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September 24, 2003

Abstract

We propose a new unifying approach to estimate Nairu, output gaps, and structural budget balances in the same model. A structural VAR model, designed to take the non-stationarity of European unemployment into account, is applied and we provide Swedish evidence and compare with OECD estimates.

Keywords: Nairu; Output gap; Structural budget balance; Structural VAR

JEL: C32; E23; E24; E32; E62

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1 Introduction

Policy makers and economists of national governments and at the OECD, the IMF, and the EU, for example, often focus on three unobservable variables: the NAIRU, the output gap, and the structural budget balance. If correctly estimated, all three provide crucial information to both politicians and central bankers. Numerous ways have been proposed to estimate these important variables, but the profession seems to be far from a consensus.¹

Although the approaches differ, they share the common aim to remove business-cycle effects from the observed times-series for unemployment, output, and the budget balance. Even though the effects of the same business cycle are to be removed, the three unobserved variables have, to the author's knowledge, only been estimated in the same model once before; see Chapter 4 in Hokkanen's (1998) thesis for an unobservable-components approach. For example, the so-called production-function approach (see, e.g., Mc Morrow and Roeger, 2001) uses the NAIRU (estimated elsewhere or just assumed) to estimate the output gap. Another example is Giorno et al (1995), who estimate the structural budget balance from information on the output gap (which, in turn, depends on a separate NAWRU² estimate) and on spending/tax elasticities estimated in different models.

As we are dealing with the same business cycle, we believe that, if possible, the variables in question should be estimated in a single model. One step in this direction is


²Non Accelerating Wage Rate of Unemployment.
taken in the papers by Apel and Jansson (1999a, 1999b), who estimate the NAIRU and the output gap in the same model using an unobservable-components approach. In this paper, we go a step further and estimate structural budget balances in the same model as well. We make use of a structural VAR (SVAR) approach and the Blanchard and Quah (1989) identification method to extract labor market, productivity, and business-cycle shocks. The identification is supported by the impulse-response functions and, as will be discussed in Section 2, the model is designed to take the non-stationarity of European unemployment into account. The method is exemplified in Section 3 on Swedish yearly data covering the period 1950-2004 and compared with estimates published by the OECD.³ We present our conclusions in Section 4.

2 The model

SVAR-modelling in the spirit of Blanchard and Quah (1989) makes use of long run restrictions based on economic theory in order to identify structural shocks. Originally, Blanchard and Quah estimated a VAR system consisting of two variables: output and unemployment. Accordingly, the shocks were labelled supply and demand shocks, respectively, and the restriction was imposed that only one of the two shocks – the supply shock – has long-run effects on output.

SVAR models have previously been used to estimate output gaps (see Cerra and Saxena, 2000, Funke, 1997, Scott, 2000, and St. Amant and van Norden, 1997). The variables included in the different applications differ but in every case the main objective

³We include the forecasts made by the National Institute of Economic Research (NIER, December, 2002) for the period 2002-2004.
is to remove fluctuations due to demand conditions from the output series in order to determine potential output (and thereby the output gap). For example, Funke (1997) includes manufacturing output and inflation for Germany in his model. The system is hence driven by two shocks and, with the restriction that one shock has no long-run effects on output (like Blanchard and Quah, 1989), he identifies the shocks as supply and demand shocks. Potential output is then calculated by historical decomposition addressing the question: what would the output series look like in the absence of demand shocks? In this paper, we will make use of historical decomposition to calculate NAIRU, output gaps, and structural budget balances simultaneously.

2.1 Identification

Our model consists of three variables: unemployment (u), GDP (y), and the budget balance (bb). Traditional unit root tests suggest that u and y are non-stationary while bb is stationary (see Hjelm, 2003). The data is displayed in Figure 1.

