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Tobias Böing

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Universität Duisburg-Essen, Department of Economics
Universitätsstr. 12, 45117 Essen, Germany

Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI)
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Ansgar Belke and Tobias Böing[1]

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Abstract

The purpose of this article is to deliver new estimates of the sacrifice ratio of Euro area countries. A high sacrifice ratio means a large loss of gross domestic product (GDP) or employment for a given reduction in inflation. In order to estimate the cost of adjustments in inflation rates by the sacrifice ratio, we apply, firstly, a structural vector autoregressive technique following Cecchetti and Rich (2001) and, secondly, one by Ball (1994) based on historical disinflationary episodes. Our findings indicate that most countries have sacrifice ratios of between −1 and 2 per cent of real GDP for a reduction in inflation of one percentage point. In some cases, these estimates deliver negative sacrifice ratios.

JEL Classification: E31, F49

Keywords: Sacrifice ratio; structural adjustment; Euro area; VAR; episode method; Phillips curve

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1 Ansgar Belke, Universität Duisburg-Essen, Institute for the Study of Labor, Bonn, and Monetary Experts Panel of the European Parliament, Brussels; Tobias Böing, European University Viadrina, Frankfurt (Oder). – All correspondence to: Ansgar Belke, University of Duisburg-Essen, Universitätsstr. 12, 45117 Essen, Germany, e-mail: ansgar.belke@uni-due.de

1. Introduction

Where the roots of the economic crisis in the Euro area lie from 2007 (and especially from 2009) is to some extent open to question. One line of argument concerns current account imbalances, which built up in the run-up to the crisis and were caused mainly by divergences in price levels. While Germany registered surpluses, some other countries—such as the financially distressed Euro area member countries Portugal, Ireland, Italy, Greece and Spain—had deficits. These trade imbalances were correlated with their sovereign debt or unemployment problems.[1] Taking this analysis as a starting point, there might be at least two implications. First, countries have to adjust their prices to be competitive and restore their current accounts. This would contribute to the solution of the other problems of sovereign debt and unemployment. Second, if adjustment appears too costly, there is the option of leaving the Euro area or redesigning the structure of the Euro area as a currency union (Gros et al. 2014).

To obey the purchasing power parity (PPP) condition, which should hold in a monetary union, the Euro area countries will have to adjust their price levels. Adjusting price levels requires a change in inflation rates, so that a country with a relatively high price level has to reduce its inflation rate. Hence, the adjustment of prices is an important current issue in the Euro area.[2] Here, the concept of the sacrifice ratio literally assumes that a reduction in prices, or the inflation rate, is associated with costs in terms of output or unemployment. A high sacrifice ratio means a large loss of gross domestic product (GDP) or employment for a given reduction in inflation. To be more precise, the sacrifice ratio is a concept that describes the cumulative loss of output when the inflation rate declines by one percentage point (Cecchetti and Rich 2001). A high sacrifice ratio indicates high costs in structural adjustments that relate to the changes in price levels.[3] The objective of this article is to estimate the sacrifice ratio for Euro area countries individually and in total. Based on these estimates, we can calculate the costs associated with structural adjustments within the

[1] See, for instance, Gros et al. 2014.This is one narrative of the crisis. The collapse of real estate markets, the banking crisis, etc. deliver a complementary or alternative explanation. It is not the purpose of this article to offer a comprehensive analysis of the crisis and we do not assess the validity of these theories.

[2] In accordance with all the extant Troika (European Union plus European Central Bank (ECB) and International Monetary Fund) assessments, we assume that there is at least a temporary disequilibrium of prices and inflation rates in the Euro area. Hence, there appears to be a clear need for adjustments in prices and inflation rates in some of the Euro area member countries.

[3] In order to balance the condition of purchasing power parity, or 'international competiveness', structural adjustment is an adjustment on the supply side of the economy. It refers to the change in prices rather than in nominal exchange rates. Hence, structural adjustment corresponds with an adjustment of prices.

Euro area. Hence, our contribution is to gain empirical evidence of the magnitude of the sacrifice ratio in Euro area countries based on a sample of quarterly data ranging from 1990 to 2012.

To that purpose, we proceed in Section 2 by describing the price developments in Euro area countries. In Section 3, we briefly review some theoretical foundations of the sacrifice ratio and give a short overview of previous estimation results. In Section 4, we present the dataset. Then, to estimate the sacrifice ratio, in Sections 5 and 6 we apply a structural vector autoregressive (SVAR) technique following Cecchetti and Rich (2001) and, as an alternative, an episode-based procedure developed by Ball (1994). Section 7 concludes.

2. Price Developments in the Euro Area

In this section, we provide some background information about the Euro, describe the current price developments in the Euro area and draw conclusions from the PPP condition. The Euro was introduced in 1999 by a group of European countries.[4] The goal has been to deepen European integration and enhance the economies of those countries. The single main objective of the ECB is to maintain price stability, which is defined as having an inflation rate of below, but close to, 2 per cent in the medium run. Prior to the introduction of the Euro, convergence criteria (the Maastricht criteria) were developed to ensure the success of the single currency. A convergence of inflation rates has been one of those criteria, which required that it was not more than 1.5 percentage points above the inflation rates of the countries with the lowest inflation. All countries officially satisfied the criteria. The goal of the criteria was to assess the convergence of the economies. The idea was that if convergence was ensured, a single monetary policy would impose low costs because it had to be similar for each country with respect to interest rates or monetary growth.

Table 1 shows the developments in price levels and inflation rates in the Euro area countries since 1999. These calculations are based on the GDP deflator.[5] Here, a natural reference for the comparison of Euro area member countries is the Euro area in total. Its

[4] The following countries introduced the Euro in 1999: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. Since 1999, the ECB has conducted monetary policy. The cash was introduced in 2002. Greece joined the Euro area in 2001, while Cyprus followed in 2008. The United Kingdom, Denmark and Sweden have not joined the Euro area.

[5] The data stems from Eurostat (name of the series: namq_gdp_p).

average annual inflation rate was 1.93 per cent, which is close to the price stability objective of the ECB.[6]

Among Euro area countries, Germany was an exception, with its low average inflation rate of 0.92 per cent. On the other hand, Cyprus, Greece,[7] Luxembourg and Spain had average inflation rates of 3 per cent or even more. The remainder of the countries recorded inflation rates that were moderately above average (Belgium, Italy, Netherlands and Portugal) or very close to the average (Austria, Finland, France and Ireland).

