Is the Impact of Labour Taxes on Unemployment Asymmetric?∗

Tino Berger† and Gerdie Everaert‡

1 Institute for International Economics, University Münster & SHERPPA, Ghent University
2 SHERPPA, Ghent University

September 20, 2010

Abstract

This paper tests whether increases and decreases in labour taxes have an asymmetric impact on unemployment. Using a panel of 16 OECD countries over the period 1970-2005, we estimate a panel unobserved component model to account for the fact that unemployment rates and labour taxes are non-stationary but not cointegrated. We find a positive impact of labour tax increases on unemployment in European and Nordic countries while for labour tax decreases no significant impact is found in these countries. For Anglo-Saxon countries, both increases and decreases in labour taxes have no impact on unemployment.

JEL Classification: C15, C33, E24

Keywords: unemployment, labour taxes, asymmetry, unobserved component model

1 Introduction

High and persistent unemployment in many OECD countries is one of the biggest challenges for policymakers and labour economists in recent times. It is a widespread belief, especially among policymakers, that the increase in labour taxes over the last decades is one of the prime factors responsible for the increase in unemployment. Consequently, the alleviation of the high tax burden on labour has been declared to be one of the prime instruments to fight high unemployment. This strategy relies on the assumption that the alleged impact of labour taxes on unemployment is more or less symmetric, i.e. cutting taxes will reduce unemployment as much as its increase induced unemployment to go up.

In standard labour market models, the impact of an increase in labour taxes on unemployment depends on the degree to which employees succeed in shifting the higher tax burden on the

∗We thank Freddy Heylen, Siem Jan Koopman, Lorenzo Pozzi, Tara Sinclair and an anonymous referee for helpful suggestions and constructive comments on an earlier version of this paper. We acknowledge financial support from the Interuniversity Attraction Poles Program - Belgian Science Policy, contract no. P5/21.
†Corresponding author: Institute for International Economics, Universitätsstrasse 14-16, 48143 Münster, Germany. Email: tino.berger@wiwi.uni-muenster.de. Website: http://www.wiwi.uni-muenster.de/iioe/organisation/Berger.html.
employer. This shifting forward is only possible if alternative income sources, e.g. unemployment benefits, are not equally affected by the increase in taxes (Pissarides, 1998; Nickell and Layard, 1999; Daveri and Tabellini, 2000). In this case, labour taxes have a positive impact on unemployment as they drive a wedge between labour income and alternative income. The extent of this impact crucially depends on the amount of labour market competition. Excessive labour market regulations (e.g. extensive employment protection and high minimum wages), high union bargaining power and insider behaviour of employed workers all obstruct competition on the labour market implying a higher proportion of taxes being shifted forward to labour costs. Calmfors and Driffill (1988) have argued, though, that both in highly centralised/co-ordinated wage bargaining systems and in fully decentralised/competitive systems, unions are likely to take a more moderate stand in response to adverse shocks, e.g. a tax increase, hitting the economy.

Surveying the empirical literature, the estimated elasticity of unemployment with respect to labour taxes ranges from zero (Bean et al., 1986; Layard et al., 2005; Nickell, 1997; Blanchard and Wolfers, 2000) over medium-sized (Elmeskov et al., 1998; Nickell and Layard, 1999; Nickell et al., 2005; Planas et al., 2007; Berger and Everaert, 2010) up to large (Daveri and Tabellini, 2000). All these studies assume the impact of taxes to be symmetric. The contribution of this paper is to test whether the impact of labour taxes on unemployment is asymmetric. To the best of our knowledge, this has not yet been tested empirically.

The plan of the paper is as follows. Section (2) gives reasons of why the labour taxes-unemployment trade-off might be asymmetric. Section (3) lays out the empirical model and presents the results. Section (4) concludes.

