds to the asymmetric output shocks in a nonlinear pattern, which smooths or reduces the spillover effects during the financial crises. When the output fluctuates, the disequilibrium relationship between unemployment and output can be gradually calibrated over time by the adjustment of asymmetries in the dynamic nonlinear model. In other words, the economy was plunged in to recession during the financial crises and had been at the bottom of the business cycle. However, it could survive by the implementation of appropriate structural reforms. Another reason could be the responsiveness

[16] The positive and negative short run asymmetry coefficients could be derived from the lagged Δy^+_{t-j} and Δy^-_{t-j} .

of the unemployment to the nonlinear combination of the explanatory variables (real outputs), as indicated by the Ramsey RESET test.

5.4 Dynamic Multipliers

The dynamic multiplier represents the adjustments of unemployment-output tradeoff from its initial equilibrium to the new equilibrium over time.[17] It is associated with unit changes in y_t^+ and y_t^- on un_t, respectively. Figure 2 presents the asymmetric dynamic multipliers for the Eurozone economies. The curves combine the dynamic long run and short run asymmetry shocks.[18] Shade areas are the 90% confidence intervals. The imposed restrictions are in line with the asymmetry tests in Table 4.[19] Together with the diagnostic tests, the invalid long run asymmetry restrictions endanger the identification of long run unemployment-output relations and the estimation of dynamic multipliers, such as in Finland, Greece, Luxembourg, Portugal, and Spain.

Insert Figure 2 here.

As the dynamic multipliers demonstrate, the labour markets respond rapidly and powerfully to cyclical slump of outputs in the short run in Austria, Belgium, Estonia, Italy, Malta, Slovakia and Slovenia. Approximately, 60% of the disequilibrium could be corrected within 5 quarters, but the full adjustments towards new long run equilibrium take very long time. Intuitively, the unemployment-output relationship is symmetric in Malta, which might be due to its strategic location, being situated in the middle of the Mediterranean Sea.[20] Other countries demonstrate the existence of asymmetric effects in the unemployment-output tradeoff, which

[17] The initial equilibrium in this context is the stable unemployment-output relationship. The relationship becomes unstable after receiving a shock, but it could be adjusted toward to the new equilibrium by implementing appropriate structural reforms.

[18] In this study, the long run and short run symmetry restrictions are $\beta^+ = \beta^-$ and $\sum_{i=0}^{q-1} \pi_t^+ = \sum_{i=0}^{q-1} \pi_t^-$, respectively.

[19] Some models are misspecified in Table 4, but the long run and short run asymmetry restrictions are still carried out to get the impression of the cumulative effect of cyclical output on unemployment.

[20] Geographical conditions are of importance for the development of productivity among member states (Norén, 2011).

are either dominated by a positive output shock or negative output shock. For the two largest economies in the region, the dynamic multipliers for Germany and France are almost representing symmetric output shocks across all time periods, except the very short run (1-2 quarters). Although the unemployment-output tradeoffs are symmetric for the two economies in the long run, the dynamic multipliers indicate that the short run asymmetric relationships are asymmetric.[21] Concerning Spain, the negative shock is almost constant and the correction of the disequilibrium is dominated by the positive shock, irrespective of the model misspecification. Around the second quarter, the asymmetric effect reaches the peak after a strong positive output shock. Noticing that 50% of the disequilibrium could be adjusted either within one quarter or ten quarters, other economies, such as Luxembourg and Portugal, the multipliers are in a terrible mess due to the misidentified long run unemployment-output tradeoffs.

Insert Table 5 here.

Since the incorrect asymmetry restrictions could jeopardise the identification of the long run relationship and affect the dynamic multipliers (Shin et al., 2014), we need to further confirm the dominance of the output shocks. Thus, Table 5 reports the comparison of positive and negative output shocks. The cumulative effects of positive and negative output shocks are not the same size. Despite the cumulative positive output shocks are larger and more probable than the cumulative negative shocks in Austria, Belgium, Finland, and France, the average size of the two types of shocks are almost equal. The remaining countries show the dominance of cumulative negative output shocks, which are more likely to happen in the unemployment-out correlation. In line with the depicted dynamic multipliers, the asymmetric effects are dominated by negative shocks in Greece, Italy, Netherland, Portugal, Slovakia, and Slovenia. This indicates that the labour markets quickly respond to the economic downturn. The employers speedily lay

[21] In Table 4, the dynamic asymmetric estimation of the unemployment-output tradeoff in France suggests that both the long run and short run correlation are symmetric. However, the cumulative output shocks on unemployment are asymmetric in the short run.

off employees in order to cut costs during recession, howbeit, they are slow to hire. This is explained as the hysteresis in the labour market. The probable positive and negative shocks do not demonstrate significant disparities in Austria, Belgium, Finland, and France. Moveover, the dynamic multipliers show the dominance of negative shocks. This could be the case that the sum of both the short run and long run shocks supports the dominance of negative shocks. Other reasons might be the misspecified models since some variables are not statistically significant in the dynamic asymmetric model.

5.5 Labour Market Reforms Analysis

In conjunction with the labour market reforms, we turn to the simple analysis of the effectiveness of the identified asymmetric unemployment-output relationship. Since the outbreak of the world financial crisis in 2008, the German government implemented four types of supply-side policies in the same year, including three career-oriented programs for reducing structural unemployment and cyclical unemployment, and the permanent increase in working hours for municipal employees. The duration of these measures were two to three years, which had helped to adjust the asymmetric unemployment-output tradeoff toward new equilibrium. While the dynamic multiplier demonstrates that the disequilibrium could be fully corrected within 5 quarters (irrespective the model misspecification). When the long run relationship returns to normal, the remaining and continuous structural reforms are helpful in stabilizing the unemployment-output tradeoff. Therefore, the labour market reforms in Germany are effective and successful among time. With regard to France, training and unemployment benefits were given to employees during financial crisis. The measures of increasing minimum wage and allowing financial payments instead of days off work also were carried out. In line with the identified long run and short run symmetric unemployment-output relationship, these reforms were enough to correct the short run disequilibrium (around one quarter), which might further reduce the effect of negative output shocks. Thus, we could say that these measures were functional and powerful. In terms of Spain, there were two temporary labour tax reduction measures adopted by the Spanish government during the crisis. These reforms did not fundamentally give incentives to the unemployed and get them back to work. Moreover, these measures failed to adjust the disequilibrium to new equilibrium within certain periods, the asymmetric effects became wider and deeper. Added to that, policymakers could not implement effect reforms to get people into work without recognising the asymmetry determinants. This could be one of the reasons for interpreting the high rates of long term unemployment in Spain.[22] Therefore, further investigation of the asymmetry determinants is of importance for policymakers to carry out effective policies.