The stationary vector of the variables at hand is hence: \[ \dot{x}_t = \mu + C(L) \varepsilon_t, \] and the structural moving-average representation of the system is given by:

where \( \dot{x}_t = \vec{c}_x \) is a 3\times1 vector of constants, \( L \) is a lag operator, and \( \varepsilon_t = \begin{bmatrix} \varepsilon_{t}^{LM} \\ \varepsilon_{t}^{P} \\ \varepsilon_{t}^{BC} \end{bmatrix} \) is a vector of (by assumption) orthogonal, unobserved structural shocks. For many European countries, we believe that the following identification scheme (including the necessary three assumptions) is a fair description of reality:

(i) Labor Market Shock (\( \varepsilon_{t}^{LM} \)): Owing to factors like changes in social security systems, the structure of the economies, demography, and hysteresis, the vertical long-run Phillips
Figure 1: The data: official unemployment rate, GDP, and the consolidated budget balance (base year 2002). Time period: 1950–2004.
curve has shifted in many European countries. This shock corresponds to such shifts and, as the level of GDP is closely related to the labor market, it is allowed to affect both unemployment and GDP in the long run.\footnote{As the budget balance is stationary, there are, by definition, no long-run effects on this variable for any of the shocks.}

(ii) Productivity Shock ($\varepsilon_t^P$): This shock concerns shifts in the aggregate supply curve due to productivity shocks. While allowing such shocks to have long-run effects on GDP, we assume that there are no long-run effects on unemployment. Hence, our model suggests that, over the long run, the level of unemployment is determined only by the structure of the labor market, not by the development of productivity.

(iii) Business-cycle Shock ($\varepsilon_t^{BC}$): This shock is a traditional business-cycle shock and we assume that it has no long-run effects on neither unemployment nor GDP. By imposing the three mentioned long-run assumptions, we have the following long-run representation of equation (1):

\[
\begin{align*}
\varepsilon_{ut} & = P_{k=0}^1 c_{11}(k) \varepsilon_{LM}^t + \mu_u \\
\varepsilon_{yt} & = P_{k=0}^1 c_{21}(k) \varepsilon_{LM}^t + \mu_y \\
bb_t & = P_{k=0}^1 c_{31}(k) \varepsilon_{LM}^t + \mu_{bb}
\end{align*}
\]

where $P_{k=0}^1 c_{ij}(k) \varepsilon_{LM}^t$ is the long-run effect of labor-market shocks on $\varepsilon_{ut}$ etc. It is well known that the identifying assumptions in SVAR-models cannot be tested statistically. We can, however, examine how the variables respond to the shocks. If they respond as we would expect from the labelling of the shocks, support (but no proof) is provided for the identification (and interpretation) of the system. Our model satisfies this criteria for all combinations of variables and shocks, see Figure 2.
2 $u$ responds positively, while $y$ and $bb$ respond negatively to an adverse labor-market shock;

2 $u$ responds negatively, while $y$ and $bb$ respond positively to a favorable productivity shock;

2 $u$ responds negatively, while $y$ and $bb$ respond positively to a favorable business-cycle shock.

Hence, all responses are consistent on the identification (and thereby interpretation) of the model. Finally, we obtain our three unobservable variables by calculating the historical decomposition. (i) Nairu: what would the unemployment series look like in absence of productivity and business-cycle shocks? (ii) Potential GDP ($y^\pi$): what would the GDP series look like in absence of business cycle shocks? The output gap is then calculated using the formula: $\frac{y}{y^\pi} - 1 \times 100$. (iii) Structural budget balance ($sbb$): what would the budget balance series look like in absence of business-cycle shocks?

3 Swedish evidence and OECD comparison\textsuperscript{5}

Yearly data for the period 1950–2004\textsuperscript{6} is applied.\textsuperscript{7} We believe it is unlikely that the data-generating process for unemployment during the 1990s (see the mid-left graph of Figure 5) The OECD uses three different models to estimate the three unobservable variables (see Giorno et al, 1995, and Richardson et al, 2000). Values are taken from the Economic Outlook, various issues.

\textsuperscript{5} Of course, only realized data could be used - that is ending in 2002. We compare, however, with the longest available series supplied by the OECD which includes forecast up to 2004.