Quite frequently, the issue of diverging prices is related to the international competitiveness of an economy and current account positions (Belke and Schnabl 2014). In this context, the GDP deflator serves as an indicator of the competiveness of an economy because the ability to sell products in global markets is related to its producer price. An alternative measure of competitiveness is that of unit labour costs. But, we observe a close correlation between unit labour costs and producer prices, so we have decided to base our study on prices. If relative prices increase and product quality does not change, international competitiveness declines and vice versa. As a consequence, those countries with high relative prices export less and import more than countries with low relative prices (Gros et al. 2014). Hence, prices determine the current account—holding demand effects constant—so that countries with low competitiveness record current account deficits (Belke and Dreger 2013; Belke and Schnabl 2013; Belke, Zemanek and Schnabl 2010).

The PPP condition implies that the prices of a bundle of goods should be the same in different countries if measured in one currency.[8] As a consequence of the common currency in the Euro area, in which the nominal foreign exchange rate is fixed, prices have to adjust—at least in the long run.[9] For example, if one assumes the parities of 1999 as a reliable equilibrium of relative prices, the right column in Table 1 should display the magnitude of necessary price adjustments. For instance, if Spain reduced its prices by 18.42 per cent, it would reach the equilibrium parity of 1999. Generally, if average inflation rates are above the Euro area average, the price level should drop relative to the average and vice

[6] The ECB's definition of price stability is of an inflation rate below, but close to, 2 per cent. But this definition relates to the measurement of price by the Harmonised Index of Consumer Prices.

[7] Owing to non-availability of data, our sample (2000:01– 2011:01) for Greece differs from those of other Euro area member countries.

[8] Of course, PPP does not hold exactly, for various reasons, but there is some evidence that it does hold in the long run (Sarno and Taylor 2002). In that sense, our estimation in Table 3 provides evidence in favour of the validity of PPP. Hence, we will assume that PPP holds in the long run and that it is a useful guide to price developments.

[9] However, a problem arises from the definition of the initial equilibrium parity. If prices can diverge in the short run, but adjust in the long run, it is still not clear to which level of relative price they should converge, if one allows for the possibility of an initial disequilibrium.

versa. This implies that inflation rates in some countries have to fall below the average for a while (Gros et al. 2014). Such a decrease in the inflation rate might imply costs, which is the subject of this article.

Table 1: Descriptive Statistics of Inflation Rates Based on Gross Domestic Product Deflator from 1999Q1 to 2012Q3

Country	*% Change over sample period*[a]	*Mean inflation rate*[b]	*% Difference from Euro area*[c]
Austria	25.63	1.90	–0.48
Belgium	30.46	2.26	4.36
Cyprus	46.91	3.48	20.81
Euro area	26.11	1.93	0.00
Finland	25.32	1.88	–0.78
France	26.68	1.98	0.57
Germany	12.47	0.92	–13.63
Greece[d]	–	2.97	–
Ireland	27.02	2.00	0.92
Italy	31.26	2.32	5.16
Luxembourg	58.27	4.32	32.17
The Netherlands	31.96	2.37	5.85
Portugal	33.09	2.45	6.98
Spain	44.53	3.30	18.42

Notes: (a) This is the percentage change of the price level from 1999:01 to 2012:03, based on differences in a log series.
(b) This is the annualised arithmetic mean of the inflation rates, based on a log series.
(c) This is the difference of changes in the price level (left column; in percentage points) from the Euro area.
(d) The sample of Greece ranges from 2000:01 to 2011:01.
Sources: Eurostat; own calculations.

Table 2 shows the development of average annual inflation rates over time in the pre-crisis period, which in our case ranges up to the third quarter of 2008—when the Lehman Brothers collapsed—and over the crisis period, which started in the fourth quarter of 2008. Some countries (Cyprus, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain)[10] recorded persistently higher inflation rates in the pre-crisis period, so that the price levels of these countries diverged from the mean price level. For a convergence in price levels afterwards, the inflation rates during the crisis or in the postcrisis period have to remain below the average rate for some time. Most of the countries (Ireland, Italy, Netherlands, Portugal and Spain) have fulfilled that condition in the observed sample period, from 2008Q4.

[10] These countries had inflation rates of more than 0.5 per cent above the average.

Table 2: Descriptive Statistics of Inflation Rates Based on Gross Domestic Product Deflator from 1999Q1 to 2008Q3 and from 2008Q4 to 2012Q3

Country	*Mean inflation rate (1999Q1–2008Q3)*	*Mean inflation rate (2008Q4–2012Q3)*
Austria	1.68	2.45
Belgium	2.30	2.27
Cyprus	4.03	2.34
Euro area	2.20	1.24
Finland	1.73	2.45
France	2.17	1.35
Germany	0.82	1.20
Greece[a]	3.38	1.82
Ireland	3.34	–1.46
Italy	2.65	1.44
Luxembourg	3.38	5.40
The Netherlands	2.98	0.65
Portugal	3.27	0.55
Spain	4.46	0.65

Note: (a) The sample of Greece ranges from 2000:01 to 2011:01.
Sources: Eurostat; own calculations.

We even observe a convergence of price levels during the crisis period. But, Cyprus still has above-average, though decreasing, inflation rates. Luxembourg even has increasing inflation rates. Hence, there is evidence in favour of a price adjustment process.

Another possibility in analysing an adjustment process is to use a simple ‘error-correction’ regression framework. If the adjustment occurred, pre-crisis average inflation rates would be a predictor of the difference in average inflation rates (crisis-period rates minus precrisis period rates), so that there is a reduction in average inflation rates where the inflation rate was above average before the crisis. In Table 3, the results of such an ordinary least squares regression are given. The estimated coefficient of the pre-crisis rate turns out to be significantly negative at a 5 per cent level, which indicates an (ongoing) inflation adjustment.

3. Inflation Adjustments and the Sacrifice Ratio

3.1 Theoretical Considerations

Today, it is a textbook[11] concept and a 'stylised fact' in policy debates that a disinflation implies consequences in terms of losses of output. In this context, the sacrifice ratio measures the annualised cumulative loss in output that is a consequence of a disinflation by one percentage point (Cecchetti and Rich 2001).