2 Asymmetries in the labour taxes-unemployment trade-off

A first theoretical justification for asymmetries in the labour taxes-unemployment trade-off is the insider-outsider distinction (see e.g. Blanchard and Summers, 1986; Lindbeck and Snower, 1987). It states that insiders (those currently employed) are insulated from competition of outsiders (those currently unemployed) due to labour turnover costs (i.e. costs associated with hiring, training and firing). As a result, insiders have scope to push wages above the market-clearing level, i.e. they may use their privileged position to shift the tax burden to the employer (resulting in higher unemployment) in response to an increase in taxes and try to push for higher net wages (instead of lower unemployment) in response to a decrease in taxes. It is often argued, though, that insider-outsider effects are less strong when unions are centralised (as they are in e.g. the Nordic countries). There are at least two reasons for this. First, higher wages in one sector of the economy cause unemployment to rise and consequently implies (i) a fall in output and in the

---

1 Huizinga and Schiantarelli (1992) study the insider-outsider distinction within a general equilibrium model and confirm that it gives rise to an asymmetric response of employment in expansions and recessions.
taxable base and (ii) higher costs for unemployment benefits. These negative wage externalities will be internalised in a centralised wage setting system (Calmfors and Driffill, 1988), giving rise to more moderate wage claims. Second, membership rules in centralised wage settings are more favourable to the unemployed who typically remain union members. Thus they receive more attention in the wage bargaining process implying that insiders have less incentives to push wages above the market-clearing level (see e.g. Layard et al., 2005; Blanchard and Summers, 1986). Insider-outsider effects in wage formation may therefore be a less appropriate explanation for potential asymmetries in the labour taxes-unemployment trade-off in countries with a centralised wage bargaining system.

A second theoretical justification of asymmetries in the labour taxes-unemployment trade-off is the occurrence of asymmetric adjustment costs. Different costs for hiring and firing imply a different speed of adjustment for employment and hence unemployment in response to a labour market shock. A large literature provides considerably empirical evidence in support of asymmetries in labour demand. Using various different techniques and functional forms Holly and Turner (2001); Pfann and Palm (1993); Burgess (1992a,b); Hamermesh and Pfann (1996) show that there are asymmetries in labour demand due to asymmetric adjustment costs.

3 Empirical analysis

3.1 Data

Our dataset consists of yearly observations for 16 OECD countries over the period 1970-2005. The unemployment rate is taken from the OECD Economic Outlook. As a measure of labour taxes we use an update of the effective tax rates on employed labour from Martinez-Mongay (2003). This tax rate has been calculated with the so-called Mendoza-Razin-Tezar approach (see Mendoza et al., 1994) using the EU AMECO database. Figure 1 shows that labour taxes steadily increased in most OECD countries until the mid 1990s. Only recently, a decrease in labour taxes can be observed in a number of countries, most notably in Finland, Ireland and the Netherlands. With the availability of this recent data, it is now possible to analyse the response of unemployment to decreasing labour taxes.

---

2In addition to this fiscal externality there are at least six other negative wage externalities. See Calmfors (1993) for an overview.
3However, as pointed out by Calmfors (1993) only employed union members elect the union officials who represent the union in the wage bargaining process. The advantage of being a union member for the unemployed is therefore not obvious.
4We would like to thank Carloz Martinez-Mongay for providing this dataset.
3.2 Empirical specification: an unobserved component approach

Empirical studies on the determinants of unemployment typically estimate a reduced form unemployment equation linking the rate of unemployment to various labour market institutions and macroeconomic shocks (see e.g. Nickell et al., 2005, for a recent example). One major concern with this approach is that observed unemployment rates are found to exhibit unit root behaviour in most OECD countries over the past four decades.\(^5\) Thus, unless there is a cointegrating relation between unemployment and its alleged determinants, standard estimation methods yield spurious results. Using a panel of yearly data for 16 OECD countries ranging from 1960 to 1995, Berger and Everaert (2009) show that unemployment is not cointegrated with a large set of labour market institutions.

