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A multivariate filter to estimate potential output and NAIRU for the Maltese economy

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Abstract

This paper applies a multivariate filter on a small macroeconomic model to derive estimates of Malta's potential output growth, the output gap and NAIRU. These unobservable variables are derived from a system that accounts for the interactions between output, core inflation, unemployment and foreign demand, the latter reflecting the structural characteristics of Malta as a small and open economy. The model is estimated using Bayesian inference methods on quarterly data for the period 1999-2013. The estimates from the multivariate filter are compared with those derived from a univariate filter and production function approaches. The economic and financial crisis of 2009 had a negative impact on Malta's growth potential, although there are tentative signs of a gradual recovery in 2013. On the contrary, the crisis had no permanent impact on NAIRU.

1. Introduction

Estimating potential output has always been a challenge for policymakers, especially in economies undergoing structural changes. The Maltese economy is a typical example. From around 4% in the second half of the 1990s, GDP growth decelerated to around 2% per annum over the past decade. But even this period masks considerable differences, with the economy being hit by a combination of demand and supply shocks. Real GDP growth between 2001 and 2004 was anemic, as the economy was hit by adverse demand shocks, which had a negative impact on the electronics and tourism industries, respectively. At the same time, a number of manufacturing industries were adversely affected by the liberalization policies and the dismantling of trade barriers in the run-up to EU membership. Economic activity recovered in the pre-crisis period driven by the cyclical upswing in Malta's trading partners and the diversification of the economy towards high value-added sectors, mostly in the services sector. The introduction of low cost airlines boosted the tourism industry, as it increased the connectivity of the island to mainland Europe. The economic and financial crisis of 2009 led to a sharp contraction in output but growth rebounded strongly in 2010, though it decelerated again afterwards in part due to slowdown in the euro area following the sovereign debt crisis of 2012. The latest projections by the Central Bank of Malta point to GDP growth in excess of 2.0% in the medium-term.

A number of studies have documented that financial and economic crisis have a sizeable impact on the level of potential output and that, following their occurrence, output does not revert back to its pre-crisis growth trend but rather remains permanently below it (European Commission, 2009). There are a number of factors that can affect the economy's supply capacity after a recession. On the production side, examples include the scrapping of existing capital stock due to business failures, a slowdown in investment due to high uncertainty about future prospects and tight credit conditions to firms. This process can, in turn, depress the growth rate of total factor productivity, especially if high uncertainty leads to a slowdown in private investment in research and development. On the labour market front, in addition to the erosion of skills, some workers that lose their jobs may become discouraged of finding a replacement and leave the labour force.

The implications of the recession for the growth rate of potential output and whether the economy will settle down on a lower growth path are still open issues. Estimates of potential output growth using a production function approach suggest that potential output growth in Malta has been

adversely affected by the 2009 recession (Grech and Micallef, 2013). Apart from the impact of the crisis, demographic developments represent an additional factor that will adversely affect the economy's potential output growth rate in a number of countries in the coming years, due to the shrinkage of the workforce from an ageing population. The assessment of such effects on the growth path of medium term potential output remains a key issue for economic policy analysis.

Potential output is closely associated with two other unobserved variables: the output gap and the non-accelerating inflation rate of unemployment, also known as NAIRU. The output gap, defined as the difference between the actual and potential output, relates to the state of the economy in its business cycle. A positive output gap refers to a situation in which the economy is growing above its potential. If maintained for an extended period of time, a positive output gap will lead to an overutilization of an economy's productive resources and the build-up of inflationary pressures. Such a situation is typically associated with a tight labour market, leading to intensification of wage pressures that will eventually spill over to higher prices. As a result, NAIRU refers to the unemployment rate that is consistent with stable inflation.

The uncertainty related to the measurement of these variables is due to the fact that they are not directly observed in practice and have to be inferred from the data using statistical and/or econometric techniques. In addition, different estimation methods are likely to yield different results. Another complication relates to the significant revisions to actual GDP, which tend to be particularly pronounced for the most recent quarters, as additional information becomes available to the national statistical authorities.

Potential output and the associated cyclical position of the economy also have an effect on the conduct and evaluation of fiscal policy. Recent changes in domestic and European fiscal frameworks, such as the "Fiscal Compact", place more emphasis on the calculation of the underlying fiscal position and the specification of medium-term objectives (MTO) in structural terms. In turn, independent fiscal councils in each member states are supposed to supervise domestic compliance with the new fiscal rules.

The Central Bank of Malta uses the production function approach to measure potential output (see Grech *et al*., 2013; Grech and Micallef, 2013). However, given the advantages and drawbacks of the various approaches used in the literature, central banks do not usually rely exclusively on a single estimate of potential output. The most common approach is to rely on a

production function approach and then compute alternative estimates, most likely from a statistical model, as a cross-check. Disparities across potential output estimates and comparison with those published by international institutions like the IMF and the European Commission, are often seen as an indication of the uncertainty surrounding these estimates. When available, survey data on the degree of capacity utilisation can also be used either as a check on output gap estimates or as complementary information to inform policy makers on the current state of the economy.

In light of the above, this paper develops a complementary model to calculate potential output and NAIRU and cross-check the estimates with those derived from other approaches for Malta. Preference was given to a multivariate filter, similar to the one proposed by Benes *et al*. (2010), which is commonly used in the literature. In this model, unobserved components are estimated using the Kalman filter with Bayesian inference methods. This multivariate filter is considered a hybrid approach, blending statistical filters with economic theory. This approach in fact incorporates long-standing relationships in economic theory, such as the Phillips Curve and Okun's Law. An advantage of this framework is that, in addition to potential output, the model allows for the simultaneous estimate of the output gap, NAIRU and the unemployment gap.

The rest of the paper is organized as follows. Section 2 provides a brief review of the literature on the main approaches used to estimate potential output and NAIRU. Section 3 describes the multivariate filter, including the estimation methodology and the choice of priors. Section 4 reports the empirical estimates of the permanent and cyclical components of GDP and the unemployment rate. Sections 5 and 6 compare the estimates from the multivariate filter with alternative estimates for Malta and from survey data, respectively. Section 7 reports on sensitivity analysis to assess the robustness of the estimates. Section 8 concludes and provides avenues for future research.

2. Literature Review

There are broadly three approaches in the literature to estimate potential output[2].

The first approach relies on statistical techniques to extract the trend and cyclical components of output. In general, this category can be divided into two distinct categories, univariate and multivariate ones.