Table 3: Ordinary Least-Squares Regression of the Difference in Inflation Rates on Mean Inflation Rates (1999Q1–2008Q3) Across Countries

Dependent variable: mean inflation (2008Q4–2012Q3) – mean inflation (1999Q1–2008Q3)	
Constant	1.693
	(–1.416)[a]
Mean inflation (1999:01–2008:03)	–1.058**[b]
	(0.476)
R^2	0.310

Notes: (a) Standard errors are in parentheses.
(b) ** indicates significance at the 5 per cent level.
Sources: Eurostat; own calculations.

However, such an effect is not self-evident from a theoretical perspective. Early theoretical foundations were based on Phillips curves[12] with adaptive expectations. Here, the inflation rate depends on inflation expectations, which are formed in an adaptive way, and the unemployment gap.[13] The relationship between the unemployment gap and the inflation rate is assumed to bear a negative sign. If unemployment is negatively correlated with the output via Okun's law, the estimate of the sacrifice ratio in terms of output should be positive. What is more, it can be estimated by the parameters of such a Phillips curve.

The value of the sacrifice ratio depends on the speed of price adjustments. The adaptive formation of expectations implies sticky prices. If—contrary to adaptive expectations—the inflation expectations immediately adjust, the actual inflation can immediately adjust too. An increase in unemployment or a decrease in output will not be

[11] This is in particularly valid for content in undergraduate textbooks such as Blanchard (2010).
[12] These Phillips curves typically contain unemployment as a variable. However, concepts using output are related to these specifications, owing to the close correlation between unemployment and the output gap (Okun's law).
[13] The unemployment gap refers to the difference of the actual unemployment rate from the natural rate of unemployment.

necessary. As a result of sticky expectation formation, the Phillips curve with adaptive expectations leads to a positive sacrifice ratio. However, if expectations of the inflation rates are rational and forward-looking, a rise in unemployment and a reduction in output are not necessary for an adjustment in prices. Here, a popular recent concept is the new Keynesian Phillips curve (NKPC), which assumes Calvo-type sticky prices (Gali and Gertler 1999). In that framework, the inflation rates positively depend on the expected inflation rates and on the marginal costs or the output gap in deviation of its steady state.[14] If the price-setters expected a decrease in future inflation rates, the actual inflation rates would not quickly adjust, so the sacrifice ratio would be very low or even zero (Wieland 2008). However, this concept has been criticised by some because it does not capture inertia in inflation rates, which is often claimed to be a core property of inflation dynamics (Fuhrer and Moore 1995; Mankiw and Reis 2002).

There are some ways to construct a model with a kind of backwardness in the inflation process, which generates inertia in inflation rates and positive sacrifice ratios. A first case arises if, for example, the policy authority that announces a disinflation is not perfectly credible. In the absence of a credible commitment, there might be costs in terms of output (Ball 1995). Second, some authors suggest a sticky information Phillips curve rather than the NKPC, which transforms into a sticky prices relation (Mankiw and Reis 2002). Here, price-setters do not receive new information with certainty in every period, which induces backwardness and implies inflation inertia. Third, some firms might apply a rule of thumb to forecast inflation and use the prices of the previous period to estimate future prices, which again implies backwardness (Gali and Gertler 1999). In contrast to traditional macroeconomic concepts, such as the Phillips curve with adaptive expectations, more recent concepts do not generally support the view of a positive sacrifice ratio.

[14] With respect to steady-state inflation rates in the Euro area, the assumption of a rate of 2 per cent might be justifiable with an eye on the inflation target of the ECB and equal to slightly below 2 percent HCPI inflation and PPP. Thus, gaps are transitory phenomena because of PPP.

3.2 Previous Empirical Findings

Here, we present some findings from more recent empirical studies that estimate the sacrifice ratio. These studies are based on Phillips curves with adaptive expectations, on SVAR models and on a method based on historical disinflation episodes.

Cuñado and Pérez de Gracia (2003) employ a version of a Phillips curve with adaptive expectations to estimate the magnitude of the sacrifice ratio. They use the unemployment gap as a measure of real activity and find empirical sacrifice ratios of between 0.55 and 1.96 per cent in terms of an annualised increase in the unemployment rate for Euro area countries. However, the coefficients pertaining to the unemployment rate are insignificant or negative in some cases (Italy, Luxembourg, Spain and France). Beccarini and Gros (2008) also estimate a Phillips curve with adaptive expectations. They find a sacrifice ratio of between 1.35 and 4.08 per cent of output for the Euro area and between 2.26 and 3.19 per cent for the United States.

Cecchetti and Rich (2001) apply different SVAR models and calculate the sacrifice ratio through the impulse response functions. Their study relies on US data and finds empirical realisations of the sacrifice ratio of between 0.19 and 9.87 per cent of the GDP. Durand, Huchet-Bourdon and Licheron (2008) apply the SVAR method to the Euro area and estimate a sacrifice ratio of 1.19 per cent for the Euro area in total and between –0.02 and 2.07 per cent, with a mean of 0.568 per cent, for individual countries. Their sample covers the period from 1972Q1 to 2003Q4.

Ball (1994) calculates the sacrifice ratio by using historical disinflationary episodes (that is, the episode method). His sample includes most industrialised countries and he finds sacrifice ratios of between –0.86 and 3.92 per cent of GDP. Coffinet, Matheron and Poilly (2007) estimate a sacrifice ratio of 1.37 per cent of GDP for the Euro area in total by using the episode method.

There is a tendency to find positive sacrifice ratios in previous empirical studies. However, most estimates fall in the range of between zero and three, which may still be regarded as a relatively low sacrifice ratio. But, some estimates even indicate a negative sacrifice ratio. In addition, estimates of the NKPC with the output gap as a measure of real activity are often not reliable with respect to the output gap (Rudd and Whelan 2007).