\(^5\)Since the unemployment rate is bounded between zero and unity one would expect it to be stationary. Over longer periods of time this indeed seems to be the case. Using postwar data though, it shows a clear upward trend and strong persistence resulting in the non-stationary behaviour as typically documented by unit root tests. This small sample behaviour requires the unemployment rate to be treated as a non-stationary process. Note that this is in line with the current practice in the literature (see e.g. Apel and Jansson, 1999b,a; Fabiani and Mestre, 2004).
institutions and macroeconomic shocks. The finding of no panel cointegration does not imply that there is no relation between unemployment and labour market institutions, though. Economic theory relates the equilibrium rate of unemployment to a large variety of factors, some of them being difficult to measure or even unobservable, e.g. the reservation wage which is a function of, among others, the value of leisure. By inducing a unit root component in the residuals, both missing non-stationary variables and measurement errors in non-stationary variables turn an otherwise cointegrating relation into a spurious regression (see Everaert, 2007, for a simulation experiment).

To solve this missing variables problem, Planas et al. (2007) and Berger and Everaert (2010) set up an unobserved component model in which the sum of all missing variables is treated as a latent state variable and identified through the Kalman filter. Here, we follow Berger and Everaert but extend their model to allow for an asymmetric impact of labour taxes on unemployment.

Let the total unemployment rate $u_{it}$ be the sum of an equilibrium component $u^*_it$ which is a function of structural factors driving long-run unemployment, and a temporary component $u^c_{it}$ which we label cyclical unemployment,

$$ u_{it} = u^*_it + u^c_{it}, \quad i = 1, \ldots, N, \quad t = 1, \ldots, T, \quad (1) $$

where $N$ is the number of countries and $T$ is the number of time series observations. In order to allow cyclical unemployment to exhibit the standard hump-shaped pattern, $u^c_{it}$ is assumed to be an AR(2) process

$$ u^c_{it} = \phi_1 u^c_{i,t-1} + \phi_2 u^c_{i,t-2} + \eta^c_{i,t-1}, \quad \eta^c_{i,t-1} \sim NID(0, \sigma^2_{\eta^c_{i}}). \quad (2) $$

The equilibrium rate $u^*_it$ is assumed to be given by

$$ u^*_it = u^*_i{t-1} + \varepsilon_{it}, \quad (3) $$

such that $\varepsilon_{it}$ reflects all factors that induce a permanent shift in the equilibrium rate of unemployment. In order to estimate the impact of labour taxes on $u^*_it$ we disentangle $\varepsilon_{it}$ into the impact of labour taxes $\varepsilon^T_{it}$ and the impact of all other factors $\varepsilon^Z_{it}$, i.e. $\varepsilon_{it} = \varepsilon^T_{it} + \varepsilon^Z_{it}$ where

$$ \varepsilon^T_{it} = \beta_1 \Delta TAX_{it} + \beta_2 D_{it} \Delta TAX_{it}, \quad (4) $$

$$ \varepsilon^Z_{it} = \delta \varepsilon^Z_{i,t-1} + \eta^Z_{i,t-1}, \quad \eta^Z_{i,t-1} \sim NID(0, \sigma^2_{\eta^Z_{i}}) \quad (5) $$

with $D_{it} = 1$ if $\Delta TAX_{it} < 0$ and zero otherwise. Thus, the impact of labour taxes on $u_{it}$ is measured by $\beta_1$ and $\beta_2$ in equation (4). Accounting for a potential asymmetric impact, $\beta_1$ measures the impact of increasing labour taxes whereas $\beta_2$ measures the differential impact of decreasing labour taxes on unemployment. Thus $\beta_1 + \beta_2$ measures the effect of decreasing labour taxes on unemployment. If there are asymmetric effects one would expect $\beta_2 \neq 0$, in particular $\beta_2 < 0$. Equation (5) describes the stochastic process of the other determinants of equilibrium.
unemployment. As a pure random walk process would result in a non-smooth series that is hard to reconcile with the expected smooth evolution of the structural characteristics driving equilibrium unemployment, the AR(1) specification in equation (5) allows for a smooth evolution of $\varepsilon_{it}$ over time, i.e. the closer $\delta$ to one the smoother $\varepsilon_{it}$. If $\delta = 0$, $\varepsilon_{it}$ is a pure random walk process. Note that in order to induce smoothness, the equilibrium rate of unemployment is nowadays often modelled as an I(2) series, i.e. $\delta$ is set to one (see e.g. Orlandi and Pichelmann, 2000). We do not restrict $\delta$ to be equal to one in equation (5) as in this case $\varepsilon_{it}$, and therefore also $u_{it}$, would exhibit a (time-varying) drift, which is hard to justify from an economic perspective.