Univariate approaches refer to methods which extract the trend from the information contained in the output series in isolation, without using the information contained in other variables. A very widely used approach in the estimation of potential output is the Hodrick and Prescott (1997) filter. This filter extracts a trend component by trying to balance a good fit to the actual series with a certain degree of smoothness in the trend. These approaches are deemed most useful in circumstances of bad quality or non-reliable data on certain variables needed in more sophisticated approaches. These approaches, however, suffer from a number of major drawbacks. The choice of the smoothing parameter needed for its computation is critical but ultimately arbitrary. Focusing on the US business cycle, Kydland and Prescott (1990) proposed a value of 1600 for quarterly data, which has since become an international standard. Other small economies, however, have found that different values produce more reasonable business cycles for their specific economies. For instance, Sturod and Hagelund (2012) use a smoothing parameter of 40000 in their analysis of the Norwegian economy, while a value of 7680 is proposed for quarterly Portuguese data in Almedia (2009). The filter suffers from poor reliability of the end-of-sample estimates, which limits its usefulness for estimating the current value of potential output. By definition, univariate filters take no account of economic theory or of information in other series which may help to identify the trend-cycle decomposition. They also tend to smooth structural breaks, even if these take the form of clear shifts in the level or the rate of growth of the series and, therefore, it generates misleading estimates of potential output around these periods. Moreover, the HP-filter is ill-adapted to handle the high degree of volatility manifested in the time series of very small open economies (Grech, 2013).

Another commonly used method is the band-pass filter which tries to extract frequencies corresponding to the length of the business cycle, normally two to eight years. These filters constitute a weighted moving average of past and future observations. This is implemented either

[2] A non-technical exposition of these approaches is available in Mishkin (2007).

along the guidelines suggested in Baxter and King (1999) or Christiano and Fitzgerald (2003). However, most of the criticism on the Hodrick-Prescott filter applies also to these methods.

Univariate 'unobserved component' methods are based on the concept that an unobservable variable, in this case real GDP, can be decomposed in two components that are not observable. Among the simplest models in this category is the local linear trend model (Clark, 1987). One advantage of this method is that both the permanent and cyclical components are modelled directly. The results depend, however, on the modelling assumptions used for estimating these unobserved components.

Multivariate approaches attempt to extract the trend using the information in the output series in conjunction with information contained in other variables. These techniques typically attempt to take into account empirical relationships, such as the Phillips curve and Okun's Law. In general, these methods assume that the output gap influences inflationary pressures of domestically produced goods and services and that there is a relationship between labour market tightness and the output gap. Benes *et al* (2010) apply a similar filter using GDP, unemployment, core inflation, inflation expectations and capacity utilization in manufacturing to simultaneously estimate potential output, the output gap and NAIRU.

Structural vector autoregressions (SVAR) is another commonly used approach within this category. In this approach, GDP is split into three components, a deterministic trend and disturbances or shocks that are assumed to have a permanent effect on activity (supply side shocks) and a temporary effect (demand side shocks). For instance, Blanchard and Quah (1989) use a SVAR model with long-run restrictions using data on GDP and the unemployment rate to distinguish between demand and supply shocks.

The second category is the **production function** framework, which is generally considered a useful way to explain the key economic forces underlying developments in potential output growth in the medium term. This approach provides a comprehensive economic framework for estimating potential output, with a clear link between output and its long-term fundamental determinants, namely total factor productivity and capital and labour inputs. In Grech and Micallef (2013), the latter is further decomposed into the main labour market components, like the working-age population, the trend participation rate, the structural unemployment rate and trend hours worked. But other decompositions are also possible. For example, the OECD uses a

Cobb-Douglas production function with physical capital, trend employment, human capital and a measure of labour efficiency (Johannsson et al, 2013), whereas ECB estimates using the New Multi Country Model are based on a CES production function with labour, physical capital and exogenous factor-augmenting technology (Dieppe *et al*, 2011).

The production function approach is the method used by the Central Bank of Malta for assessing supply side developments of the Maltese economy. This approach is also adopted by the European Commission for the calculation of the cyclically-adjusted fiscal balances for the purposes of the Stability and Convergence Reports (see D'Auria *et al*, 2010) and by most Eurosystem central banks for the purpose of macroeconomic projections.

The production function approach, however, also suffers from certain disadvantages. First, it raises important data problems, in particular measures of capital stock are not very reliable and data on hours of worked are often not available. Second, it requires measures of the trend components of the inputs. Different assumptions of these trend components can lead to very different estimates of potential output.

Finally, measures of potential output can also be derived using **DSGE models**. The latter are micro-founded models in which some real and nominal rigidities are used to match the macro-dynamics observed in the data (see Smets and Wouters, 2003, 2007). Removing these rigidities offers a natural way to define a measure of potential output in a model-consistent way. The model-consistent measure of potential output is thus defined as the output level that would be realised in equilibrium if prices and wages were perfectly flexible. The drawback of this approach is that, without rigidities, output – identified as "potential output" in this framework – is allowed to jump more rapidly than observed in the data and this gives rise to more volatile measures of potential output than usually obtained by other methods. Furthermore, DSGE estimates of potential output are considered to be more model-dependent.

3. The Multivariate Filter

The multivariate model developed in this paper builds heavily on similar models in the literature to estimate potential output, most notably the applications on 12 industrial countries in Benes *et al* (2010). Other similar models are Benes and N'Diaye (2004) and Nemec and Vasicek (2007)

for the Czech Republic and Sramkova *et al* (2010) for Slovakia. The model also resembles the Quarterly Projection Models developed by IMF staff (Carabenciov *et al*., 2008a, b, c). The multivariate filter consists of the following 8 equations.

The Multivariate Model

(1) $Y_t = YBAR_t + YGAP_t$

(2) $YBAR_t = YBAR_{t-1} + G_t/4 - \vartheta(UNRBAR_t - UNRBAR_{t-1}) - (1-\vartheta)(UNRBAR_{t-1} - UNRBAR_{t-20})/19 + \varepsilon^{YBAR}$

(3) $G_t = (1-\tau)G_{t-1} + \tau GSS_t + \varepsilon^{G}$

(4) $YGAP_t = \theta_1 YGAP_{t-1} + \theta_2 YGAP^{*}_{t-1} - \theta_3(PIEX4_{t-1} - \overline{PIEX4}) + \varepsilon^{YGAP}$

(5) $UNR_t = UNRBAR_t + UNRGAP_t$

(6) $UNRBAR_t = UNRBAR_{t-1} - \omega YGAP_{t-1} + \varepsilon^{UNRBAR}$

(7) $UNRGAP_t = \alpha_1 UNRGAP_{t-1} - \alpha_2 YGAP_t + \varepsilon^{UNRGAP}$

(8) $PIEX4_t = PIEX4_{t-1} + \mu_1 YGAP_{t-1} + \mu_2 \Delta YGAP_t + \varepsilon^{PIEX4}$

Equation (1) is an identity, defining GDP (Y) as the sum of two unobserved components, the trend component, the potential output (YBAR) and the cyclical component, the output gap (YGAP). Output refers to the natural logarithm of the seasonally-adjusted real GDP as published by Eurostat.