5.6 Cross-Sectional Analysis of Asymmetry Determinants

The NARDL estimates and the dynamic multipliers represent the asymmetric effects of labour markets responding to the cyclical changes in outputs. We now turn to interpret the cross-section variation of long run asymmetries.

Insert Table 6 here.

Due to the unavailability of the minimum wage data for some countries, such as Cyprus, Finland, and Italy, we first run multivariate regression by including minimum wage variable with the three countries excluded. Considering the bias of small sample, we run the bootstrap regression to get the standard error of LR_i^{asy}, then estimate Equation (9) by weighting each observation using the inverse of the standard error (column 3). As demonstrated in Table 6, tax rate, government deficit/surplus, industrial production and foreign trade are associated with long run asymmetries. Minimum wage and labour cost exhibit little correlation with the long run asymmetric unemployment-output relationships.

The results above show that exports widen the asymmetric effects. This means that if

[22] Noticing that the misspecified NARDL model for Spain does not indicate the existence of asymmetric effects, which could be due to the regional disparities in productivity growth in Spain (Villaverde and Maza, 2009).

member states are export-driven growth, the asymmetric unemployment-output relationship becomes stronger. It seems reasonable to suggest that reducing the dependence on export-driven growth could reduce the asymmetric effects. The evidence also reveals that imports have a negative impact on the asymmetric effects. Notice that the coefficient for CPI is significant in the multivariate regression, which suggests that a higher inflation could widen the asymmetric unemployment-output relationship as well. However, the increase of prices for domestic goods and services might lead to the increase of imports, which in return reduces asymmetries. Further, The increase of tax rate and industrial production may reduce the magnitude of long run asymmetries, but the results from weighted regression do not support this. Moreover, government deficit/surplus exhibit strong negative correlation with long run asymmetries. This implies that increasing government spending is also helpful in correcting the disequilibrium unemployment-output relationship. If the minimum wage variable is excluded, the results are consistent with the former estimates.

The cross-sectional analysis of asymmetry determinants shows that government budget and trade situation are the key factors influencing the asymmetric unemployment-output tradeoff. The increase of government spending could stimulate domestic consumption, and further leads to the upturn of domestic goods prices and industrial production. The growth of industrial production can expand exports to some extent. Our study also supports the evidence from Fernández-Villaverde et al. (2011) that, fiscal reforms can be used to fight these asymmetries, and supply-side policies, like labour market reforms, are just additional tools that can be applied in certain circumstances, since most structural reforms take some time before having an effect. However, notice that since the Stability and Growth Pact (SGP) has outlined maximum limit for government deficit and debt,[23] member states have more incentives to appropriately modify fiscal policy to make up the potential government debts. The implication of fiscal consolidation,

[23] The Stability and Growth Pact (SGP) is a set of rules designed to ensure that member states in the Eurozone seek sound public finances and adjust their fiscal policies.

such increasing government spending and taxes, is also suggested by Anderson et al. (2014) and Frankel (2015). Moreover, the SGP with its reliance on deficit targets are insufficient to achieve fiscal stabilisation, replacing the deficit target by an expenditure target could also reduce negative growth effects Brück and Zwiener (2006), which further reduce asymmetric effects in the unemployment-output relationship.

6 Concluding Remarks

This study has investigated the asymmetric unemployment-output tradeoff in the Eurozone using the NARDL approach. Initially, the static linear, static asymmetric and dynamic linear models fail to explain the long run tradeoff between unemployment and output due to severe model misspecifications. Nonetheless, the NARDL estimates conclude that a long run relationship between unemployment and output exists in some Eurozone economies, yet majority of them are subject to asymmetric effects. The long run relationship between unemployment and output are found in 12 Eurozone economies, where 7 of them suffer from asymmetric effects. Only in Belgium, both the long run and short run unemployment-output correlation are found to be asymmetric. With respect to the two largest economies in the region, we find evidence of short run asymmetry in Germany, while both the long run and short run unemployment-output tradeoff are symmetric in France. For the remaining countries, the diagnostic tests suggest the misspecifications of these models. Possible solution could be the data denoising, which might provide more accurate estimates (Jammazi et al., 2015). Interestingly, the NARDL model fails in capturing structural instabilities during the two major crises, since the long run and short run asymmetric effects alleviate or reduce the effects of the financial crisis in the dynamic nonlinear model. Furthermore, majority of these dynamic multipliers show that the labour markets respond quickly and strongly to the cyclical output downturns in the short run. Commonly, 60% of the disequilibrium could be adjusted within 5 quarters although the fully correction takes very long time (more than 20 quarters). These asymmetric effects are mainly dominated by negative output shocks. In spite of the discrepancies of asymmetries, our findings on the asymmetric unemployment-output tradeoff have important policy implications for labour market reforms. In conjunction with the probable and size of asymmetries, structural reforms could be carried out in keeping with the effects of asymmetry determinants.

In order to explain the size of identified long run asymmetries, we estimate the asymmetry determinants by fitting multivariate regressions. The findings suggest that government deficit/surplus and foreign trade situations are the key factors influencing the asymmetric unemployment-output relationships. To reduce the asymmetric effects, member states may consider increasing government spending and adjust their trade situations (reducing the dependence on export-driven growth). Since the SGP has outlined maximum limit for government deficit and debt among member states, hence, flexible application of fiscal reforms, such as increasing spending and taxes,[24] could help to reduce the asymmetric effects notwithstanding the fact that countries in the euro area lack monetary sovereignty.

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[24]In this case, increasing government spending and tax rate could reduce the asymmetric effects in the unemployment-output relationship as shown in Table 6.