The model in equations (1)-(5) can be written in a panel linear Gaussian state space representation from which the unobserved states can be identified using the Kalman filter and the unknown parameters can be estimated using maximum likelihood (see Appendix A for more details).

3.3 Country grouping

In order to take into account possible heterogeneity of the impact of taxes on unemployment, we group countries according to their wage-setting institutions. Following Daveri and Tabellini (2000), Doménech and García (2008) and Berger and Everaert (2010), and using the same notation, we classify countries in three different groups. The empirical specification, outlined in equations (1)-(5), is estimated separately for each of these three groups, i.e. the parameters $\phi_1$, $\phi_2$, $\beta_1$, $\beta_2$ and $\delta$ are assumed to be homogeneous within each of the three considered country groups but heterogeneous over these groups. The first group (NORDIC) includes Austria, Denmark, Finland and Sweden. These countries are characterised by strong unions, wage bargaining at a central level and/or a high degree of co-ordination. The unemployment incidence of labour taxes is expected to be moderate in these countries. The second group (EUCON) includes Belgium, France, Germany, Italy, the Netherlands, Portugal, Spain and Greece. In these countries, wages are generally bargained at the intermediate level without a strong tendency for co-ordination across bargaining units. In this setting, unions are expected to use their bargaining power to shift the burden of higher labour taxes onto employers. The third group (ANGLO) includes Japan, Ireland, the US and the UK. In these countries unions are typically not strong enough to shift the tax burden.

3.4 Results

Before looking at the specific coefficient estimates, we perform some diagnostic tests. In the unobserved component model presented in equations (1)-(5), the innovations $\eta_{ft}^{c}$ and $\eta_{zt}^{c}$ are assumed to be white Gaussian noise. Following Durbin and Koopman (2001) we check whether this property holds by testing for autocorrelation and non-normality in the standardised one-step ahead prediction errors $v_{it}$ of the state space model. On the country group level, we use two LM
tests for autocorrelation suggested by Baltagi and Li (1995). The first test specifies the residuals as an \(AR(1)\) process, i.e. \(v_{it} = \rho v_{i,t-1} + \varepsilon_{it}\), and tests the null hypothesis that \(\rho = 0\). The second test models the residuals as an \(MA(1)\) process, i.e. \(v_{it} = \varepsilon_{it} + \lambda \varepsilon_{i,t-1}\), and tests the null hypothesis that \(\lambda = 0\). The results are reported in Table 1. Both tests show that we cannot reject the null of no autocorrelation in any of the three country groups. More detailed country-specific diagnostic tests, including normality tests and higher order autocorrelation tests using Ljung-Box \(Q\)-tests, are reported in Table 2 in Appendix B. For the majority of countries the null hypotheses of normality and no autocorrelation cannot be rejected.

Table 1: Parameter estimates

<table>
<thead>
<tr>
<th></th>
<th>ANGLO</th>
<th>EUCON</th>
<th>NORDIC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(N = 4)</td>
<td>(N = 8)</td>
<td>(N = 4)</td>
</tr>
<tr>
<td>(\beta_1)</td>
<td>0.01</td>
<td>0.16***</td>
<td>0.07***</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td>(0.04)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>(\beta_2)</td>
<td>-0.23</td>
<td>-0.15**</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>(0.15)</td>
<td>(0.08)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>(\phi_1)</td>
<td>0.87***</td>
<td>1.48***</td>
<td>1.28***</td>
</tr>
<tr>
<td></td>
<td>(0.24)</td>
<td>(0.06)</td>
<td>(0.21)</td>
</tr>
<tr>
<td>(\phi_2)</td>
<td>-0.39</td>
<td>-0.76***</td>
<td>-0.71***</td>
</tr>
<tr>
<td></td>
<td>(0.25)</td>
<td>(0.06)</td>
<td>(0.15)</td>
</tr>
<tr>
<td>(\delta_1)</td>
<td>0.62***</td>
<td>0.54***</td>
<td>0.54***</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(0.07)</td>
<td>(0.18)</td>
</tr>
</tbody>
</table>