Equation (2) describes the stochastic behaviour of the trend component, YBAR, which follows a random walk with a time-varying drift. ε^{YBAR} is a shock to the level of potential output. Potential output depends on the underlying trend growth (G_t) and on changes in NAIRU. Changes in NAIRU may cause potential growth to differ from G_t, where the first difference, $UNRBAR_t - UNRBAR_{t-1}$, captures the impact of changes in the equilibrium level of unemployment on the growth rate of potential output, with ϑ being the share of labour in GDP. As in Benes *et al* (2010), the 19-quarter difference in NAIRU captures the effect of induced changes in the capital stock. This means that a one-quarter impact of a permanent 1 percentage point increase in NAIRU results in a decline in potential of ϑ percent, with the negative effect continues for an additional 19 quarters, such that the long-run decline in the level of potential output is 1 percent.

Equation (3) describes the time-varying drift in the growth rate of potential output. In the long run, the growth rate of potential output is equal to its steady state growth rate, GSS. In the short to medium term, however, it can diverge from this steady state growth rate following a shock to the growth rate of potential output, ε^G. The parameter τ determines the speed with which the economy returns to its steady state growth rate after a shock.

Equation (4) describes the dynamics of the output gap, $YGAP_t$, which is assumed to depend on its own lagged value, the lagged value of the cyclical component of foreign demand ($YGAP^*_{t-1}$) and the deviation of domestic prices from their target, which captures the importance of external price competitiveness for a small and open economy like Malta. The latter is also necessitated by the absence of monetary policy from the model. As explained in Benes *et al* (2010), the negative effect on demand from deviations of inflation from its long-term value is consistent with a broad range of monetary regimes. In an inflation-targeting regime, an increase in inflation from its target will be met by a tightening of monetary policy from the central bank, which will reduce the output gap. In the context of a fixed exchange rate regime, higher inflation will lead to an appreciation of the real exchange rate, which will eventually dampen excess demand.

Equations (5) to (7) constitute the labour market block. Equation (5) is an identity, defining the seasonally-adjusted unemployment rate as the sum of the trend component, $UNRBAR_t$ and the cyclical component, $UNRGAP_t$. The trend component refers to the NAIRU. Equation (6) describes the dynamics of NAIRU, which is modeled as a random walk stochastic process. The inclusion of the output gap in NAIRU represents a partial hysteresis effect from economy-wide demand fluctuations. Equation (7) specifies a dynamic Okun's Law, linking the unemployment gap to the output gap. The persistence of the unemployment gap is captured by the parameter α_1.

Equation (8) describes a Phillips Curve relationship to explain the dynamics of the inflation process, defined as the annual growth rate of HICP excluding energy, food, alcohol and tobacco. The lagged term, $PIEX4_{t-1}$, captures inertia and rigidity in the price adjustment mechanism and, in the absence of a suitable variable to capture forward-looking inflation expectations, also represents an adaptive process in forming expectations. The restriction of one implies the absence of a long-run tradeoff between the nominal and the real side of the economy. Core inflation is also influenced by the lagged level ($YGAP_{t-1}$) and the change ($\Delta YGAP_t$) in the output gap. The former incorporates the standard short-run tradeoff between economic activity and inflation, while the latter reflects certain rigidities in the adjustment of the economy.

Foreign demand is modeled as a first-order autoregressive process. The error terms in all equations are assumed to follow standard assumptions, i.e. are identically and independently normally distributed and uncorrelated.

2.1. Estimation

The model is estimated in DYNARE, which is a freeware software based on a collection of MATLAB routines. The sample period is 1999Q1 to 2013Q4. The following domestic variables are used: real GDP, year-on-year HICP inflation (excluding energy, food, alcohol and tobacco) and the unemployment rate. The foreign variable refers to the cyclical component of foreign demand.[3] Appendix A plots the data used in the estimation process.

The model is estimated using Bayesian inference techniques. As explained in Carabenciov *et al* (2008a, b, c), an important advantage of this methodology is the use of prior information that restricts parameters to remain within economically sensible regions. This is especially important in the case of Malta where the sample size is relatively small and the data could be uninformative about several parameters. The relative weight put by the researcher on the data and the priors depend on the tightness (e.g. the standard deviation) of the prior distribution: a tight prior distribution (e.g. a small standard deviation) puts more weight on the prior chosen by the researcher while a diffuse or non-informative distribution puts more weight on the data.

Three parameters were calibrated ex-ante. The steady-state growth rate is calibrated at 2.2%, which is equivalent to Malta's GDP growth rate over the sample period. The steady-state inflation rate is calibrated at 2.0%, broadly in line with its average over this period and the inflation target of the monetary authority. The share of labour in GDP (ϑ) is calibrated at 0.58, equivalent to the share of wages in Gross Value Added, adjusted for the share of self-employed.[4]

[3] The smoothing parameter is set equal to 1600, which is a common value for quarterly series. The foreign variable was extended by three years using projections provided by the ECB to mitigate the end-of-sample bias inherent in the HP filter.

[4] The share of compensation of employees in Gross Value Added between 1995 and 2010 stood at 51.5%. This figure, however, fails to account for the self-employed, the income of which is included in gross operating surplus and mixed income. Following Kappler (2007), the adjustment is computed as: *Unadjusted labour share x (No. of employees + No. of self-employed)/No. of employees*. The adjustment is based on average annual National Accounts data for the period 2000-2010.

2.2 Priors

The choice of priors relied heavily on similar studies in the literature, in particular to Carabenciov *et al* (2008a, b, c) and Benes *et al* (2010). The choice of prior distributions reflects restrictions on the parameters, such as non-negativity or interval restrictions. Beta distribution was used for parameters constrained on the unit interval, while the gamma distribution was chosen for parameters in R^+. Inverse gamma distribution was chosen for the standard deviation of the shock processes. Appendix B reports the prior mean, standard deviation and distribution of the estimated parameters.

The prior mean on the parameter τ, which determines how fast an economy converges to its steady-state growth rate, was set at 0.1, in line with Benes *et al* (2010). This low value assumes that the economy will only return slowly to its steady state growth rate in response to shocks, which is a reasonable assumption for an economy undergoing structural change, and in line with the similar priors set for the Czech Republic in Benes and N'Diaye (2004).