4. Data

Table 4: Data Description

Country	*Period*	*Variable*	*ADF[a] test: test statistics: SBC lags[b]*	*ADF test: test statistics: SBC lags, time trend*
Austria	1990:03–2012:03	GDP[c] growth	–4.84***[d]	–5.01***
		Δ Inflation rate	–6.33***	–6.30***
Belgium	1995:02–2012:03	GDP growth	–4.61***	–4.88***
		Δ Inflation rate	–11.87***	–11.81***
Cyprus	1995:03–2012:03	GDP growth	–3.03**	–3.63**
		Δ Inflation rate	–11.30***	–11.26***
Euro area	1995:03–2012:03	GDP growth	–3.67***	–3.94**
		Δ Inflation rate	–7.56***	–7.51***
Finland	1990:03–2012:03	GDP growth	–6.60***	6.56***
		Δ Inflation rate	–7.51***	–7.46***
France	1990:03–2012:03	GDP growth	–4.78***	–4.86***
		Δ Inflation rate	–12.58***	–12.50***
Germany	1991:03–2012:03	GDP growth	–6.78***	–6.74***
		Δ Inflation rate	–6.88***	–6.86***
Greece	2000:03–2008:02	GDP growth	–4.43***	–3.30*
		Δ Inflation rate	6.99***	–6.89***
Ireland	1997:03–2012:03	GDP growth	–2.66*	–10.92***
		Δ Inflation rate	–11.08***	–10.93***
Italy	1991:03–2012:03	GDP growth	–5.27***	–5.60***
		Δ Inflation rate	–7.19***	–7.28***
Luxembourg	1995:03–2012:03	GDP growth	–10.26***	–10.94***
		Δ Inflation rate	–7.63***	–7.57***
The Netherlands	1995:03–2012:03	GDP growth	–5.54***	–6.02***
		Δ Inflation rate	–12.44***	–12.35***
Portugal	1995:03–2012:03	GDP growth	–5.94***	–7.87***
		Δ Inflation rate	–6.96***	–6.05***
Spain	1995:03–2012:03	GDP growth	–0.90	–2.46
		Δ Inflation rate	–7.68***	–4.36***

Notes: (a) ADF denotes augmented Dickey–Fuller.
(b) SBC lags: optimal lags with respect to the Schwarz Bayesian Criterion.
(c) GDP denotes gross domestic product.
(d) *, ** and *** indicate a significance level of 10 per cent, 5 per cent and 1 per cent, respectively.
Sources: Eurostat (deflator) and the European Central Bank (GDP); own calculations.

For our estimates, we use quarterly real GDP data from the ECB and GDP deflator data from Eurostat. The sample covers the period from 1990 to 2012, with the exception of a few cases in which the sample period is smaller owing to the lack of data availability. These are shown in Table 4.

The focus of our article is on the adjustment of structural imbalances within the Euro area, which are more closely linked to production costs than to consumer prices. The GDP deflator captures the prices of produced goods. Because of this, we employ the GDP deflator as a proxy for the inflation rate.

5. Structural Vector Autoregressive-Based Estimates of the Sacrifice Ratio

5.1 The Structural Vector Autoregressive Method

For our estimation exercise, we choose a (country-specific) vector autoregression (VAR) approach because it is an established method for the estimation of the sacrifice ratio and we can compare our results with previous findings. It keeps track of the dynamics of a system, but does not rely on a specific model. Empirical models of this type tend to include the interest rate as a key variable. But in a textbook currency union, the common interest rate should not react to country-specific shocks. Hence, we decided in the end not to include the interest rate in the country-specific VAR. Although the method is intended to analyse the effect of a monetary policy shock, we generalise this idea to demand shocks,[15] which include fiscal policy, consumption and also exports.

We incorporate the growth rate of GDP and the first difference of the inflation rate as variables. Furthermore, we employ the empirical approach of Cecchetti and Rich (2001), which is based essentially on a supply and a demand shock. A demand shock could be interpreted as a fiscal shock, a trade shock (for instance, a decrease in demand for exports owing to a decline in competitiveness) or a shock due to distortions in the financial system.

Next, we will briefly outline the Cecchetti and Rich (2001) method.[16] For this purpose, consider the following structural VAR system:

$$\begin{bmatrix} g_t \\ \Delta\pi_t \end{bmatrix} = \alpha + A_1 \begin{bmatrix} g_{t-1} \\ \Delta\pi_{t-1} \end{bmatrix} + \cdots + A_p \begin{bmatrix} g_{t-p} \\ \Delta\pi_{t-p} \end{bmatrix} + B \begin{bmatrix} \varepsilon_t^s \\ \varepsilon_t^d \end{bmatrix} \qquad (1)$$

[15] Actually, Cecchetti and Rich (2001) labelled the shocks as ‘aggregate supply’ and ‘aggregate demand’ shocks, so we interpret it as a general model and not as a specific model that captures only monetary policy.
[16] See, for instance, Blanchard and Quah (1989), Cecchetti and Rich (2001) or Lütkepohl and Krätzig (2004) for a more detailed description of this method.

where g is the growth rate of the GDP and $\Delta\pi$ is the difference in the inflation rate, based on the GDP deflator. The 2 x 1 vector a includes constants and the 2 x 2 matrices A_i, i=1,…,p, include coefficients related to the lagged variables of the system. The 2 x 2 matrix B includes coefficients that capture the impact of the supply shock ε_t^s and the demand shock ε_t^d. The shocks have expected values of zero and are assumed to be mutually uncorrelated and to not display autocorrelation.

The system represented by equation (1) is not necessarily identified. The growth rate of real GDP and the change in the inflation rate can be governed either by a supply shock ε_t^s or a demand shock ε_t^d. But, we cannot infer the unique contribution of a single shock without one further restriction (Lütkepohl and Krätzig 2004). One possibility here would be to set one element in B to a fixed value, for instance to zero. Then, we could calculate the shocks by taking the residual in the row of the system with that restriction. By inferring the first shock, we can calculate the second. However, such a method is well known as empirically refutable.

This is because the growth rate of GDP can be influenced by a supply shock (for example, a technology shock or a capital shock) or by a demand shock (for example, a fiscal or a monetary shock) in the same way as the change in inflation rate may be driven by a supply shock (lower production costs) or by a demand shock (excess demand).

A natural alternative to relying on such a type of short-run restriction is thus to impose a long run restriction, following Blanchard and Quah (1989), who assume that one shock does not have a long-run impact on the level of a certain variable. In our case, we correspondingly start from the assumption that a demand shock does not have a long-run impact on the GDP level, which is instead set by theory to be determined by supply factors such as the state of technology and the capital intensity. Aggregate demand might influence real GDP in the short run, but the effects are only transitory. Imposing such a restriction identifies the system (Cecchetti and Rich 2001; Lütkepohl and Krätzig 2004). We are thus able to calculate the supply and the demand shocks. We follow that approach. The model analysis is carried out using JMulti, which employs a maximum likelihood estimator.

A positive demand shock is generally expected to increase output in the short run and the inflation rate in the long run. We need two ingredients to calculate the sacrifice ratio. First, we take the increase in output resulting from that demand shock on an annual basis,[17] which is the numerator in equation (2).