\(t_{\beta_2<0}\) is a one-sided \(t\)-test for the null hypothesis \(H_0 : \beta_2 = 0\) against the alternative \(H_1 : \beta_2 < 0\). \(t_{\beta_1+\beta_2\neq0}\) is a two-sided \(t\)-test for the null hypothesis \(H_0 : \beta_1 + \beta_2 = 0\) against the alternative \(H_1 : \beta_1 + \beta_2 \neq 0\). \(LM_{AR}\) and \(LM_{MA}\) are LM tests for an \(AR(1)\) respectively \(MA(1)\) structure in the one-step ahead prediction errors (null hypothesis is no autocorrelation). Standard errors are in parentheses. \(p\)-values are in brackets. *, ** and *** indicate significance at the 10%, 5% and 1% level respectively (using a two-sided \(t\)-test).

The parameter estimates are presented in Table 1. For the ANGLO group we do not find a clear significant impact of labour taxes on unemployment neither for an increase nor for a decrease in taxes. In contrast, there is a significant positive impact of increases in labour taxes on unemployment in both the EUCON and the NORDIC group, with the impact being more moderate in the latter. Moreover, in the EUCON group there is clear evidence of an asymmetric impact of
labour taxes, i.e. the differential impact of tax decreases $\beta_2$ is significantly negative (as indicated by the one-sided test $t_{\beta_2<0}$) with the total impact of tax decreases $\beta_1 + \beta_2$ not being significantly different from zero (as indicated by the two-sided test $t_{\beta_1+\beta_2\neq 0}$). In the NORDIC group, there is less evidence of asymmetry as the point estimate of $\beta_2$ is negative but not statistically significant different from zero. However, as in the other two groups the impact of tax decreases is also not statistically significant different from zero. As far as the other coefficients are concerned, the estimates of $\delta_1$ indicate that equilibrium unemployment is considerably smoother than a simple random walk but not as smooth as an $I(2)$ process. Further, $\phi_1$ and $\phi_2$ imply that cyclical unemployment exhibits the standard hump-shaped pattern in all country groups.

Figure 2 visualises the asymmetry for the Netherlands. It shows the evolution of labour taxes and their contribution to unemployment, as measured by the cumulated values of $\varepsilon_{it}^T$. We have chosen to graph data for the Netherlands as this country (i) shows a notable decline in labour taxes since 1994 and (ii) belongs to the EUCON group, where there is clear evidence of asymmetry. Labour taxes in the Netherlands increased from about 32.5% in 1970 to around 43% in 1993. This induced a rise in unemployment with 2.7% points. Due to the asymmetric impact, the subsequent strong decline in labour taxes to 33% by 2005 did not lead unemployment to go down, though. For the average of the country group EUCON (graph not included), the increase in labour taxes from 22% to 36% between 1970 and 1998 accounts for a 2.25% points increase in the average unemployment rate. Again, the slight decline in labour taxes after 1998 did not lead unemployment to go down.

**Figure 2:** Labour taxes and their contribution to unemployment (as measured by cumulating $\varepsilon_{it}^T$) for the Netherlands
4 Conclusion

This paper tests whether the impact of labour taxes on unemployment is asymmetric. The insider-outsider hypothesis and the occurrence of asymmetric adjustment costs both give reasons to suspect that the impact on unemployment is stronger for increases than for decreases in labour taxes. We estimate a panel unobserved component model to account for the fact that unemployment rates and labour taxes are non-stationary but not cointegrated due to unobserved non-stationary variables driving unemployment. The 16 considered OECD countries are divided in three groups to allow for heterogeneity in the labour taxes-unemployment trade-off depending on their labour market characteristics. The results show that labour taxes do not affect unemployment in the Anglo-Saxon countries. Increasing labour taxes have a significant positive impact on unemployment in the European and Nordic countries with the impact being more moderate in the latter. In both these country groups, the impact of tax decreases is smaller than for increases and is not significantly different from zero. These results imply that the strategy of reducing labour taxes to fight high unemployment is not too promising.
References