The time series properties of the latent variables depend crucially on the choice of the priors, especially the standard deviations of the shocks. In particular, the prior means for ε^{UNRBAR} and ε^{G} are key for the estimation of the NAIRU and the growth rate of potential output, respectively. For instance, an assumption of $\varepsilon^{UNRBAR}=0$ implies a completely constant NAIRU whereas higher values, say 0.4, lead to highly volatile series that is very similar to the actual unemployment rate. In line with other studies, ε^{UNRBAR} was calibrated at 0.1, which according to Gordon (1997, pg. 22), '*results in NAIRU series that exhibits substantial movements but just avoids sharp quarter-to-quarter zig-zags*'.[5] The prior mean for the standard deviation of the shock to the level of potential output was set at 0.35, in line with the concept of a relatively smooth level of potential output. Prior means for the standard deviations of potential output growth and the unemployment gap were set at 0.65 and 0.50, respectively, while those for the remaining shocks were centered at a relatively higher 0.75.

[5] Some studies opt to fix this standard deviation ex-ante at an adequate value, different from zero (Centeno *et al*, 2009).

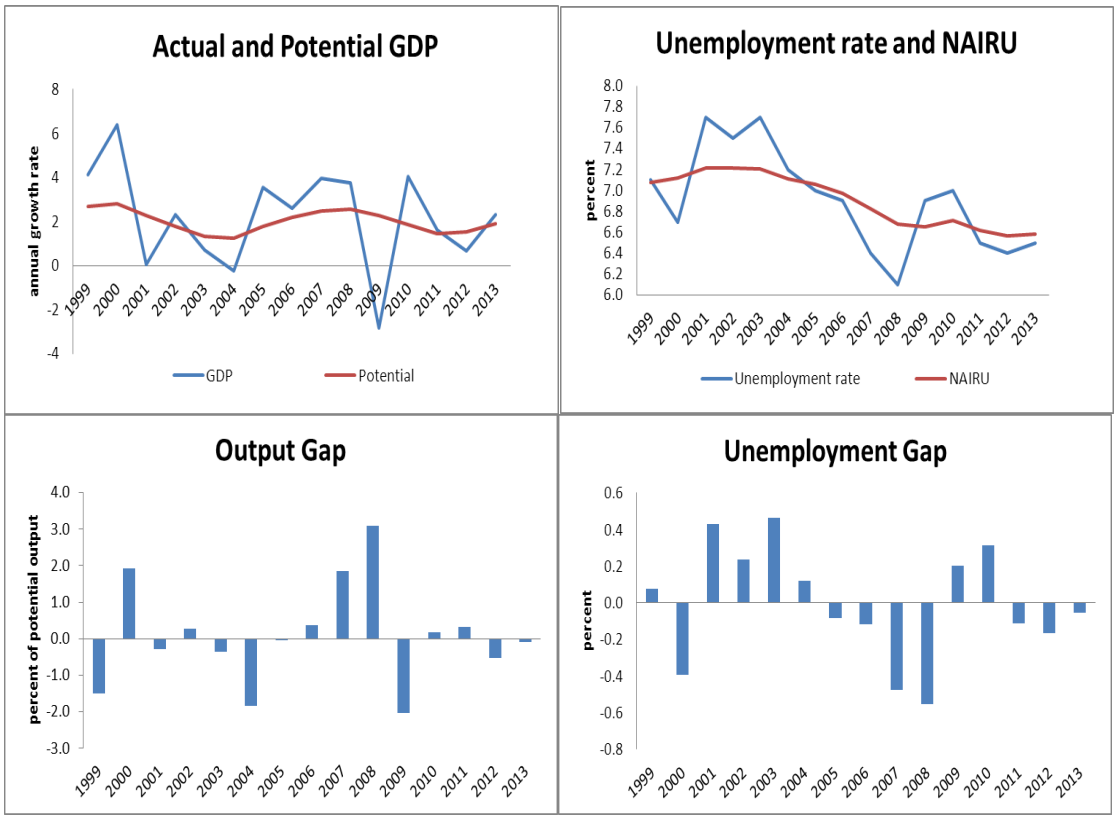
4. Empirical results

Appendix B reports the posterior means and the 5 and 95 percent confidence intervals of the posterior distribution computed with the Metropolis Hastings algorithm. The results are based on two distinct chains of 100,000 draws each, after discarding the first 20% of the draws. The average acceptance rate is around 25% for both chains, which is broadly in line with optimal acceptance rate suggested in Griffoli (2007).

The posterior mean of the parameter τ is estimated at 0.12 which implies that the impact of shocks on the growth rate of potential output is very persistent. This result is in line with the findings in the literature. In the output gap equation, the weight of the lagged output gap parameter is estimated at 0.51, which implies a moderately persistent output gap. The lagged foreign demand indicator is estimated at 0.16, which although lower than the prior mean, confirms the importance of foreign demand in shaping the dynamics of the domestic output gap. The weight of the price competitive term is around 0.05, broadly in line with the prior. Turning to Okun's Law equation, the lagged impact of the unemployment gap is estimated at around 0.62, which implies a moderately persistent unemployment gap. The elasticity of the unemployment gap to the lagged output gap is estimated at around 0.10, in line with estimates for Okun's Law in Malta presented in Micallef (2013b). In the Phillip's Curve equation, the parameters of the level and change in the output gap in the inflation equation are estimated at 0.09 and 0.14, respectively. In both cases, these estimates are lower than the priors, suggesting that the impact of domestic demand on inflation is lower than what is usually found for larger economies.

Turning to the main results, the four exhibits in Figure 1 plots the trend and the cyclical component of GDP and the unemployment rate. Although the calculations are based on quarterly data, in Figure 1 the quarterly figures have been aggregated to annual figures. As expected, the estimated potential GDP growth rate is smoother than the actual GDP growth rate, which was quite volatile in the period under consideration, ranging from 6.4% in 2000 to -2.6% in 2009. According to the multivariate filter, potential GDP growth stood at slightly less than 3% in 2000 but declined to slightly above 1% in 2004, following four years in which real GDP growth averaged less than 1% per annum. Potential GDP growth increased gradually and peaked at around 2.5% in 2007 and 2008. The financial crisis, however, had a negative impact on potential GDP growth, which stabilized at around 1 percentage point lower than its pre-crisis peak in 2011 and 2012, before recovering to slightly less than 2% in 2013.

Fig 1: Trend and Cyclical Components of GDP and Unemployment



With the economy growing less than potential for a number of years in the early 2000s, the output gap was mostly in negative territory during this period, reaching a trough in 2004. The output gap turned positive in 2007 and peaked at around 2.5% in 2008. The onset of the global recession in 2009 led to a sharp contraction in output growth, with the output gap turning sharply negative again. The speed of the recovery in Malta's output growth after the financial crisis stabilized the output gap but the slowdown in 2012 led to a reopening of a negative output gap.