It is the cumulative gain over time in output after a positive demand shock. Here, y is the log output. The denominator captures the effect on the inflation rate. It is the change in the inflation rate that occurs after a demand shock. Then, the sacrifice ratio results as the cumulative τ-period sum of the short-run sacrifice ratios (Cecchetti and Rich 2001):

$$SR(\tau) = \sum_{i=0}^{\tau} \left(\frac{\partial y_{t+i}}{\partial \varepsilon_t^d}\right) / \left(\frac{\partial \pi_{t+\tau}}{\partial \varepsilon_t^d}\right) \qquad (2)$$

This measure of the sacrifice ratio can be computed using the impulse response functions of a demand shock to the inflation rate and the GDP. One purpose of our article is to compare the sacrifice ratios among Euro area member countries. In other words, we would like to assess the costs of disinflation in these economies, which have become a hot topic more recently during the crisis as some of these countries have strived to regain international competitiveness and thus credibility as debtors on international capital markets. With an eye on comparability, we chose a specification with a lag length of four in the VAR system that was described in equation (1) for all countries. This proved to be sufficient to accommodate autocorrelation and it should provide comparability.

5.2 Results

The inflation rate is calculated by taking the first differences of the log deflator. We then compute the first differences of this inflation rate (Cecchetti and Rich 2001) to measure the change in the inflation rate. The real GDP growth is calculated by the first difference of the log real GDP. Most time series are stationary, as indicated in an augmented Dickey–Fuller test (Table 4). Here, an exception is the GDP growth in the case of Spain, so one has to apply caution when interpreting the results. For a better comparison and to account for autocorrelation, we estimate the SVAR model with four lags.

The estimated sacrifice ratios based on the SVAR method are given in Table 5, which includes the empirical realisations of sacrifice ratios based on 5 years (τ =20) and 8 years (τ =32). However, the results turn out to be quite similar if we consider that demand

[17] A one-percentage output gap in every quarter of a certain year does not imply a cumulative loss in output of 4 per cent, but of 1 per cent on an annual basis.

shocks fade away in the medium run. In Figure A1, we provide the impulse response functions.

The empirical results take values ranging from –1.025 to 3.143 in terms of the cumulative output loss in per cent of real GDP as the consequence of a disinflation by one percentage point. The arithmetic mean and the standard deviation of the sacrifice ratios are 0.256 and 1.064, respectively. In comparison with previous findings, the estimates appear to be rather low, but not completely out of line regarding their arithmetic mean and the range of the sacrifice ratios. However, the sign of seven out of 14 estimated sacrifice ratios is negative, which contrasts with the assumption of a positive sacrifice ratio. Most estimates (12 out of 14) are in the range of between –1 and 2.

Table 5: Sacrifice Ratios (SR) *Based* on Vector Autoregression Method (Four Lags)

Country	*SR (5 years)*	*SR (8 years)*
Austria	–0.633	–0.633
Belgium	–0.016	–0.016
Cyprus	–0.760	–0.902
Euro area	1.696	1.696
Finland	–0.034	–0.034
France	0.314	0.314
Germany	–0.417	–0.417
Greece	0.019	0.019
Ireland	0.238	0.245
Italy	0.121	0.121
Luxembourg	–0.343	–0.347
The Netherlands	1.323	1.396
Portugal	–1.025	–1.025
Spain	3.107	3.143
Mean	0.256	0.254
Standard deviation	1.064	1.087

Source: Own calculations.

Spain has the highest estimated sacrifice ratio, at 3.143. However, because GDP growth is a non-stationary series in the case of Spain, one has to interpret this carefully. Of the financially distressed Euro area member countries,[18] four out of five have a positive sacrifice ratio, according to our estimates. The estimated sacrifice ratio for the Euro area as

[18] Portugal, Ireland, Italy, Greece and Spain.

a whole has a relatively high value of 1.694, while the arithmetic mean estimate of the sample countries consisting of individual Euro area economies is only 0.256.

The differing results can be attributed to the use of the GDP deflator instead of the consumer price index and to a different sample with respect to the country selection and the observation period. Although the problem of the identification of demand shocks is captured by our method, any solution of it might be questionable.

6. Episode-Based Estimates of the Sacrifice Ratio

6.1 The Episode-Based Method by Ball

As a complement to the previous method and to provide additional evidence that might serve as a robustness check, we apply a method based on the analysis of historical disinflationary episodes. This method, developed by Ball (1994), calculates the loss of output and relates it to the magnitude of any disinflation. In essence, it calculates whether disinflations are associated with booms or busts in the business cycle, as indicated by the output gap.

Following this approach, we have to first define disinflationary episodes, which itself requires a definition of inflation rates. A property of calculations based on first differences of the log price index is that it does not show a well-structured pattern or cycle. Thus, we calculate annualised inflation rates. But this inflation rate might have too many spikes, which will influence the results. If there is a steep peak in one quarter, the magnitude of a disinflation is higher. Because of this problem, we smooth the time series by calculating the moving average of the previous, current and following quarterly inflation rates. We do this because we are not interested in extreme events, but rather in a more 'structural' shift of the inflation rate. In this series, we search for spikes in the inflation rate. A disinflationary episode has to be at least four quarters long with a monotonic decrease in the inflation rate of more than 1.5 percentage points. We measure the change in the inflation rate by the difference between it at the beginning of the disinflationary episode and at the end.

Second, we have to calculate the loss in output during disinflationary episodes. For this purpose, we simply detrend the GDP variable to calculate the output gap (Ball 1994). The sum of output gaps over time in the disinflationary episode, which is projected on an annual basis, serves as a measure for the cumulative loss in output. It can be interpreted as the sum of output below the potential output due to the demand shocks that are necessary for a certain decrease in the inflation rate. We calculate the log output gap[19] by way of the Hodrick–Prescott (HP) filter with a parameter λ of 1,600, 400 and 6,400. We choose different calibrations to increase the robustness of our results.

6.2 Results

Employing the episode method, we find estimated sacrifice ratios in the range of between –1.073 and 1.409 per cent of GDP (see Table 6) in the case of a λ of 1,600. In contrast to the SVAR method used in our first approach, most estimated sacrifice ratios here turn out to be positive (22 out of 29). The empirical realisation of the arithmetic mean is also positive (0.060). Obtaining positive estimated sacrifice ratios in the majority of cases, our results are in line with previous studies.