\textsuperscript{6} We use four lags which implies that the null of no (multivariate) autocorrelation and (multivariate) normality, respectively, could not be rejected using standard significance levels (see Lütkepohl, 1993).
Figure 2: Impulse response functions of unemployment (u), GDP, and the budget balance (bb) to the three structural shocks (‘years’ on the horizontal axis)
1) is the same as for the rest of the sample. We therefore include a dummy variable to account for the extreme changes in unemployment during 1993–2000.  

3.1 Output gap

The left column of Figure 3 shows the SVAR-estimates for the whole period while we concentrate our comments on the right column which compares with the OECD estimates for the period 1980–2004. Beginning with the output gap, the SVAR-gap is somewhat less volatile in general (see the upper-right graph of Figure 3). From 1993 and onwards, the two gaps are very similar. Which gap is best then? Well, one important usage of output gaps is their ability to predict inflation and, it turns out, that the two gaps are similar in this respect. More specifically, it is often believed that, for yearly data, a positive gap in \( t \) implies higher level of inflation in \( t + 1 \). A simple Phillips curve, augmented for expected inflation, could be expressed as (see Coe and McDermott, 1997):

\[
\pi_t = \alpha_0 + \pi_t^e + \sum_{i=0}^{\infty} \beta_i \text{gap}_{t-i} + \varepsilon_t,
\]

DeSerres and Guay (1995) show that when some shocks only have temporary effects on one of the variables, the VAR representation will in general contain an MA term which implies that the number of lags required to generate a fair decomposition of the structural shocks and the dynamics increases. We believe four yearly lags fulfills this requirement in our application.

8 Parallel results not using the dummy can be found in Hjelm (2003). The unemployment variable is in first differences, and the size of the following dummy is determined by the size of the change in the variable in the respective years and: \( D_{1993} = 1, D_{1998} = 0.5, D_{1999} = 0.25, D_{2000} = 0.25 \). The dummy is significant at the 1% and 10% levels, respectively, in the \( \zeta_u \) and \( \zeta_y \) equations (t-values: 4.0 and 1.8, respectively) but insignificant in the \( \zeta_b \) equation (t-value: 1.4).
where $\pi$, $\pi^e$, and $\text{gap}$ is inflation, inflation expectations in $t$, and output gap, respectively. We allow for a flexible degree of adaptive expectations ($\pi^e = \alpha_1 \pi^e_{t-1}$) and, based on pre-testing of lag length, the gap is measured in $t - 1$. Hence, the following equation is estimated for the two output gaps:

$$\pi_t = \alpha_0 + \alpha_1 \pi^e_{t-1} + \alpha_2 \text{gap}_{t-1} + \varepsilon_t.$$  

The sensitivity of inflation to the two different output gaps is similar. $\alpha_2$ equals 0.31 (p-value 0.07) in the SVAR-model and 0.40 (p-value 0.01) in the OECD-model. Hence, an output gap of 1% in year $t$ implies an increase in the inflation rate by 0.31 to 0.40 percent in $t + 1$, according to the two models. Finally, we may note that the OECD-model implies slightly higher $R^2$ compared to the SVAR-model (0.71 compared to 0.68).

### 3.2 Nairu

Turning to the Nairu, both SVAR and OECD implies that actual unemployment was higher than the Nairu in the beginning of the 1980s and during the second half of the 1990s while unemployment was lower than Nairu in the late 1990s, see the mid-right graph of Figure 3. One can also note that the OECD predicts a higher Nairu from 1986 and onwards but the differences are rather small between 1993-2004. The Nairu is predicted to be about 0.3 percentage points higher in the SVAR model during 2003-2004 with, compared to the OECD estimates, implies somewhat greater labor market tightness.
3.3 Structural Budget Balance

Finally, focusing on the structural budget balance, the SVAR and the OECD give a similar picture, even though there are some important differences (see the bottom-right graph of Figure 3). During the 1990s, a larger share of the total deficit is explained by the business cycle in the SVAR-model. When the actual deficit peaked in 1993 (11.6%), the SVAR-model devotes 4.7% to structural factors while the OECD counterpart is 6.7%. One important reason for this result is that the SVAR-model implied a smaller increase in the Nairu which is an important structural factor determining the size of the structural deficit. In the end of the sample, there greater similarities between the two estimates and for the period 2003–2004, the Swedish government’s explicit goal of 2% surplus over a business cycle is not reached.

3.4 Interpretation of the structural shocks

As mentioned above, the historical decomposition used to calculate the three variables above depends on the structural shocks. One benefit of using a SVAR approach is that one can analyze these time series of structural shocks (i.e., labor-market, productivity, and business-cycle shocks). By inspecting the calculated time series of the these shocks, we get information about their timing and relative magnitude. For example, by analyzing the shocks in the beginning of the 1990s we get some information of the causes of the deep recession during this period. It is important to remember, however, that the relationship between the variables and the shocks are not that straightforward because some shocks are allowed to have an long run impact on some of the variables. This implies, for example, that all labor-market shocks except those after year $t$ (see Figure 4), influence the NAIRU
in year $t$. Their relative importance are determined by (a) the magnitude of the relevant impulse-response function (see Figure 2) and (b) the size of the shock (see Figure 4).

In the calculation of the NAIRU, the labor-market shocks are the only ones having an effect, as neither productivity nor business-cycle shocks are assumed to have any impact on unemployment in the long run. Acknowledging that positive shocks correspond to unfavorable changes in behavior on the labor market, we see in Figure 4 that the periods 1990-1992 and 1995-96 were characterized by relatively large unfavorable labor-market
shocks. We can also note the series of favorable (i.e. negative) labor-market shocks during the end of the sample period; these partly explain the reduction of the NAIRU estimates in the end of the sample period.

Productivity shocks are allowed to have long-run effects on GDP. It is interesting to note that productivity shocks do not appear to have played a significant role in the crises in the early 1990s. Several favorable productivity shocks occurred in the end of the sample. This is promising for the future as the effects of these shocks (most notably, the increase of potential GDP) will carry on for several years after 2004.9

Finally, the business-cycle shocks are relatively large and negative in the beginning of the 1990s. By comparing the business-cycle shocks for the 1960s and 1990s, one can easily understand the different macroeconomic outcomes. In the 1960s, the vast majority of the business-cycle shocks were favorable, whereas the opposite was true in the 1990s. One could also note that the upturn at the end of the 1990s cannot be explained by positive business cycle shocks at that time (as they are mainly negative) but rather by the favorable labor market and productivity shocks discussed above.

4 Conclusions

We suggest a new method that estimates Nairu, output gaps, and structural budget balances in the same model using a structural VAR (SVAR) approach. We consider this feature important as it is principally the effects of the same business cycle that are to

9One has to remember, however, that for the period 2002-2004, the estimated shocks as well as the three estimated unobservable variables rely on NIER’s forecasts of unemployment, GDP, and budget balance.
be removed from the three series. The method is designed to take the non-stationarity of European unemployment into account by allowing for labor market shocks to have long-run effects on the unemployment rate and hence the Nairu. Another strength of the proposed method is the possibility of interpreting the time series of structural shocks that are calculated. For example, the upturn of the economy during the second half of the 1990s was primarily due to favorable labor market and productivity shocks while the business cycle shocks were mainly negative.

A weakness of the approach is that it requires rather long yearly (enough quarterly data is not available) data series. Since long data series of the budget balance of the consolidated government sector is not published in any official source, one has to combine different sources at national statistical offices, a cumbersome procedure if the study is to cover many countries.

A second problem with the SVAR approach is that there are more 'humps' to pass in order to carry out the analysis than is the case, for example, in calculating an output gap with a production function approach. The series must meet the integration tests if the shocks and the model are to be given the same interpretation as we use in this paper. Moreover, applying the present interpretation of the model requires that the signs of the impulse-response functions be the same as the ones presented in this paper.

Despite these weaknesses, the suggested unifying method could be useful to national government and research institutes as a complement to the existing methods applied by, for example, the OECD. As the three series are unobservable, their believed sizes are to an important extent a matter of judgement. In this process of judgement, we believe it would be wise to use and weigh information arising from several models. The present
SVAR-model could arguably be one of these. This is currently the case at the National Institute of Economic Research in Sweden.

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