Appendix A  State space representation

The model in equations (1)-(5) can be written in a panel linear Gaussian state space representation, which consists of an observation and a state equation. The observation equation models the vector of observed unemployment rates \( u_t = [u_{1t}, \ldots, u_{Nt}]' \) as a function of a vector of unobserved states \( \alpha_t \). More specifically

\[
\begin{bmatrix}
  u_{1t} \\
  \vdots \\
  u_{Nt}
\end{bmatrix} =
\begin{bmatrix}
  I_N & O_N & I_N & O_N & O_N \\
  \vdots & \vdots & \vdots & \vdots & \vdots \\
  O_N & O_N & I_N & O_N & O_N
\end{bmatrix}
\begin{bmatrix}
  u_t \\
  I_N & O_N & O_N & O_N
\end{bmatrix}
\begin{bmatrix}
  \eta_t \\
  \eta_{t-1} \\
  \varepsilon_T
\end{bmatrix},
\]

\[ u_t = Z \alpha_t, \quad \text{(A-1)} \]

where \( I_N \) is the identity matrix of order \( N \), \( O_N \) is an \( N \times N \) matrix of zeros and \( \nu_T \) is an \( N \times 1 \) column vector of ones. The unobserved states in the state vectors \( u_t^c = [u_{1t}, \ldots, u_{Nt}]' \), \( u_t = [u_{1t}, \ldots, u_{Nt}]' \), \( \varepsilon_T = [\varepsilon_{1t}, \ldots, \varepsilon_{Nt}]' \) and \( \varepsilon_T^c = [\varepsilon_{1t}, \ldots, \varepsilon_{Nt}]' \) are defined in equations (2), (3), (4) and (5) respectively. The unobserved states are modelled in the following state equation

\[
\begin{bmatrix}
  u_{t+1}^c \\
  u_t^c \\
  u_{t+1} \\
  \varepsilon_T^{t+1}
\end{bmatrix} =
\begin{bmatrix}
  \phi_1 I_N & \phi_1 I_N & O_N & O_N & O_N \\
  I_N & O_N & O_N & O_N & O_N \\
  O_N & O_N & I_N & O_N & O_N \\
  O_N & O_N & O_N & I_N & O_N
\end{bmatrix}
\begin{bmatrix}
  u_t^c \\
  u_{t-1}^c \\
  u_t^c \\
  \varepsilon_T^c
\end{bmatrix} +
\begin{bmatrix}
  I_N & O_N \\
  O_N & O_N \\
  O_N & I_N \\
  O_N & O_N
\end{bmatrix}
\begin{bmatrix}
  \eta_t^c \\
  \eta_t^c \\
  \eta_T
\end{bmatrix},
\]

\[ \alpha_{t+1} = S \alpha_t + R \eta_t, \quad \text{(A-2)} \]

where \( \beta_t = \beta_1 \text{diag} [\Delta Tax_{1t} \ldots \Delta Tax_{Nt}] + \beta_2 \text{diag} [D_{1t} \Delta Tax_{1t} + \ldots + D_{Nt} \Delta Tax_{Nt}] \), \( \eta_t^c = [\eta_{1t}, \ldots, \eta_{Nt}]' \) and \( \eta_T^c = [\eta_T, \ldots, \eta_T]'. \) We assume that the innovations in \( \eta_t \) are mutually independent normally distributed with variances that are heterogeneous over countries, i.e. \( \eta_t \sim N(0, Q) \) with

\[
Q = \begin{bmatrix}
\text{diag} [\sigma^2_{\eta_t}] & O_N \\
O_N & \text{diag} [\sigma^2_{\eta_T}]
\end{bmatrix},
\]

\[ \text{diag} \left[ \sigma^2_{\eta_t}, \ldots, \sigma^2_{\eta_T} \right]' \] and \( \sigma^2_{\eta_T} = [\sigma^2_{\eta_{1t}}, \ldots, \sigma^2_{\eta_{Nt}}]' \).