The interpretation and measurement of the output gap might be one of the few drawbacks of this method. If the deviations from trend output could be attributed purely to aggregate demand shocks, problems of interpretation would not emerge. However, supply shocks might also play a role in the explanation of output gaps. This issue is related to the measurement problems of the output gap if it is generated by the HP filter, an essentially nontheoretical method. It does not include information about the trend output, which is determined mainly by supply factors.

[19] An output gap of, say, –0.01 can be interpreted approximately as an output of 1 per cent below the trend output.

Table 6: Sacrifice Ratios (SR) Based on the Episode Method[a]

Country	*Length*[b]	*Period*	*Δ Inflation*[c]	*SR (HP 1,600)*[d]	*SR (HP 400)*[d]	*SR (HP 6,400)*[d]
Austria						
	5	1993:02–1994:03	–4.7	0.168	0.136	0.075
	8	1995:02–1997:02	–7.7	0.163	0.071	0.104
Cyprus						
	5	1996:01–1997:02	–3.3	–0.529	0.434	0.392
	4	2003:02–2004:02	–4.5	–0.497	0.282	0.753
Finland						
	7	1991:02–1993:01[e]	–16.9	0.007	–0.132	–0.235
	4	1995:02–1996:02	–16.7	0.027	0.011	–0.139
France						
	4	1993:01–1994:01	–5.1	0.240	–0.210	–0.316
	5	1996:01–1997:02	–3.9	0.325	–0.186	–0.549
	5	2008:02–2009:03	–2.2	0.529	–0.506	–0.470
Germany						
	5	1992:02–1993:03	–6.2	0.187	–0.143	–0.242
	8	1994:02–1996:02	–7.6	0.044	0.007	–0.121
	5	1998:01–1999:02	–2.3	–0.089	–0.020	0.296
Ireland						
	10	2001:03–2004:01	–4.2	0.566	–0.262	–0.562
	8	2006:02–2008:02	–7.1	–1.073	–0.684	–1.527
Italy						
	4	1992:02–1993:02[e]	–16.3	0.027	0.017	0.026
	5	1994:01–1995:02	–6.5	0.036	–0.012	0.113
	7	1996:03–1998:02	–12.9	0.013	0.002	0.056
Luxembourg						
	4	1996:02–1997:02[e]	–9.3	0.287	0.208	0.337
	4	2003:03–2004:03	–4.8	0.476	0.281	0.512
	9	2006:01–2008:02	–7.5	–0.937	–0.643	–1.253

continued

Table 6 continued: Sacrifice Ratios (SR) Based on the Episode Method[a]

Country	*Length*[b]	*Period*	*Δ Inflation*[c]	*SR (HP 1,600)*[d]	*SR (HP 400)*[d]	*SR (HP 6,400)*[d]
The Netherlands						
	5	1993:02–1994:03	–3.9	0.338	0.174	0.621
	7	1995:02–1997:01	–6.5	0.229	0.083	0.424
	12	2001:02–2004:02	–4.5	0.328	0.151	0.358
	4	2008:04–2009:04	–2.8	0.500	0.614	0.350
Portugal						
	4	1997:01–1998:01	–2.8	0.392	0.274	0.474
	7	2002:04–2004:03	–1.5	1.409	0.905	1.455
	13	2007:02–2010:03	–2.4	–0.665	–0.240	–0.950
Spain						
	4	1996:02–1997:02	–6.8	0.141	0.101	0.170
	14	2006:02–2009:04	–4.4	–0.905	–0.407	–1.642
Mean				0.060	0.011	–0.051
Standard deviation				0.511	0.337	0.667

Notes: (a) There are no disinflation periods in Belgium, Greece or the Euro area by the definition applied.
(b) Length in quarter of a disinflation episode, based on our definition.
(c) The change in the inflation rate over the full disinflation period.
(d) HP 1,600, HP 400 and HP 6,400 refer to the use of alternative Lambda parameters in the calculation of the Hodrick–Prescott (HP) filter of 1,600, 400 and 6,400, respectively.
(e) Indicates an episode at the edge of the sample period. It could be at the beginning of the series or at the current edge of it.

7. Conclusion

This article arrives at some new estimates of the sacrifice ratio for Euro area member countries and the Euro area as a whole. To achieve this, we apply two different estimation techniques, first a VAR method and then a procedure based on disinflationary episodes. Our main motivation has been to calculate the costs of the structural adjustments of prices in Euro area member countries, which are usually measured by the sacrifice ratio. Let us now turn to the main empirical results gained in this article.

First, we do not find robust evidence in favour of costs of adjustment higher than 2 per cent of GDP. Indeed, we find only one estimate above 2 per cent; that is, Spain, by employing the VAR method. Second, some estimates even indicate negative sacrifice ratios, which are in contrast to some aspects of the theory, especially in the more classical literature. However, the arithmetic means across the Euro area countries under both methods reveal a positive sign, corroboration of an ongoing adjustment of inflation rates towards the ECB's objective of below, but close to, 2 per cent. For example, the financially distressed Economic and Monetary Union member countries Portugal, Italy, Ireland, Greece and Spain already had average inflation rates of more or less below 2 per cent at the beginning of the crisis.

In relation to policy matters, there is a lack of convincing evidence of high sacrifice ratios in the Euro area. The data do not support empirical evidence of overly high sacrifice ratios and hence, on average, indicate relatively modest costs of structural adjustments in the Euro area.[20] If one considers that there is or was a need for an inflation adjustment of maybe 2 per cent and the estimates indicate a sacrifice ratio of 1 per cent, then the total costs of adjustment are 2 per cent of GDP. Of course, this might be interpreted as a substantial cost.[21] Also, there might be some bias regarding the methods or the measurements of variables.

[20] Of course, this formulation requires a definition of "high costs". Although such a figure is problematic anyway, one might think of 10 per cent to 20 per cent of real GDP as a 'substantial' cost.

[21] A policy perspective might be to take a sacrifice ratio as given for a country and take action based on such a figure. Alternatively, one may think of tackling the determinants of the sacrifice ratio. Here, a related question might be whether, which and how labour (and product) market institutions affect the sacrifice ratio and in what way policy should reform these institutions. Moreover, the "quality of government" as measured by some World Bank indicators comes into play in this context as well. See Belke, Herz and Vogel (2006) and Gros et al. (2014). However, it is not the main focus of this article to deal with the question of the determinants of the sacrifice ratio. We leave this task for further research.