Developments in NAIRU were broadly positive over the last decade, with a trend decline from above 7% in the early 2000s to around 6.5% in 2013. In particular, the effects of the recession

had only a minor and temporary impact on NAIRU due to the resilience of the domestic labour market, in particular, in terms of employment growth.[6]

The unemployment gap, the difference between actual unemployment rate and NAIRU, captures slack in the domestic labour market and broadly mirrors developments in the output gap. This gap has been broadly positive in the early 2000s due to the increase in the unemployment rate, mainly as a result of the restructuring in the manufacturing industry, especially the downsizing of the relatively labour-intensive textile and clothing sectors. The subsequent decline in the unemployment rate from around 7.6% between 2001 and 2003 to 6.1% before the onset of the financial crisis in 2008 was the result of buoyant economic activity and the restructuring of the economic base towards higher value-added activities, mostly services oriented. As a result, the unemployment gap turned negative in 2007 and 2008. The increase in the unemployment rate during the recession of 2009, with the manufacturing and tourism industries being the worst hit, led the unemployment gap to turn positive again. As the impact of the recession was less severe in Malta compared with other euro area countries, the rise in the unemployment rate started to be reversed already by 2010. As a result, the build-up of the positive unemployment gap during the recession was short-lived and the cyclical component of the unemployment rate returned to slightly negative levels between 2011 and 2013.

While the two cyclical indicators – the output and unemployment gaps – tend to move in synch in opposite directions, the output gap is much more volatile than the unemployment gap. This is to a large extent influenced by the fact that over the past decade, the volatility of output was much pronounced than that of the unemployment rate, which, despite the large shocks hitting the economy over this period, fluctuated between the relatively narrow range of 6% to 8%.

A word of caution is warranted in the interpretation of the results. As with most econometric models, the results are naturally conditioned on the underlying system of equations, in particular, the standard deviations of the shocks of the unobserved variables. In addition, estimates of these unobserved variables may change as additional data becomes available. Rather than focusing on point estimates *per se*, it is advisable to use these estimates in conjunction with those obtained from other approaches to provide a range of possible estimates. This range will serve to highlight the unavoidable uncertainty associated with the estimation of these unobserved variables,

[6] See Micallef (2013a) for an analysis of the main factors underpinning the resilience of the domestic labour market after the crisis.

especially in real time. A similar exercise, comparing the above results with those obtained from alternative approaches, is conducted in the next section.

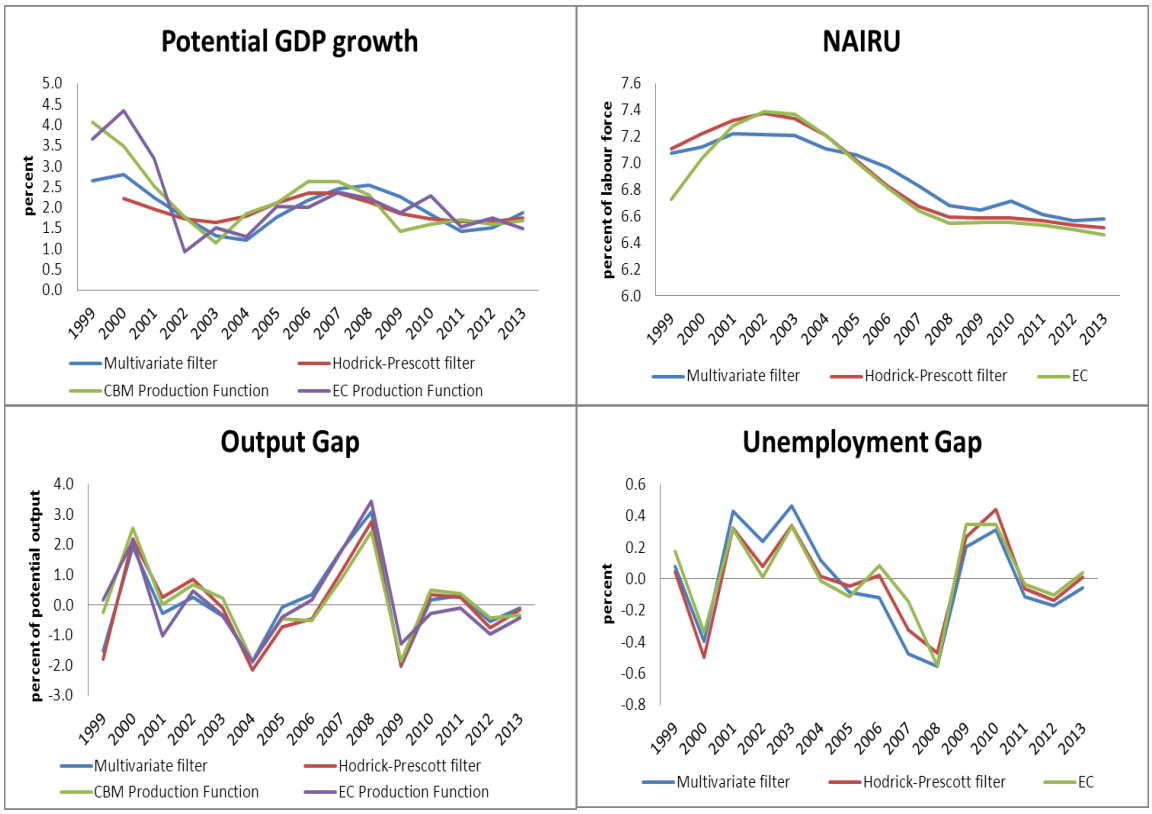
5. Comparison with alternative approaches

Figure 2 compares the trend and cyclical estimates of GDP and the unemployment rate from the multivariate filter with three alternative approaches. The first is a univariate filter, the HP filter, which is one of the most common filters used in the literature, using a smoothing parameter of 1600. The other two refer to the estimates by the Central Bank of Malta and the European Commission, both of which use a production function approach to estimate potential output. The Bank's estimates are those published in the context of the December 2013 Broad Macroeconomic Projection Exercise, while the Commission's estimates refer to the Winter 2013 projections.

With the exception of the late 1990s and early 2000s, the various approaches point towards broadly similar dynamics of potential output growth. All four approaches show a decline in potential output growth in the early 2000s from the level prevailing in the late 1990s. The recovery in potential output growth peaked during 2007 and 2008 before it was negatively affected by the recession of 2009. Despite some differences in point estimates, all approaches indicates that, after the recession, potential output growth remained subdued and did not recover to the pre-crisis growth rates. The methods give somewhat conflicting results for 2013, with the multivariate filter suggesting a recovery in potential output growth to slightly less than 2%, whereas the other approaches indicate a broadly unchanged potential growth rate in the range of 1.5% to 1.7%.

All four approaches yield relatively similar stories about the dynamics of the business cycle in Malta. There are two periods in which the economy was operating above potential, the first one in 2000 and the other one in the pre-crisis period. All indicators suggest that the output gap stabilized relatively quickly after the recession of 2009 before the economy started to operate below potential again following the slowdown in economic activity associated with the re-intensification of the recession in the euro area due to the sovereign debt crisis. All estimates point towards a gradual narrowing of the output gap in 2013, though it still remained in slightly negative territory.

Fig 2: Comparison across alternative methods



The four alternative methods point to broadly similar developments in NAIRU though point estimates differ somewhat, especially in the beginning of the sample. NAIRU increased gradually in the late 1990s reaching a peak in the early 2000s of between 7.2% to 7.4%. From 2003 onwards, all approaches point to a downward trend in NAIRU which was briefly interrupted by the 2009 recession. According to the multivariate filter, the recession led to a slight, though temporary increase in NAIRU whereas the HP filter and the estimates by the European Commission remained relatively flat. Estimates of NAIRU for 2013 are broadly similar across the different approaches, at around 6.5% to 6.6%. The similarity of the NAIRU estimates is in turn reflected in very similar dynamics of the unemployment gap, with a slight exception for the period 2001-2003.

6. Comparison with survey data and other indicators

Another possibly important source of information on the cyclical position of the economy is from the business surveys. This section tries to link developments in the cyclical component of GDP, the output gap, with survey indicators from the European Commission. For Malta, monthly survey indicators are available from November 2002 and quarterly indicators from 2003Q1. Other well-known monthly indicators, like the Purchasing Managers' Index (PMI), are not available for Malta.

The Commission's Economic Sentiment Indicator (ESI) is a composite indicator made up of five sectoral sub-indices with different weights for industry, services, consumers, construction and retail trade.[7] Figure 3 plots the four quarter moving average of the ESI, advanced by one quarter, with the four quarter moving average of the output gap derived from the multivariate filter. The use of moving averages is intended to filter out the noise in the series, thereby focusing on the underlying movements in both variables.

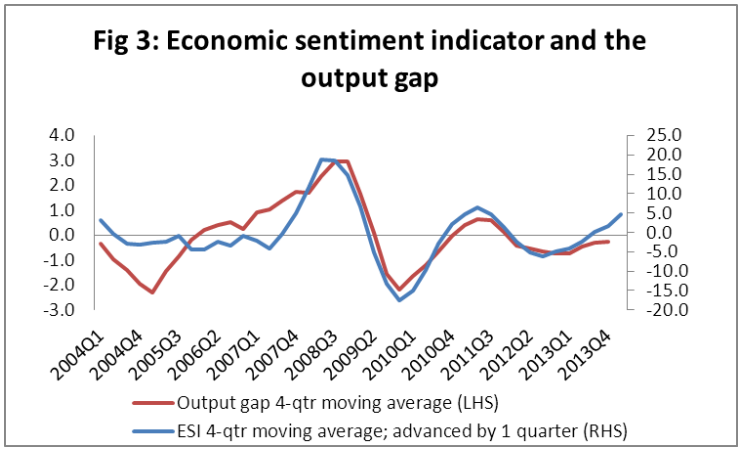


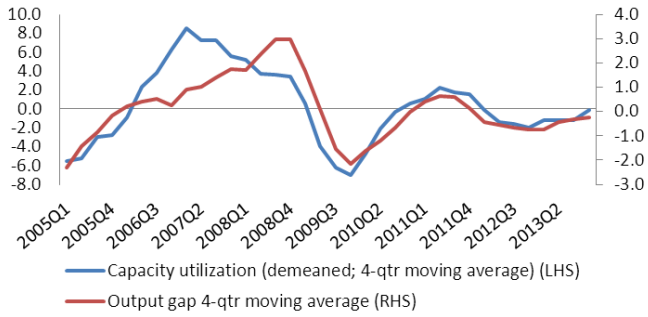
Figure 3 shows that the ESI is a good leading indicator of the cyclical position of the Maltese economy, as represented by the output gap. In particular, the ESI has accurately captured the turning points of the pre-crisis period, the recession of 2009, the ensuing recovery and the

[7] Confidence indicators are arithmetic means of seasonally adjusted balances of answers to a selection of questions closely related to the reference variable they are supposed to track (e.g. industrial production for the industrial confidence indicator). Surveys are defined within the Joint Harmonized EU Programme of Business and Consumer Surveys. The ESI is calculated as an index with mean value of 100 and standard deviation of 10 over a fixed standardised sample period. Data are compiled according to the Statistical classification of economic activities in the European Community (NACE Rev. 2).

slowdown associated with the European sovereign debt crisis. If the past relationship between the two series is maintained in the future, the latest information from survey statistics suggest that the negative output gap will close down and turn positive in 2014.

Another commonly used indicator is capacity utilization in industry. More specifically, industrial companies are asked the following question: *At what capacity is your company currently operating (as a percentage of full capacity)?* Figure 4 plots the four-quarter moving average of the deviation of capacity utilization from its long-run average with the output gap. Contrary to the ESI, however, this indicator is more of a coincident indicator and its relationship with the output gap was quite weak in the pre-crisis period, although it has tended to track the business cycle dynamics relatively well since 2009. According to this indicator, the industry capacity utilization has been broadly in line with its long-run average at the end of 2013, suggesting a broadly balanced output gap.

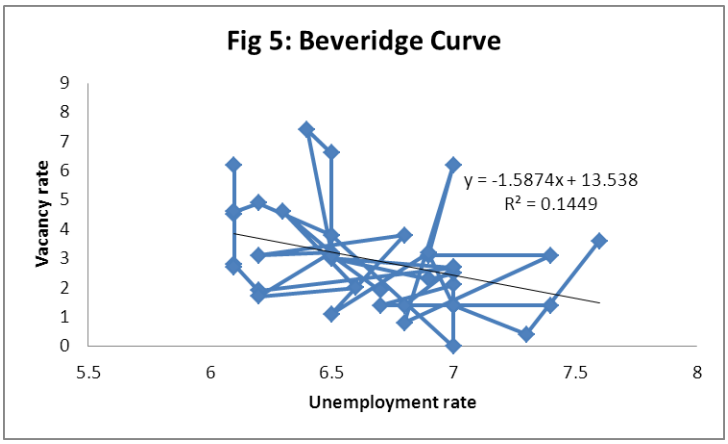
Fig 4: Capacity utilization and the output gap



Turning to the labour market, the downward trend in NAIRU is consistent with the declining share of trade union membership and the share of labour in gross value added. For instance, according to Baldacchino and Gatt (2009), the share of private sector employees covered by a collective agreement declined from 32.9% in 1995 to 26.7% in 2008. The share of labour in gross value added declined from 53% in 1995 to 51.5% in 2013.