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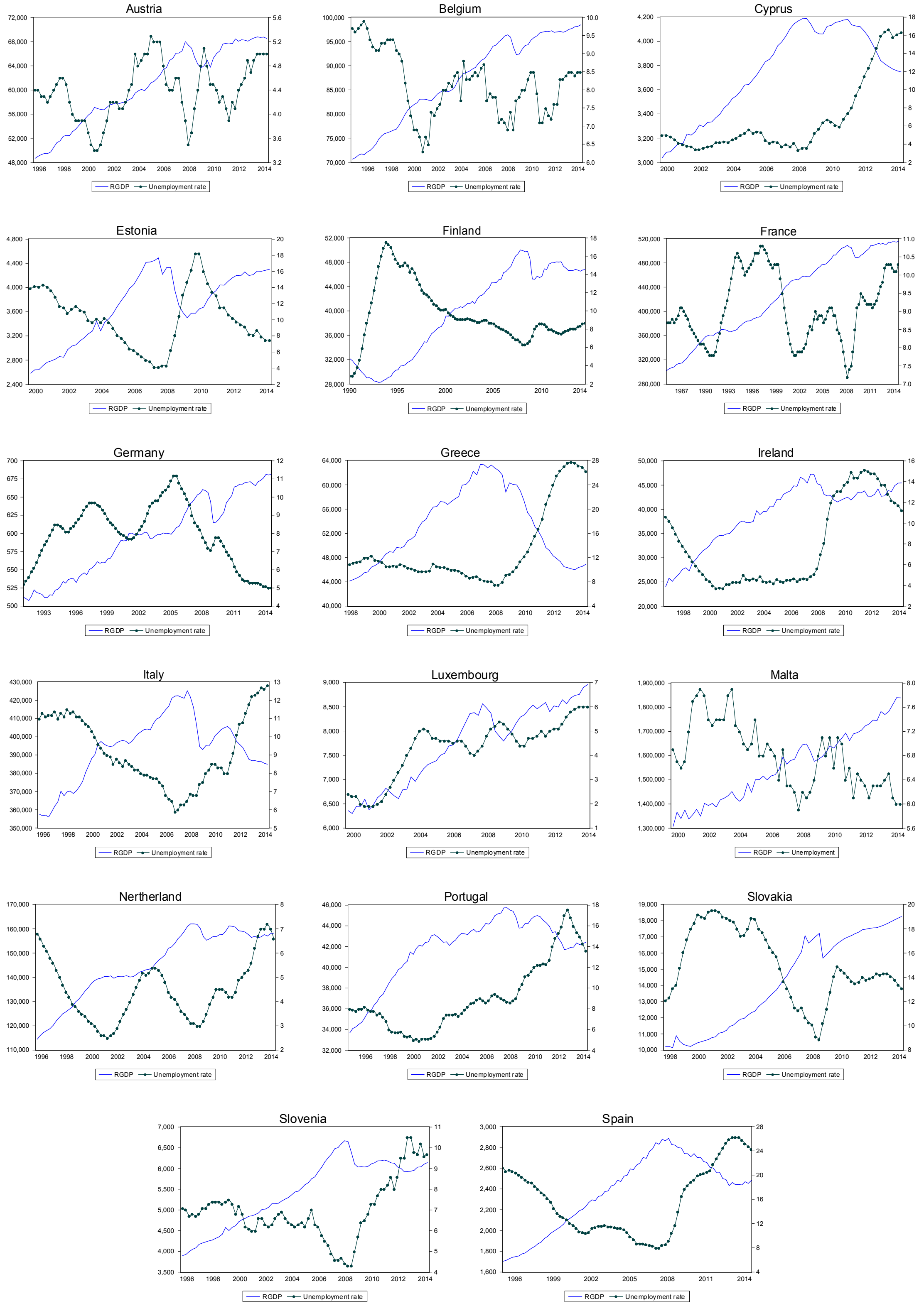
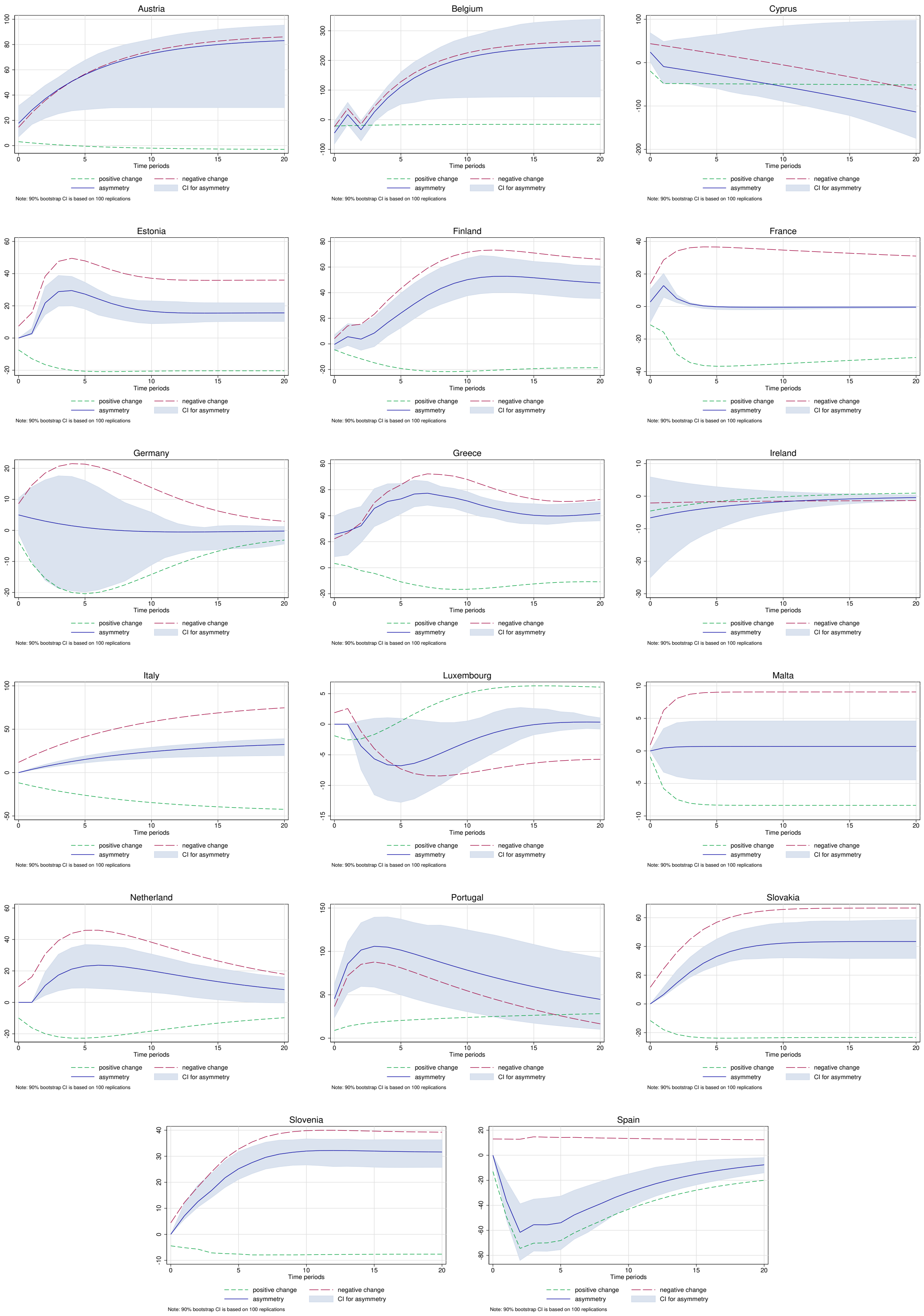
Figure 1: Unemployment rates and real outputs in the eurozone



Note: The units for RGDP in this region are measured in million euros, except the RGDP in Malta which is calculated in thousands euros.

Figure 2: The unemployment-output tradeoff dynamic multipliers



Note: These graphs give cumulative effects of positive and negative output shocks on unemployment. Shade areas are the 90% confidence intervals. The imposed restrictions are in line with the identified asymmetries in Table 4.

Table 1: Cointegration test of the unemployment-output tradeoff

(Static linear regression)

Country(sample)	Constant	y_t	D_1	D_2	Trend	$\bar{R}^2$	χ^2_{LM}	χ^2_{ARCH}	χ^2_N	χ^2_{RESET}	EG
Austria(96q1-14q3)	171.80[.000]	-15.54[.000]	-0.92[.000]	-0.71[.000]	0.11[.000]	0.59	31.42[.000]	10.12[.002]	1.74[.420]	2.82[.050]	-3.86
Belgium(95q1-14q3)	323.12[.000]	-28.11[.000]	-0.69[.024]	-0.35[.302]	0.12[.000]	0.56	49.64[.000]	34.03[.000]	4.77[.092]	6.12[.000]	-2.97
Cyprus (00q1-14q3)	342.95[.000]	-42.33[.000]	-0.80[.056]	-0.05[.914]	0.41[.000]	0.96	36.15[.000]	14.74[.000]	2.36[.307]	17.51[.000]	-2.377
Estonia(00q1-14q3)	176.29[.000]	-20.47[.000]	2.76[.017]	3.56[.004]	-0.03[.739]	0.78	40.70[.000]	21.74[.000]	4.31[.116]	4.20[.010]	-2.22
Finland(90q1-14q3)	521.48[.000]	-49.88[.000]	-3.67[.000]	-4.41[.000]	0.35[.000]	0.73	78.26[.000]	69.23[.000]	4.81[.090]	18.14[.000]	-2.59
France (85q1-14q3)	394.59[.000]	-30.51[.000]	-2.28[.000]	-0.00[.999]	0.17[.000]	0.48	102.02[.000]	67.31[.000]	3.42[.181]	1.76[.160]	-2.29
Germany(91q1-14q3)	195.91[.000]	-30.34[.000]	-3.33[.000]	-2.58[.000]	0.15[.000]	0.76	58.90[.000]	58.89[.000]	1.29[.524]	6.00[.001]	3.23
Greece (98q1-14q3)	493.15[.000]	-45.08[.000]	-3.63[.000]	-1.29[.037]	0.37[.000]	0.98	25.29[.000]	9.46[.002]	2.32[.323]	44.62[.000]	-3.68
Ireland(97q1-14q3)	198.96[.000]	-18.84[.000]	3.18[.000]	2.42[.007]	0.17[.001]	0.91	46.17[.000]	28.62[.000]	0.77[.679]	45.08[.000]	-2.17
Italy (96q1-14q3)	602.05[.000]	-46.15[.000]	-1.54[.000]	0.98[.000]	0.05[.000]	0.85	49.27[.000]	25.35[.000]	1.87[.393]	10.62[.000]	-2.73
Luxembourg(00q1-14q3)	47.51[.025]	-5.21[.032]	-0.63[.023]	-1.49[.000]	0.14[.000]	0.83	41.43[.000]	38.40[.000]	1.90[0.387]	25.05[.000]	-2.30
Malta (00q1-14q3)	140.99[.003]	-9.47[.005]	-0.18[.349]	0.31[.094]	0.03[.178]	0.57	14.23[.000]	6.50[.011]	0.35[.939]	2.51[.069]	-4.73
Netherland(96q1-14q3)	413.56[.000]	-34.99[.000]	-1.00[.000]	-0.58[.034]	0.19[.000]	0.86	51.53[.000]	26.74[.000]	1.60[.450]	9.51[.000]	-3.95
Portugal(95q1-14q3)	344.85[.000]	-32.33[.000]	-0.66[.000]	0.72[.000]	0.21[.000]	0.96	56.32[.000]	59.69[.000]	132.20[.000]	25.55[.000]	-1.24
Slovakia(98q1-14q3)	387.65[.000]	-40.35[.000]	-2.34[.001]	0.63[.395]	0.38[.000]	0.80	42.63[.000]	31.95[.000]	11.61[.003]	11.54[.000]	-3.50
Slovenia(96q1-14q3)	159.65[.000]	-18.43[.000]	-1.17[.000]	0.87[.004]	0.15[.000]	0.91	21.06[.000]	4.01[.045]	1.03[.599]	4.73[.005]	-4.73
Spain (95q1-14q3)	333.18[.000]	-42.23[.000]	5.16[.000]	2.65[.004]	0.19[.000]	0.94	49.89[.000]	38.03[.000]	2.83[.243]	17.47[.000]	-2.91

Note: D_1 and D_2 are two dummy variables. $\bar{R}^2$ is the adjusted R^2. χ^2_{LM} denotes the Breusch-Godfrey test for higher-order serial correlation. χ^2_{ARCH} is the test for ARCH effects in the residuals. χ^2_N designates the Jarque-Bera asymptotic test for normality. χ^2_{RESET} denotes the Ramsey RESET test using powers of the fitted value of unemployment rate. EG denotes the Engle-Granger residual-based ADF test. The critical values for the EG tests at the 5% level are -3.37(without lags) and -3.17(with lags), respectively. Numbers in brackets are the associated p-values.

Table 2: Cointegration test of the unemployment-output tradeoff

(Static asymmetric regression)

	Constant	y_t^+	y_t^-	D_1	D_2	$\bar{R}^2$	χ^2_{LM}	χ^2_{ARCH}	χ^2_{N}	χ^2_{RESET}	$L_{y^+} = L_{y^-}$	EG
Austria	4.12[.000]	0.36[.604]	-23.13[.000]	-1.19[.000]	-0.92[.004]	0.29	49.59[.000]	33.08[.000]	0.42[.809]	4.99[.004]	22.37[.000]	-2.75
Belgium	9.35[.000]	-7.71[.000]	-34.84[.007]	-0.58[.165]	0.18[.654]	0.42	56.08[.000]	45.72[.000]	12.41[.002]	14.95[.000]	4.91[.030]	-2.51
Cyprus	4.02[.000]	-1.86[.278]	-91.36[.000]	-0.83[.085]	1.27[.009]	0.96	42.65[.000]	30.64[.000]	2.08[.353]	19.35[.000]	380.92[.000]	-2.09
Estonia	15.26[.000]	-23.12[.000]	-43.94[.000]	-1.09[.348]	0.67[.483]	0.83	37.44[.000]	28.43[.000]	10.86[.004]	5.72[.002]	14.01[.000]	-2.19
Finland	3.14[.000]	-16.15[.000]	-89.90[.000]	-4.09[.000]	-4.72[.000]	0.74	68.56[.000]	52.593[.000]	3.39[.184]	33.17[.000]	145.61[.000]	-3.23
France	9.31[.000]	-4.37[.000]	-107.59[.000]	-2.92[.000]	-0.50[.214]	0.45	91.54[.000]	77.92[.000]	4.49[.106]	28.25[.000]	69.65[.000]	-2.91
Germany	6.56[.000]	-2.64[.244]	-47.89[.000]	-3.70[.000]	-3.39[.000]	0.72	56.27[.000]	50.59[.000]	2.59[.273]	12.14[.000]	45.44[.000]	-4.51
Greece	11.98[.000]	-11.55[.000]	-67.57[.000]	-3.68[.000]	-1.88[.004]	0.98	23.65[.000]	16.32[.000]	0.39[.824]	41.85[.000]	542.04[.000]	-4.06
Ireland	8.21[.000]	-9.14[.000]	-20.80[.014]	3.91[.000]	3.70[.000]	0.89	44.06[.000]	25.04[.000]	1.422[.491]	52.05[.000]	2.59[.112]	-2.75
Italy	11.83[.000]	-35.30[.000]	-56.82[.000]	-1.72[.000]	0.77[.094]	0.85	48.51[.000]	24.87[.000]	0.32[.852]	19.32[.000]	16.72[.000]	-2.74
Luxembourg	1.76[.000]	4.51[.000]	-15.98[.000]	-0.86[.002]	-1.38[.000]	0.85	37.43[.000]	32.80[.000]	0.53[.768]	31.44[.000]	59.17[.000]	-3.03
Malta	7.46[.000]	-8.45[.000]	-13.18[.001]	-0.21[.267]	0.40[.018]	0.59	11.69[.000]	4.47[.035]	1.31[.520]	0.79[.504]	5.09[.028]	-4.88
Netherland	5.50[.000]	-8.48[.000]	-66.89[.000]	-1.17[.000]	-0.28[.584]	0.61	62.00[.000]	47.07[.000]	2.99[.224]	7.54[.000]	43.16[.000]	-3.07
Portugal	7.65[.000]	-7.68[.000]	-65.35[.000]	0.13[.762]	0.67[.181]	0.93	65.31[.000]	52.40[.000]	7.54[.023]	27.27[.000]	157.02[.000]	-1.19
Slovakia	14.93[.000]	-13.17[.000]	-70.85[.000]	-6.13[.000]	1.25[.107]	0.76	36.73[.000]	20.04[.000]	3.09[.214]	39.64[.000]	47.90[.000]	-3.34
Slovenia	7.37[.000]	-4.70[.000]	-29.58[.000]	-1.70[.000]	1.61[.000]	0.83	33.80[.000]	12.51[.000]	1.38[.502]	17.71[.000]	44.51[.000]	-3.73
Spain	19.64[.000]	-25.55[.000]	-62.81[.000]	4.98[.000]	2.65[.003]	0.95	50.54[.000]	34.96[.000]	3.33[.190]	14.26[.000]	42.32[.000]	-2.85

Note: y_t^+ and y_t^- denote the positive and negative partial sum process. D_1 and D_2 are two dummy variables. $\bar{R}^2$ is the adjusted R^2. χ^2_{LM} denotes the Breusch-Godfrey test for higher-order serial correlation. χ^2_{ARCH} is the test for ARCH effects in the residuals. χ^2_N designates the Jarque-Bera asymptotic test for normality. χ^2_{RESET} denotes the Ramsey RESET test using powers of the fitted value of unemployment rate. $L_{y^+} = L_{y^-}$ test the equality of the positive and negative asymmetry effects. EG denotes the Engle-Granger residual-based ADF test. The critical values for the EG tests at the 5% level are -3.37(without lags) and -3.17(with lags), respectively. Numbers in brackets are the associated p-values.

Table 3: Dynamic linear modelling of the unemployment-output tradeoff

(Dynamic linear regression)

	Austria	Belgium	Cyprus	Estonia	Finland	France	Germany	Greece
un_{t-1}	-0.01[.810]	-0.13[.030]	-0.03[.170]	-0.10[.002]	-0.04[.000]	-0.02[.212]	-0.04[.001]	-0.05[.003]
y_{t-1}	-0.20[.406]	-0.44[.364]	-0.40[.546]	-1.13[.127]	-0.69[.000]	-0.19[.027]	0.06[.798]	-0.79[.191]
Δun_{t-1}				0.36[.007]	0.62[.000]	0.32[.001]	0.66[.000]	0.37[.003]
Δun_{t-2}		0.24[.034]	0.25[.037]			0.19[.028]		0.28[.022]
Δun_{t-4}	-0.39[.000]							
Δy_t	-1.33[.600]	-9.12[.222]	-13.44[.063]	-5.06[.204]	-5.09[.010]	-13.49[.000]	-4.84[.001]	-10.37[.012]
Δy_{t-1}	-8.25[.001]		-26.00[.000]		-5.15[.013]	-6.71[.048]	-5.15[.001]	
Δy_{t-2}	-6.92[.005]			-11.74[.003]				
Δy_{t-3}				-8.49[.038]				
Δy_{t-4}			26.87[.002]					
D_1							-0.16[.002]	
D_2			0.50[.012]					0.54[.022]
Constant	2.82[.259]	6.06[.294]	3.56[.520]	10.46[.097]	7.76[.000]	2.68[.015]	0.00[.998]	9.21[.170]
L_y	47.17[.911]	-3.51[.298]	-11.99[.542]	-11.12[.061]	-17.63[.000]	-10.77[.298]	1.56[.794]	2.69[.106]
$\bar{R}^2$	0.36	0.56	0.56	0.60	0.82	0.58	0.78	0.71
χ^2_{LM}	3.06[.080]	2.55[.110]	0.61[.434]	3.77[.052]	2.56[.110]	2.63[.105]	0.95[.329]	1.93[.165]
χ^2_{ARCH}	0.01[.927]	1.78[.183]	0.24[0.625]	0.54[.463]	21.90[.000]	1.35[.246]	1.23[.268]	1.54[.215]
χ^2_N	0.80[.670]	5.91[.052]	6.03[.049]	0.43[.807]	51.28[.000]	0.30[.860]	4.57[.101]	9.72[.008]
χ^2_{RESET}	1.56[.209]	1.11[.351]	1.87[.149]	3.06[.038]	5.63[.001]	1.04[.379]	4.23[.001]	0.86[.467]
F_{PSS}	0.63[.535]	2.48[.091]	1.01[.372]	5.38[.008]	9.12[.000]	3.64[.030]	7.17[.001]	5.02[.010]

Note: This table reports the dynamic linear estimates. The final model specification technique is the general-to-specific method (starting from 4 lags). Those insignificant distributed lags and dummy variables have been excluded from the model. χ^2_{LM} denotes the Breusch Godfrey test for higher-order serial correlation. χ^2_{ARCH} is the test for ARCH effects in the residuals. χ^2_N designates the Jarque-Bera asymptotic test for normality. χ^2_{RESET} denotes the Ramsey RESET test using powers of the fitted value of unemployment rate. L_y is the long run coefficient defined by $\hat{\beta} = -\hat{\theta}/\hat{\rho}$. F_{PSS} tests the null hypothesis $\rho = \theta = 0$. The asymptotic critical value for the F-statistic is 5.73 in the case of unrestricted intercept without trend. Numbers in brackets are the associated p-values.

Table 3 continued

	Ireland	Italy	Luxembourg	Malta	Netherland	Portugal	Slovakia	Slovenia	Spain
un_{t-1}	-0.10[.000]	-0.08[.022]	-0.08[.016]	-0.35[.002]	-0.03[.033]	-0.04[.001]	-0.08[.001]	-0.11[.022]	-0.08[.000]
y_{t-1}	-0.17[.666]	-3.29[.030]	0.61[.078]	-3.06[.001]	-0.08[.674]	-0.13[.797]	-1.16[.001]	-1.11[.006]	-1.06[.024]
Δun_{t-1}	0.26[.025]	0.03[.771]	0.66[.000]	-0.10[.436]	0.70[.000]	0.42[.000]	0.53[.000]	-0.04[.719]	0.48[.000]
Δun_{t-2}	0.33[.003]	0.28[.014]						-0.33[.008]	
Δun_{t-4}								-0.26[.027]	-0.18[.026]
Δy_t	0.99[.707]	-12.63[.006]	-1.21[.359]	0.53[.810]	-10.09[.000]	-14.92[.003]	-12.03[.000]	-3.78[.272]	-6.80
Δy_{t-1}						-17.46[.001]		-9.40[.009]	-10.84[.055]
Δy_{t-2}							-4.12[.073]		-20.72[.001]
Δy_{t-3}							-6.76[.004]	-10.85[.005]	-14.05[.029]
D_1	0.86[.001]			0.23[.095]					0.51[.023]
D_2		0.26[.006]						0.55[.004]	
Constant	2.19[.590]	43.12[.030]	-5.11[.088]	45.96[.001]	1.14[.623]	1.84[.729]	12.49[.001]	10.41[.004]	9.59[.012]
L_y	-1.65[.655]	-40.06[.000]	7.97[.002]	10.78[0.002]	-2.84[.677]	-3.44[.798]	-13.96[.000]	-10.10[.005]	-13.28[.002]
$\bar{R}^2$	0.56	0.37	0.44	0.22	0.70	0.53	0.73	0.36	0.83
χ^2_{LM}	5.98[.014]	3.82[.051]	2.16[.142]	2.28[.131]	2.48[.115]	0.02[.894]	0.09[.761]	0.40[526]	0.07[.789]
χ^2_{ARCH}	0.21[.649]	0.07[.799]	0.01[.904]	0.00[.976]	0.92[.339]	0.56[.454]	1.11[.293]	0.32[.571]	4.58[.032]
χ^2_N	3.08[.215]	0.93[.628]	2.30[.317]	1.60[.450]	0.95[.621]	1.32[.517]	0.15[.929]	3.05[.217]	0.95[.622]
χ^2_{RESET}	1.69[.178]	0.51[.680]	0.45[.716]	2.57[.065]	0.73[.539]	0.45[.720]	0.19[.901]	3.86[.014]	2.58[.061]
F_{PSS}	9.49[.000]	2.80[.068]	3.29[.045]	8.38[.000]	2.40[.098]	5.86[.004]	6.57[.003]	4.41[.016]	18.21[.000]

Note: This table reports the dynamic linear estimates. The final model specification technique is the general-to-specific method (starting from 4 lags). Those insignificant distributed lags and dummy variables have been excluded from the model. χ^2_{LM} denotes the Breusch-Godfrey test for higher-order serial correlation. χ^2_{ARCH} is the test for ARCH effects in the residuals. χ^2_N designates the Jarque-Bera asymptotic test for normality. χ^2_{RESET} denotes the Ramsey RESET test using powers of the fitted value of unemployment rate. L_y is the long run coefficient defined by $\hat{\beta} = -\hat{\theta}/\hat{\rho}$. F_{PSS} tests the null hypothesis $\rho = \theta = 0$. The asymptotic critical value for the F-statistic is 5.73 in the case of unrestricted intercept without trend. Numbers in brackets are the associated p-values.

