MEASURING AND DECOMPOSING OUTPUT GAP: A PRODUCTION FUNCTION APPROACH OF THE USA AND EU-27 COUNTRIES

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Abstract: The ICT-based techno-economic paradigm shift was sharpened by income inequalities in all over the world. The economic performance of USA and Europe were seemed to more different thanks to global economic events. The main purpose of this study is to estimate various macroeconomic variables such as GDP and labour for the period of 1993-2013. In order to indicate economic growth an alternative growth accounting method was used to decompose impacts of physical capital accumulation, technological changes and labour. Analysing the time series data of various OECD countries we could conclude that a large part of the variations in the output gap stem from the cyclical variations of total labour input and the total factor productivity (TFP). Hence, our results were reflected the relevance of technological progress.


Introduction

The difference between real GDP and its trend value is usually defined as output gap. Policy makers and business cycle researchers usually interested in this variable, since the positive value indicates the economy is in boom whereas substantial negative output gap claims that the economy is in recession.

The output gap may be measured by detrending time series for the log of real GDP. Hence we firstly need a well sophisticated method for separating the growth trend from the cyclical components of output. Unfortunately, as Canova (1998) claimed that it has currently no consistent agreement on the proper procedure that generates potential trends. But, we engaged one of the widely used univariate methods in recent year, which was the so-called Hodrick-Prescott filter (Hodrick and Prescott, 1980). After using this band-pass filter a potential output level could be determined that represented a balanced state level of economy. Nevertheless, this balance provides a sustainable and noninflationary growth path of output. According to the business cycle analysis the time series of AMECO Database (EC, 2012) were decomposed by a common smoothing parameter. The (λ) was set to 100, as Ravn and Uhlig (2002) offered...
for annual data. Applying this method, we could shed light on the differences between the economic performance of USA and European Union countries.

The primary aim of this paper is to contribute to a better understanding of economic growth. Hence, we introduced and tested an alternative growth accounting method to factorize the components of output based on a production function approach. Finally, we conclude the main role of such economic factors as technology and labour.

**A growth accounting approach in various OECD countries**

In growth accounting approaches as a result of physical capital accumulation, or simply technological changes, the GDP apparently grows in the long run. However, determining the components of real GDP also reflects the fact that economic growth cannot simply be explained by changes in capital stock and technology but labour also expected to play an important role.

First, let us choose a simple Cobb-Douglas (Douglas, 1976) production function:

$$ Y_t = A_t K_t^\alpha L_t^{1-\alpha} $$

(1)

Where \([Y]\) is the real GDP, \([K]\) and \([L]\) are physical and labour capital in the period \([t]\).

The \([A]\) is the ‘total factor productivity’ factor measuring the combined productivity of capital and labour, which is used in this Equation 1.

Thus, we assume a constant return to scale and from the empirics (Mankiw, Romer, and Weil, 1992) of economic growth we also make an assumption that the magnitude of \((1-\alpha)\) should correspond roughly to the labour income share in total GDP, which is close to 2/3 in most countries. Let’s also similarly define the employment rate as \([e_t] = L_t/LF_t\), where LF denotes the labour force. We also know that the so-called economic activity or participation rate \([p]\) is estimated as \([p_t] = LF_t/N_t\), where \([N]\) is the active population. These equations allow us to express labour as follows: \([L_t] = p_t^* e_t^* N_t\). Hence, the production function (2) yields:

$$ Y_t = A_t K_t^\alpha L_t^{1-\alpha} = A_t K_t^\alpha (p_t e_t N_t)^{1-\alpha} $$

(2)

Suppose now that \([Y_t], [A_t], [K_t],\) and \([L_t]\) with their components all tend to fluctuate around some long-run trend levels denoted by \([Y_t], [A_t], [K_t], [p_t], [e_t], [N_t]\), respectively. By analogy to (2), we may then write trend output (also referred as potential output) as:

$$ \bar{Y}_t = A_t K_t^\alpha \bar{L}_t^{1-\alpha} = A_t K_t^\alpha (p_t \bar{e}_t N_t)^{1-\alpha} $$

(3)

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1 Total Factor Productivity (TFP) is a ‘multi-factor’ variable, which accounts for effects in total output not caused by traditionally measured inputs. TFP can be taken as a measure of a long-term technological change or technological dynamism of economy.
The output gap may be approximated by \( y_i = [Y_i - \bar{Y}_i] \), when we (2) - (3), so we can also get:

\[
Y_i - \bar{Y}_i = A_i K_i^\alpha (p_i e_i N_i)^{1-\alpha} - A_i \bar{K}_i^\alpha (p_i \bar{e}_i \bar{N}_i)^{1-\alpha} \tag{4}
\]

Taking logs of both sides of the Equation 4 leads to the following log-linear form:

\[
\ln y_i = \ln A_i - \ln \bar{A}_i + \alpha (\ln K_i - \ln \bar{K}_i) + (1-\alpha)(\ln p_i - \ln \bar{p}_i) + 
\]

\[
+ (1-\alpha)(\ln e_i - \ln \bar{e}_i) + (1-\alpha)(\ln N_i - \ln \bar{N}_i) \tag{5}
\]

Thus now the output gap may be found as the cyclical components of total factor productivity (TFP), denoted by \( \alpha \), plus the cyclical components of physical (L) and human capital (L). Following this concept we also introduce unemployment to the Equation 4 as follows.

Let's denote the unemployment rate as \([u]\), where \([u]\) = \(U_i/LF_i\), so the number of unemployed \([U_i]\) = \(u_i^*LF_i\). Thus, we also know that the labour force \(LF\) equals the sum of labour and the unemployed, so \([L_t]\) = \(LF_i - u_i^*LF_i = LF_i*(1-u_i)\). Claim that the active to total population ratio by \([a_t]\) = \(N_i/P\), where \([P]\) is the total population. Finally, labour can be substituted as \([L_t]\) = \(p_t^*a_t^*P_t*(1-u_t)\). Finally, we can use the approximation that \(\ln(1-u_t) \approx -u_t\). Hence, replace the labour by the active to total population rate, the economic activity and unemployment rates as in the previous Equation 5.

\[
\ln y_i = \ln A_i - \ln \bar{A}_i + \alpha (\ln K_i - \ln \bar{K}_i) + (1-\alpha)(\ln p_i - \ln \bar{p}_i) + 
\]

\[
+ (1-\alpha)(\ln a_i - \ln \bar{a}_i) + (1-\alpha)(\ln P_t - \ln \bar{P}_t - (1-\alpha)(u_t - \bar{u}_t) \tag{6}
\]

Now, use the available time series data of USA and EU-27 countries from the European Commission’s Annual Macroeconomic Database (AMECO). The results are reported in the following Figures.

Figure 1. shows an estimate and decomposition of the output gap in the United States based on the Equation 5 just described. The upper part of this figure shows the part of the fluctuations in the output gap that can be traced to Total Factor Productivity. The vertical distance between the curve for the output gap and curve for TFP measures the contribution of cyclical fluctuations of physical capital and labour. Similarly, if work intensity varies over the business cycle and people tend to work harder after there is more work to do, this will also be captured in the cyclical components of TFP.

Figure 2. shows a similar result of our estimations in the EU-27 countries with a less magnitude. The bottom parts of these figures shows that a large part of the variations in the output gap stems from the cyclical variation in total labour input. At the same time the cyclical component of TFP accounts for the business cycle peaks and troughs, presumably reflecting that work intensity and capacity utilization are unusually low in recessions and high in boom periods. In the separate part of the cyclical swings of labour the employment and unemployment rates are the greatest components of the input variations.
Meanwhile, the changes in the population rates or equivalently that of the participation and activity rates contributed to economic growth with a marginal effect. Hence, some labour input components does not seem to very much to the business cycle, although there is a tendency for the work force to vary in a slightly procyclical manner (while lagging a bit behind the output gap).

**Figure 1. An estimation and decomposition of the output gap in USA between 1993 and 2013 (based on the Equation 5)**

![Graph showing the output gap decomposition](image)

Source: own calculation based on AMECO Database (2012).
Notes: (1) we used the Gross Fixed Capital Stock (GFCS) and GDP in 2000 constant prices. (2): TFP - Total Factor Productivity, (3) Part_rate: - gap of participation rates, (4) Emp_rate- gap of employment rates, (5) Pop (15_64) - gap of the active population.

The total factor productivity as a residual rather than factor accumulation accounts for most of income and economic growth differences across nations (Easterly and Levine, 2001). According to the calculations of Klenow and Rodriguez-Clare (1997) about 40 per cent of income differences could be explained by human and physical capital, while the remaining part was due to TFP. Barro (1999) claimed that TFP is not only a major determinant of growth, but also the most sensitive factor. Jerzmanowski (2007) also paid attention to the sensitivity of a Cobb-Douglas production function approach of a cross
country analysis and appropriated the increasing role of technology in productivity. But the benefits of technology do not prevail everywhere. As North (1990) claimed that institutions are needed to generate economic growth, although technological changes influence productivity of countries in different way.

Based on our results, comparing USA and EU-27 countries, we found that labour market and TFP closely linked to economic growth. According to Mortensen and Pissarides (1999) the skill-biased shocks caused more rise in (un)employment rates in Europe relative to the US. These shocks increase the spread of productivity across workers, which can also lead to higher
unemployment in Europe than in the United States. We agree with Kapás and Czeglédi (2008), who stated that European institutional reforms are needed, which are enforced by the new wave of technological change.

Conclusion

According to the growth accounting results Total Factor Productivity accounts for a large fraction of the total output gap at business cycle peaks and troughs. Hence, TFP played a key role in economic growth alongside the technological shocks. Thus, most of the cyclical variation in labour input stems from fluctuations in cyclical un(employment), but population and participation rates had a less impacts to output growth.

References