A commonly used indicator to gauge the efficiency of the labour market in matching the demand for and supply of jobs is to analyze possible shifts in the Beveridge curve. The latter measures the relationship between the unemployment rate and vacancy rates. Demand shocks are expected to result mainly in movements along a stable downward sloping relationship between

unemployment and vacancies, whereas structural shifts in the relationship, for instance, due to changes in the efficiency of the matching process or in the job destruction rate would imply persistent shifts of this downward-sloping curve. For instance, there is evidence pointing towards an outward shift in the Beveridge curve for countries that were severely affected by the crisis (Arpaia and Turrini, 2014; Bonthuis *et al*, 2013). Figure 5 plots Beveridge curve for Malta using quarterly data for the period between 2004 and 2013. In the absence of a sufficiently long time series on vacancies in Malta, the vacancy data has been proxied using the European Commission's survey data concerning the question on *"factors limiting production: labour"*, which is strongly correlated with actual vacancy data.[8]



Abstracting from the quarterly noise in the curve, Figure 5 confirms the existence of a downward sloping curve between the vacancy rate and the unemployment rate in Malta.[9] The absence of a persistent shift to the right indicates no permanent distortions in the labour market matching process at an aggregate level.[10] The share of long-term unemployed as a percent of total unemployed, which is another indicator that is commonly associated with structural unemployment, declined from 66% in 2000 to 45% in 2013. This indicator has remained broadly stable in recent years, contrary to developments in the euro area, which has seen a rise in this share due to persistent increases in the unemployment rate after the 2009 recession and the sovereign debt crisis, with possible effects on the structural unemployment rate. Taken together,

[8] A similar approach is used for Arpaia and Turrini (2014) and Bonthuis *et al* (2013)
[9] Despite the relatively low R^2 value, both the intercept and the slope of the regression in Figure 5 are statistically different from zero at the 5% level of signficance. The Jacque-Bera test and the Durbin-Watson test confirms that the residuals are both normally distributed and do not suffer from serial correlation, respectively.
[10] This does not mean that skill-mismatches are not present in selected industries. See Micallef (2013a) for a discussion on this issue.

these indicators suggest that the 2009 recession did not have a long-lasting impact on the domestic labour market, which is consistent with the results of the multivariate filter.

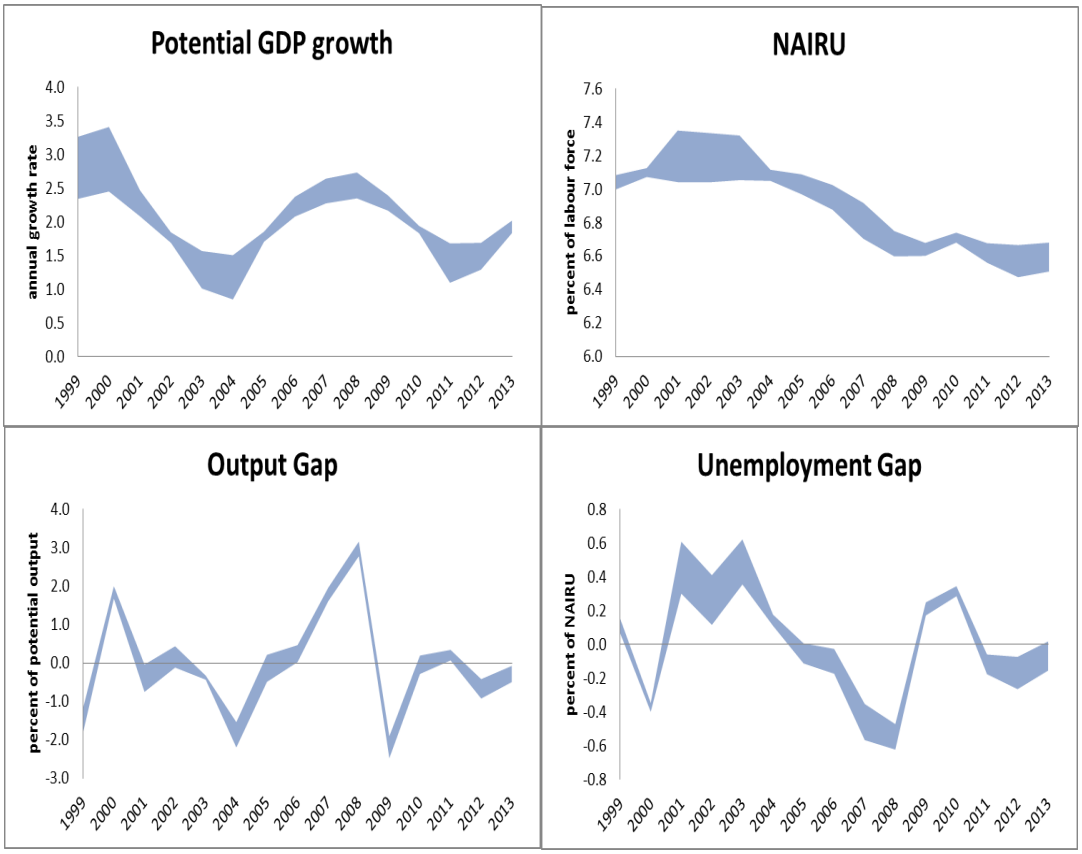
7. Sensitivity analysis

Due to their unobservable nature, estimates of potential output and NAIRU are surrounded by a high degree of uncertainty. In the context of a multivariate filter, the dynamics of the unobservable variables could be very sensitive to the priors of the shock processes, especially the ones for the stochastic processes of trend potential output growth (ε^{G} in equation 3) and NAIRU (ε^{UNRBAR} in equation 6). To assess the sensitivity of the results to these priors, these were changed in several ways and the model re-estimated in each of them.

Eight different cases were considered. The prior mean for the disturbance ε^{G} was set at 0.2 and 0.6, respectively. In two separate cases, the prior mean for the disturbance ε^{UNRBAR} was set at 0.05 and 0.15, respectively. A version of the model was estimated by omitting the Phillips curve (equation 8) from the system, thereby focusing solely on the output-unemployment block. In another version, the prior on the parameter τ was increased from 0.10 to 0.25, thereby reducing the speed with which the economy returns to the steady state after a shock. Finally, a version of the model was estimated by reducing the 20-quarter change in NAIRU that features in the level of potential output (equation 2) to 12-quarters and in another one, by eliminating this term completely.

Figure 6 displays the range of estimates for the permanent and cyclical components of GDP and unemployment to the different specifications of the model. Despite some uncertainty surrounding point estimates, the results of the sensitivity analysis exercise broadly confirm the findings and main conclusions of section 4, which compares the estimates from the multivariate filter from alternative approaches. In particular, the recession of 2009 had a negative impact on Malta's potential output growth although there are encouraging signs of recovery in 2013, although it still remains lower than in the pre-crisis period. All model variants point to a narrowing of the output gap in 2013. Finally, NAIRU has been trending downwards for the large part of the last decade and the sensitivity analysis confirm that the 2009 recession had no permanent effect on the structural unemployment rate.