Table 4: Dynamic asymmetric modelling of the unemployment-output tradeoff

	Austria	Belgium	Cyprus	Estonia	Finland	France	Germany	Greece
un_{t-1}	-0.13[.015]	-0.18[.013]	0.02[.756]	-0.23[.000]	-0.12[.000]	-0.03[.085]	-0.04[.001]	-0.19[.000]
y^{+}_{t-1}	-0.37[.290]	-2.95[.007]	-0.25[.721]	-4.71[.003]	-2.34[.000]	-0.35[.007]	-0.14[.672]	-2.59[.001]
y^{-}_{t-1}	-10.57[.000]	-51.65[.007]	7.88[.263]	-8.43[.004]	-8.82[.000]	-1.69[.145]	-0.93[.406]	-11.17[.001]
Δun_{t-1}	0.12[.279]	-0.14[.250]			0.59[.000]	0.36[.000]	0.69[.000]	0.29[.006]
Δun_{t-3}								0.35[.002]
Δun_{t-4}	-0.25[.023]							
Δy^{+}_{t}	2.34[.527]	-24.35[.034]	-5.16[.652]	-4.90[.510]	-5.01[.127]	-10.23[.006]	-2.52[.332]	-3.60[.572]
Δy^{+}_{t-1}			-35.06[.003]				-5.76[.021]	
Δy^{+}_{t-2}			-28.32[.015]	13.95[.073]		-8.56[.029]		
Δy^{+}_{t-3}						-8.25[.036]		13.33[.026]
Δy^{+}_{t-4}	-10.50[.002]		27.18[.019]					
Δy^{-}_{t}	-11.70[.071]	21.21[.175]	-40.75[.015]	-18.83[.000]	-5.01[.068]	-19.81[.001]	-9.23[.000]	-23.21[.000]
Δy^{-}_{t-2}		87.80[.038]		-27.71[.000]	10.04[.012]			
Δy^{-}_{t-4}				-21.58[.000]				
D_1	-0.32[.016]						-0.20[.008]	-0.43[.074]
D_2	-0.57[.001]	-1.97[.011]	0.43[.057]		-0.65[.002]			
Constant	0.62[.006]	1.79[.007]	0.38[.247]	2.71[.003]	0.79[.000]	0.46[.002]	0.34[.000]	2.23[.001]
L_{y^+}	-2.78[.379]	-16.70[.001]	11.42[.831]	-20.59[.000]	-19.77[.000]	-13.69[.089]	-3.83[.679]	-13.52[.000]
L_{y^-}	-78.51[.020]	-292.70[.010]	360.71[.676]	-36.84[.000]	-74.70[.000]	-65.60[.147]	-24.58[.409]	-58.29[.000]
R^2	0.43	0.17	0.52	0.68	0.83	0.59	0.77	0.78
χ^2_{LM}	0.11[.747]	2.22[.137]	0.14[.710]	0.59[.441]	3.65[.056]	1.86[.173]	0.14[.711]	2.17[.141]
χ^2_{ARCH}	0.61[.437]	1.76[.185]	0.02[.891]	0.40[.528]	18.19[.000]	1.81[.179]	0.43[.514]	0.00[.986]
χ^2_{N}	1.87[.393]	2.34[.311]	1.54[.462]	0.002[.999]	70.29[.000]	0.49[.782]	2.95[.229]	19.25[.000]
χ^2_{RESET}	1.52[.219]	0.35[.792]	4.18[.011]	1.39[.260]	3.30[.024]	0.53[.661]	3.55[.018]	0.76[.520]
F_{PSS}	8.28[.000]	4.21[.019]	0.80[.456]	4.89[.012]	15.86[.000]	3.77[.026]	12.78[.001]	6.96[.002]
$Wald_{LR}$	16.52[.000]	7.70[.007]	1.42[.240]	7.78[.008]	12.93[.000]	1.61[.207]	0.87[.354]	11.58[.001]
$Wald_{SR}$	2.67[.110]	4.50[.038]	2.36[.131]	1.89[0.176]	0.00[.999]	1.74[.190]	2.95[.089]	3.88[.054]

Note: This table reports the dynamic asymmetric estimates in the form of equation (6). The final model specification technique is the general-to-specific method (starting from 4 lags). Those insignificant distributed lags and dummy variables have been excluded from the model. χ^2_{LM}, χ^2_{ARCH} and χ^2_{N} denote the tests for serial correlation, ARCH effects and normality in the residuals, respectively. χ^2_{RESET} denotes the Ramsey RESET test using powers of the fitted value of unemployment rate. L_{y^+} and L_{y^-} are the positive and negative long run coefficients, respectively. F_{PSS} tests the null hypothesis $\rho = \theta = 0$. $Wald_{LR}$ and $Wald_{SR}$ denote the Wald test of long run symmetry and short run symmetry, respectively. Numbers in brackets are the associated p-values.

Table 4 continued

	Ireland	Italy	Luxembourg	Malta	Netherland	Portugal	Slovakia	Slovenia	Spain
un_{t-1}	-0.02[.600]	-0.09[.017]	-0.08[.023]	-0.41[.000]	-0.04[.098]	-0.05[.227]	-0.14[.000]	-0.24[.000]	-0.11[.000]
y^+_{t-1}	0.40[.507]	-3.77[.017]	0.27[.529]	-4.60[.009]	-0.27[.349]	-0.06[.922]	-3.99[.000]	-1.98[.000]	-2.02[.007]
y^-_{t-1}	2.02[.443]	-6.78[.002]	-0.26[.772]	-8.01[.029]	-1.02[.490]	-1.44[.656]	-12.94[.000]	-10.06[.000]	-4.47[.068]
Δun_{t-1}			0.68[.000]		0.63[.000]	0.52[.000]	0.38[.000]		0.52[.000]
Δun_{t-2}	0.30[.008]	0.21[.071]						-0.20[.067]	
Δun_{t-3}								0.32[.004]	
Δun_{t-4}							-0.20[.015]	-0.22[.048]	
Δy^+_t	-3.02[.423]	-3.59[.673]	-1.73[.500]	-1.49[.720]	-10.06[.020]	2.58[.757]	-8.46[.127]	1.43[0.797]	-7.14[.378]
Δy^+_{t-1}						-16.34[.038]			-19.20[.034]
Δy^+_{t-2}									-18.95[.020]
Δy^+_{t-3}								-15.92[.008]	
Δy^+_{t-4}	-5.98[.067]								
Δy^-_t	9.57[.091]	-15.54[.015]	-2.04[.474]	-3.16[.593]	-9.38[.071]	-36.67[.000]	-13.85[.001]	-6.88[.155]	-20.23[.032]
Δy^-_{t-2}			4.58[.068]		-9.65[.079]				
Δy^-_{t-3}									-20.56[.029]
Δy^-_{t-4}								11.10[.000]	
D_1	1.13[.000]								0.51[.028]
D_2	-0.75[.040]								
Constant	0.18[.648]	1.00[.031]	0.26[.011]	3.02[.000]	0.24[.058]	0.42[.234]	2.36[.000]	2.08[.000]	2.29[.000]
L_{y^+}	16.30[.744]	-43.09[.000]	3.54[.486]	-11.23[.003]	-7.44[.259]	-1.26[.918]	-29.55[.000]	-8.23[.000]	-18.68[.000]
L_{y^-}	-83.07[.716]	-77.42[.000]	-3.41[.775]	-19.57[.019]	-27.94[.343]	-28.74[.501]	-95.80[.000]	-41.90[.000]	-41.23[.004]
R^2	0.56	0.39	0.45	0.17	0.70	0.55	0.74	0.47	0.82
χ^2_{LM}	0.11[.746]	0.02[.881]	2.61[.106]	0.20[.652]	1.71[.191]	0.15[.696]	0.00[.960]	0.67[.413]	0.01[.928]
χ^2_{ARCH}	0.99[.321]	0.11[.735]	0.00[.953]	2.06[.151]	3.22[.073]	0.46[.498]	0.96[.328]	0.88[.348]	4.19[.041]
χ^2_N	1.12[.572]	1.46[.481]	1.60[.449]	1.60[.450]	0.32[.852]	2.40[.301]	1.43[.488]	0.08[.961]	3.48[.175]
χ^2_{RESET}	2.60[.062]	0.22[.882]	0.78[.510]	0.10[.960]	0.59[.624]	0.30[.823]	0.63[.597]	0.86[.468]	0.22[.884]
F_{PSS}	0.34[.713]	6.60[.003]	1.57[.219]	4.91[.011]	0.36[.698]	0.16[.851]	11.20[.000]	12.12[.000]	4.39[.016]
$Wald_{LR}$	0.54[.466]	12.81[.001]	0.85[.362]	3.13[.083]	0.36[.550]	0.24[.625]	16.02[.000]	23.68[.000]	1.84[.180]
$Wald_{LR}$	2.88[.095]	0.99[.322]	0.00[.947]	0.04[.849]	0.01[.928]	8.00[.006]	0.45[.507]	0.99[.323]	1.06[.306]