For given values of the unknown parameters, the unobserved states \( \alpha_t \) and the loglikelihood of the model in equations (A-1)-(A-2) can be calculated by a routine application of the Kalman filter from which the unknown parameters can be estimated using maximum likelihood (see e.g. Harvey, 1989; Durbin and Koopman, 2001). The stationary state variables \( (u_{1t}^c, u_{Nt}^c, \varepsilon_{1t}, \varepsilon_{Nt}) \) are initialised by drawing from their stationary distributions while a diffuse initialisation is used for the non-stationary state variables \( (u_{it}) \). Standard errors for the parameter estimates are calculated by inverting the Hessian matrix.
## Appendix B  
Country-specific diagnostic tests

<table>
<thead>
<tr>
<th>Country</th>
<th>$JB$</th>
<th>$Q(1)$</th>
<th>$Q(2)$</th>
<th>$Q(3)$</th>
<th>$Q(4)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireland</td>
<td>0.35</td>
<td>0.00</td>
<td>3.70</td>
<td>6.56</td>
<td>6.62</td>
</tr>
<tr>
<td>Japan</td>
<td>3.11</td>
<td>4.84</td>
<td>12.98</td>
<td>16.57</td>
<td>20.67</td>
</tr>
<tr>
<td>UK</td>
<td>1.60</td>
<td>6.15</td>
<td>7.13</td>
<td>8.89</td>
<td>10.25</td>
</tr>
<tr>
<td>US</td>
<td>12.63</td>
<td>0.00</td>
<td>0.30</td>
<td>0.55</td>
<td>0.66</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.22</td>
<td>1.27</td>
<td>2.85</td>
<td>2.89</td>
<td>2.99</td>
</tr>
<tr>
<td>France</td>
<td>2.40</td>
<td>0.17</td>
<td>1.35</td>
<td>1.63</td>
<td>1.83</td>
</tr>
<tr>
<td>Germany</td>
<td>0.61</td>
<td>0.18</td>
<td>2.62</td>
<td>2.66</td>
<td>2.76</td>
</tr>
<tr>
<td>Greece</td>
<td>3.75</td>
<td>1.75</td>
<td>1.81</td>
<td>2.07</td>
<td>2.08</td>
</tr>
<tr>
<td>Italy</td>
<td>0.65</td>
<td>0.59</td>
<td>0.94</td>
<td>0.98</td>
<td>1.74</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.99</td>
<td>3.72</td>
<td>4.07</td>
<td>5.06</td>
<td>6.19</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.11</td>
<td>0.12</td>
<td>0.13</td>
<td>2.68</td>
<td>2.75</td>
</tr>
<tr>
<td>Spain</td>
<td>1.58</td>
<td>1.72</td>
<td>1.81</td>
<td>1.87</td>
<td>1.88</td>
</tr>
<tr>
<td>Austria</td>
<td>1.04</td>
<td>0.07</td>
<td>5.11</td>
<td>5.12</td>
<td>5.32</td>
</tr>
<tr>
<td>Finland</td>
<td>0.42</td>
<td>0.10</td>
<td>1.84</td>
<td>3.36</td>
<td>4.24</td>
</tr>
<tr>
<td>Denmark</td>
<td>5.92</td>
<td>4.46</td>
<td>5.74</td>
<td>9.20</td>
<td>9.46</td>
</tr>
<tr>
<td>Sweden</td>
<td>2.72</td>
<td>0.00</td>
<td>1.08</td>
<td>1.45</td>
<td>3.24</td>
</tr>
</tbody>
</table>

$JB$ is the Jarque-Bera test for normality of the one-step ahead prediction errors (null hypothesis is normality). $Q(m)$ is the Ljung-Box portmanteau test for autocorrelation at lag $m$ (null hypothesis is no autocorrelation). $p$-values are in brackets.