Fig 6: Sensitivity analysis



Note: the range plots the maximum and minimum values from the different model specifications.

8. Concluding remarks

Given the uncertainty surrounding estimates of potential output, the output gap and NAIRU, it is always prudent for a central bank to base its assessment on a suite of models rather than rely solely on one method. Assessment of demand and supply pressures should also be based on expert judgment and, when available, supplementary indicators. In this paper, a multivariate filter was applied on a small macroeconomic model to derive estimates of Malta's potential output growth, the output gap and NAIRU. These unobservable variables were derived from a system that accounts for the interactions between output, core inflation, unemployment and foreign demand, reflecting the structural characteristics of Malta as a small and open economy. In turn, these estimates were compared with those derived from alternative approaches, including the

production function approach used by the Central Bank of Malta for its regular economic projections and survey data.

Several interesting and policy relevant results are worth highlighting. First, the multivariate filter confirms the significant changes in Malta's potential output growth and NAIRU over the past decade. In particular, the 2009 recession had an adverse impact on potential output growth, which dropped from around 2.4% to 2.6% before the crisis to less than 2%. However, there are tentative signs of recovery in Malta's potential output growth in 2013, though it still remains below the pre-crisis growth rates. On the contrary, NAIRU has generally been on a downward trend over the past decade and various estimates suggest that the crisis had no permanent effect on the structural unemployment rate. This is clearly at odds with the experience of other European economies.

As stated in Grech and Micallef (2013), to tackle the slowdown in potential output growth, more effort is needed to create a better business environment and reduce bureaucracy to lay the conditions to sustain more start-ups and attract new businesses to Malta. This is even more important in the context of an ageing population, in which the economy's growth potential cannot be sustained simply through higher labour inputs. Policymakers should continue to put in place the right mix of incentives for more people to join and remain longer in the labour force. The diversification of the economic base towards high-value added activities, mostly in the services sector, requires further investment in improving the quality of human capital and increase labour market flexibility. Finally, policymakers need to continue to pursue structural reforms that lead to an improvement in productivity and increase the flexibility of the economy to deal with economic shocks.

Going forward, the model could be further refined and expanded in a number of dimensions, in line with research underway on similar models by the IMF. Avenues for future research include the introduction of additional channels, such as interest rates, the exchange rate, oil and trade linkages as in Carabenciov *et al* (2008 a, b, c). A more detailed labour market specification, including data on, for instance, participation rates and population growth, could also be envisaged. This will be left for future research.

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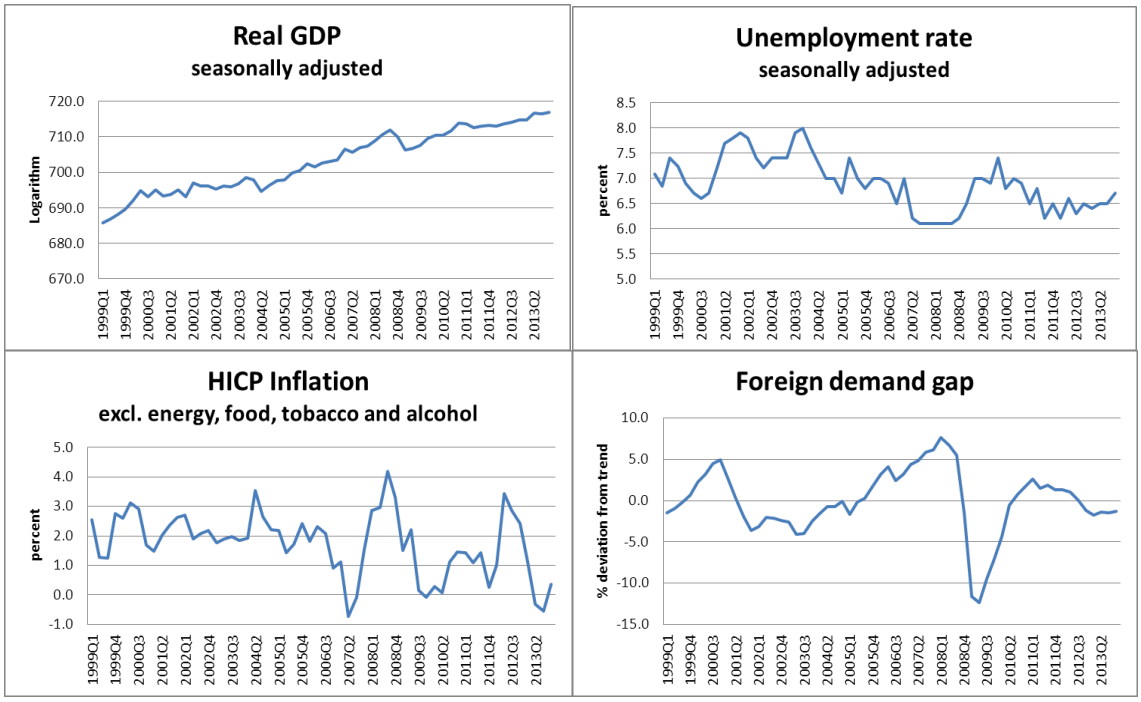
Appendix A: Historical data



Appendix B: Estimated parameters and shocks

Estimation Results

	Prior			Posterior		
Parameter	**Distribution**	**Mean**	**St.Dev.**	**Mean**	**Conf. Interval**	
τ	beta	0.10	0.05	0.12	0.03	0.19
θ_1	beta	0.70	0.10	0.51	0.35	0.66
θ_2	gamma	0.35	0.10	0.16	0.10	0.22
θ_3	gamma	5.00	3.00	6.69	1.11	11.75
ω	gamma	3.00	1.50	2.08	0.55	3.57
α_1	beta	0.70	0.10	0.62	0.47	0.77
α_2	gamma	0.15	0.05	0.09	0.05	0.14
λ_1	gamma	0.15	0.10	0.11	0.02	0.19
λ_2	gamma	0.15	0.10	0.18	0.02	0.33
ρ_{YGAP*}	beta	0.70	0.10	0.81	0.73	0.89
Standard deviation of shocks						
ε^{YBAR}	inv_gamma	0.35	inf	0.86	0.12	1.41
ε^{G}	inv_gamma	0.65	inf	0.41	0.16	0.68
ε^{YGAP}	inv_gamma	0.75	inf	0.87	0.32	1.34
ε^{UNRGAP}	inv_gamma	0.50	inf	0.27	0.22	0.32
ε^{Π}	inv_gamma	0.75	inf	0.82	0.69	0.94
ε^{YGAP*}	inv_gamma	0.75	inf	1.99	1.68	2.27