Note: This table reports the dynamic asymmetric estimates in the form of equation (6). The final model specification technique is the general-to-specific method (starting from 4 lags). Those insignificant distributed lags and dummy variables have been excluded from the model. χ^2_{LM}, χ^2_{ARCH} and χ^2_N denote the tests for serial correlation, ARCH effects and normality in the residuals, respectively. χ^2_{RESET} denotes the Ramsey RESET test using powers of the fitted value of unemployment rate. L_{y^+} and L_{y^-} are the positive and negative long run coefficients, respectively. F_{PSS} tests the null hypothesis $\rho = \theta = 0$. $Wald_{LR}$ and $Wald_{SR}$ denote the Wald test of long run symmetry and short run symmetry, respectively. Numbers in brackets are the associated p-values.

Table 5: Comparison of positive and negative output shocks

	$N(y_t^+)$	$Pr(y_t^+)$	Σy_t^+	$\bar{y}_t^+$	$\prod y_t^+$	$N(y_t^-)$	$Pr(y_t^-)$	Σy_t^-	$\bar{y}_t^-$	$\prod y_t^+$
Austria	55	0.743	0.456	0.008	0.006	19	0.257	-0.114	-0.006	-0.002
Belgium	67	0.858	0.389	0.006	0.005	11	0.141	-0.057	-0.005	-0.000
Cyprus	38	0.644	0.359	0.009	0.006	21	0.356	-8.378	-0.399	-0.142
Estonia	47	0.797	0.853	0.018	0.014	12	0.203	-8.709	-0.726	-0.148
Finland	68	0.694	0.668	0.010	0.007	30	0.306	-0.292	-0.010	-0.003
France	96	0.813	0.598	0.006	0.005	22	0.186	-0.063	-0.003	-0.000
Germany	65	0.684	0.446	0.007	0.005	29	0.305	-6.685	-0.231	-0.070
Greece	36	0.545	0.436	0.012	0.007	30	0.455	-11.132	-0.371	-0.169
Ireland	47	0.662	0.956	0.020	0.013	24	0.338	-11.043	-0.460	-0.156
Italy	44	0.587	0.237	0.005	0.003	31	0.413	-13.024	-0.420	-0.174
Luxembourg	41	0.695	0.585	0.014	0.010	18	0.305	-9.343	-0.519	-0.158
Malta	41	0.695	0.587	0.014	0.010	18	0.305	-14.670	-0.815	-0.249
Netherland	55	0.733	0.415	0.008	0.006	19	0.253	-12.062	-0.635	-0.161
Portugal	54	0.684	0.400	0.007	0.005	25	0.316	-10.825	-0.433	-0.137
Slovakia	59	0.881	0.771	0.013	0.011	8	0.119	-10.003	-1.250	-0.149
Slovenia	61	0.813	0.619	0.010	0.008	14	0.186	-8.887	-0.635	-0.118
Spain	53	0.671	0.602	0.011	0.008	26	0.329	-8.042	-0.309	-0.102

Note: $N(y_t^+)$ and $N(y_t^-)$ designate the numbers of positive and negative output shocks, respectively. $Pr(y_t^+)$ and $Pr(y_t^-)$ represent the probability of positive and negative output shocks, respectively. Σy_t^+ and Σy_t^- are the cumulative effects of positive and negative shocks, respectively. $\bar{y}_t^+$ and $\bar{y}_t^-$ are the average size of positive and negative shocks, separately. $\prod y_t^+$ and $\prod y_t^+$ designate the probable size of positive and negative shocks, respectively. Source: authors' calculation.

Table 6: Measuring asymmetry determinants

	Multivariate reg.	Weighted reg.	Multivariate reg.	Weighted reg.
Tax rate	-1.950*	-0.030	-2.487**	-0.045
	(0.834)	(0.029)	(0.778)	(0.087)
Minimum wage	-5.516	-0.369		
	(21.469)	(1.071)		
Labour cost	-2.244	-0.088	-1.425	-0.203
	(7.249)	(0.386)	(2.777)	(0.307)
Government deficit/surplus	-10.336**	-0.319**	-7.605***	-0.245***
	(2.588)	(0.157)	(2.269)	(0.050)
Industrial production	-3.260**	-0.085	-3.113***	-0.178
	(1.046)	(0.055)	(0.628)	(0.305)
CPI	4.391	0.153	4.093***	0.248
	(2.641)	(0.141)	(0.780)	(0.382)
Imports %of GDP	-3.682**	-0.109**	-3.271***	-0.084*
	(1.234)	(0.053)	(0.956)	(0.039)
Exports %of GDP	2.289*	0.084*	2.431***	0.024
	(1.087)	(0.045)	(0.824)	(0.077)

Note: The dependent variable is the degree of long run asymmetry (LR_i^{asy}). Column 2 and 4 report the simple multivariate regression results. Column 3 and 5 represent the results of weighted regression. We weight each observation by the inverse of the standard error of LR_i^{asy} from the bootstrap regression in the first stage, then the betas receive a heavier weight in the second stage (Doidge et al., 2006). As the minimum wage data are not available for some countries, we estimate equation (9) by excluding those countries (column 2 and 3) and excluding the variable (column 4 and 5), respectively. ***, ** and * designate the rejection of null hypotheses at the 1%, 5% and 10%, respectively.