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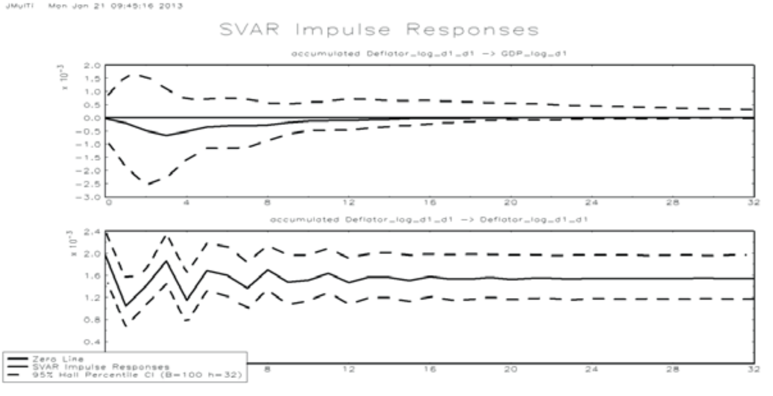
Appendix

Impulse Response Functions

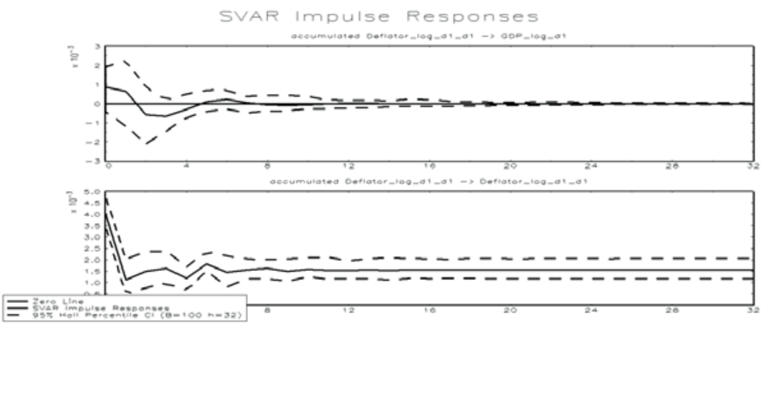
Impulse response functions following a demand shock are presented in Figure 1. The upper response functions display the cumulative effect on the GDP. The lower response functions display the effect on the inflation rate, measured by the producer prices. The units on the horizontal axis are quarterly measured periods.

Figure 1: Impulse Response Functions of the Structural Vector Autoregressive (SVAR) Model

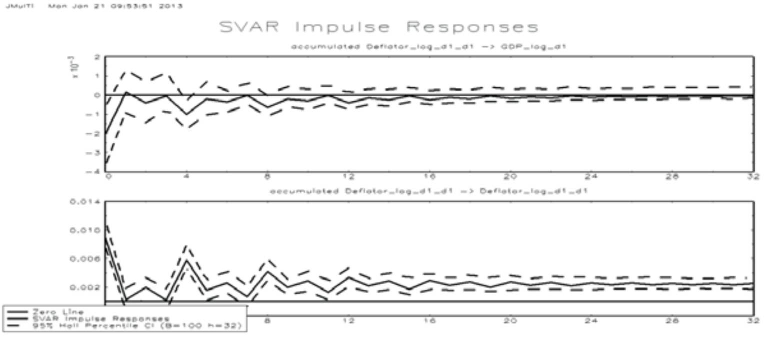
Austria:



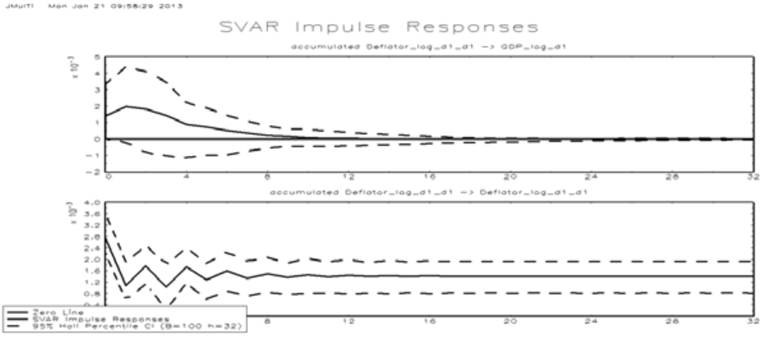
Belgium:



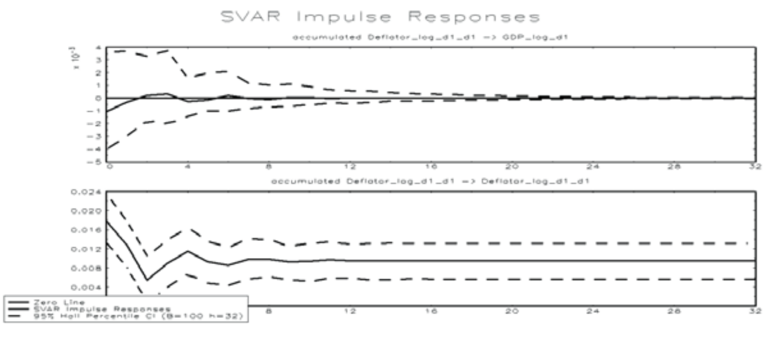
Cyprus:



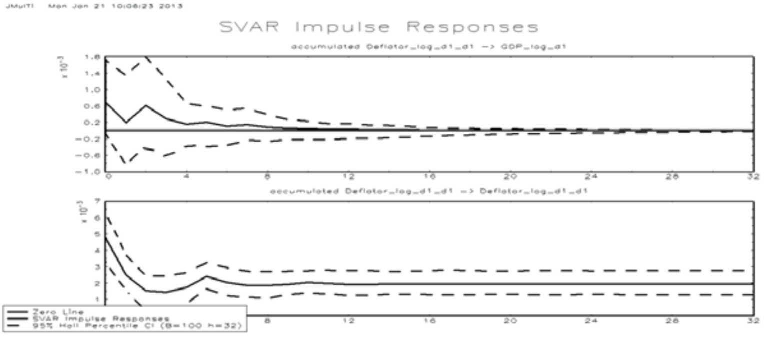
Euro area:



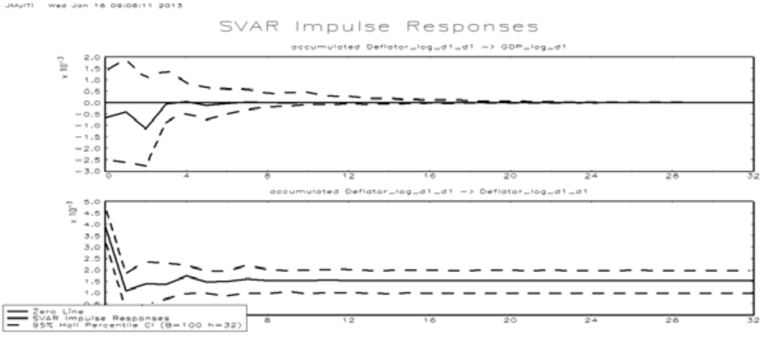
Finland:



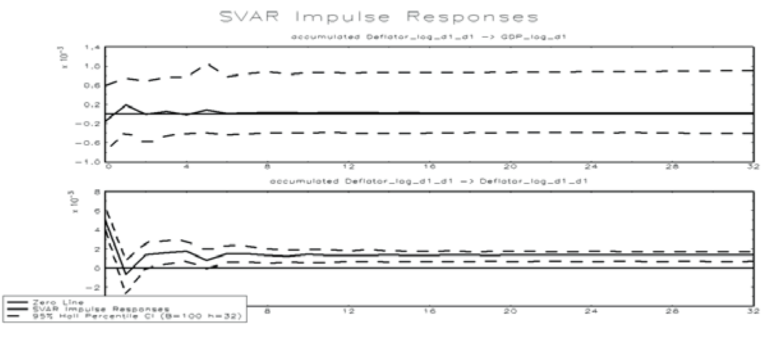
France:



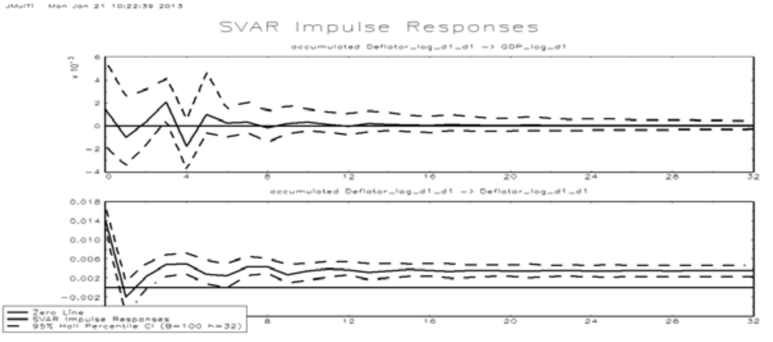
Germany:



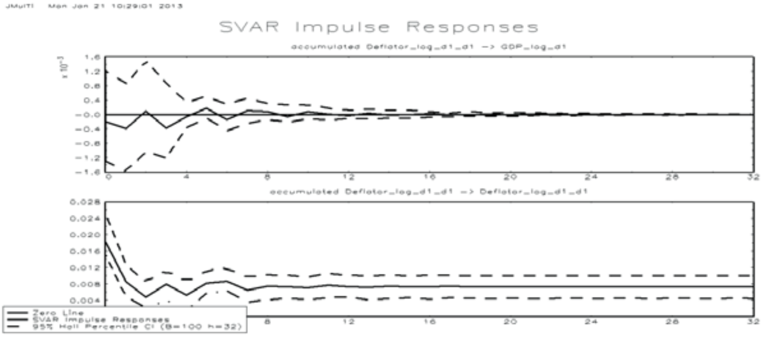
Greece:



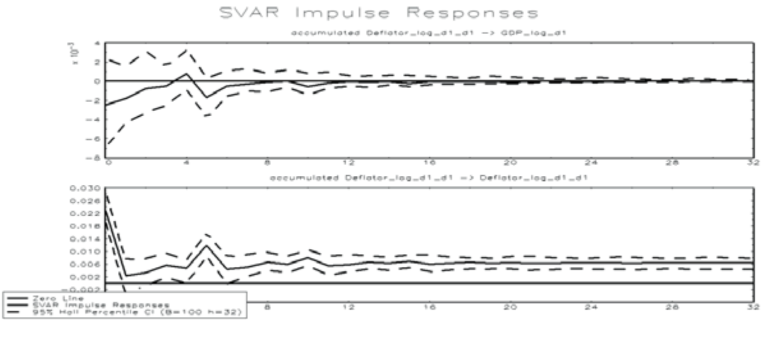
Ireland:



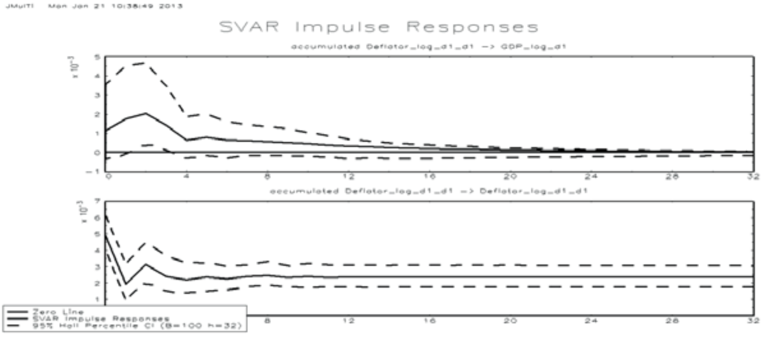
Italy:



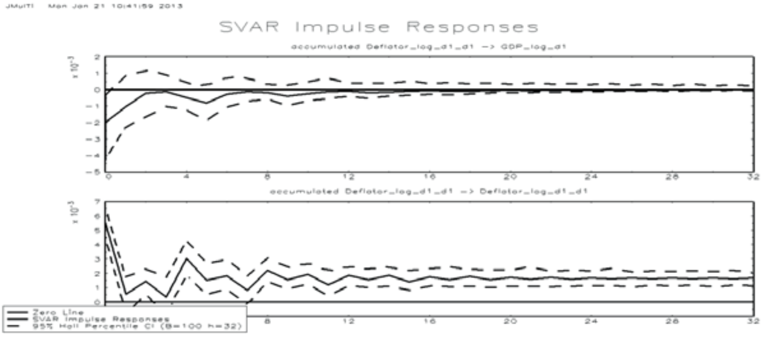
Luxembourg:



Netherlands:



Portugal:



Spain: