ESTIMATION OF POTENTIAL OUTPUT FOR THE PORTUGUESE ECONOMY

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1. INTRODUCTION

The growth rate of an economy is unquestionably one of the most relevant pieces of information for the economic authorities in each country. A slow growth may indicate persistently high unemployment levels, while extremely high rates of growth may generate unsustainable pressures on the wage formation process.

In this context, the concept of potential output can play a key role as an indicator of the aggregate supply situation. However, although widely used in economic analysis, the concept of output gap is not unique. In fact, several definitions and estimation methods exist.

Many fairly standard time series techniques identify potential output with the trend component of the time series, hence eliminating the seasonal, cyclical and irregular components. These are statistical methods and thus do not allow the interpretation of the economic factors leading to an observed output level above or below potential output.

The estimation of a production function allows establishing a relationship between the degree of utilisation of inputs and potential output. According to this interpretation, potential output growth reflects a growth of trend productivity and a level of capital utilisation compatible with those observed in the past, as well as a labour utilisation compatible with the non-existence of inflationary pressures, usually associated to the concept of the natural unemployment rate.

As it shall become clear throughout this paper, alternative methods can render quantitatively distinct estimates for potential output. Therefore, considerable uncertainty surrounds the measurement of the so-called output gap — the difference between observed and potential output levels — which requires special caution in interpreting the results. This fact suggests that the estimates obtained through different methods should be compared with other quantitative indicators of the rate of productive factor utilisation — as the unemployment rate or the rate of productive capacity utilisation.

According to the production function approach, potential output can be interpreted as an indicator of inflationary pressures in the economy. Indeed, pressure on prices tends to appear when the rate of productive capacity utilisation is high and when unemployment rate is below its natural rate\(^\text{(1)}\).

The concept of potential output is also employed in the adjustment of cyclical behaviour of some variables. In particular we may calculate changes of the General Government overall and primary balances adjusted for effects of the cyclical position of the economy, useful as guidelines to budgetary policy\(^\text{(2)}\).

The first conclusion of the study is that in the Portuguese case, alternative output gap estimation procedures lead to similar results, specially in the

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* The opinions of this paper represent the views of the authors, and are not necessarily those of the Banco de Portugal.

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\(^\text{(2)}\) See Centeno (1994).
recent past. We also find that in the last three years the economy has grown above potential output, and output is currently probably close to its potential level.

This article contains three additional sections. Section 2 briefly presents some methods to obtain estimates for potential output. Results for Portugal are described in section 3. Section 4 concludes.

2. ALTERNATIVE METHODS OF ESTIMATION OF THE OUTPUT GAP

As mentioned above, potential output is a non-observable variable, hence requiring estimation. Given the relevance of this concept, it is advisable to compare estimates obtained from the application of alternative quantitative techniques. Three different procedures are used in this study: (i) linear trend; (ii) the Hodrick-Prescott filter and (iii) the production function.

We now follow to outline each of these procedures, as well as their potentialities and drawbacks.

i) Linear trend

The simplest way to obtain an estimate for potential output consists in estimating a linear trend of log GDP at constant prices — which basically corresponds to using the average growth rate observed in the period under scrutiny(3).

For longer periods, however, the constant average growth rate assumption is not reasonable. In most western economies, for example, economic growth was stronger in the post-world war period than in the 1970’s or the 1980’s. Alternatively, the linear trend of GDP can be estimated accounting for the existence of structural breaks. This corresponds to assuming different growth rates for potential output in different time periods(4). This procedure can ultimately lead to different potential growth estimates for each economic cycle(5).

The estimation of potential growth rates that correspond to the average growth rate recorded in each economic cycle ensures the symmetry of economic cycle gaps, which is an advantage. On the other hand, the fact that the estimation results are not invariant to the definition of economic cycles constitutes a drawback of the method.

A second disadvantage is the difficulty in using this method in potential output forecasting, since structural breaks are only known a posteriori. It is also known that if GDP is integrated of order one, instead of a trend stationary series, then the adjustment of a linear trend gives rise to the so-called “spurious de-trending” phenomenon since the regression residuals (the cyclical component of output) are non-stationary. In this case, the cyclical component is of difficult interpretation, as it reflects a series that does not present mean reversion.

ii) Hodrick-Prescott filter

An alternative to the estimation of a linear trend consists in assuming that the potential growth rate is not constant in time. This can be obtained by using some statistical filters mainly aimed at identifying the trend component of a time series. Unlike the linear regression — which attributes equal weights to all observations — these filters give different weights to different observations, according to their closeness to the period under scrutiny. The Hodrick-Prescott method is the most commonly used statistical filter in estimating potential output(6). The Hodrick-Prescott(7) (HP) filter delivers estimates for potential output from the calculation of weighted moving averages.

(3) This procedure requires the utilisation of complete economic cycles.
using past and future values of observed output. Weights are greater for years closer to that for which potential output is being calculated. The Hodrick-Prescott filter requires the choice of the value of smoothing parameter $\lambda$ of the minimisation problem\(^8\). This reflects the choice between a smooth potential output series and one closer to observed output (as extreme cases, we could have a linear trend or the observed output series itself). A lower value for $\lambda$ corresponds to an output path close to that observed — thus to a more volatile series. A higher value for $\lambda$ yields a smoother output path, thus closer to a linear trend. These results are explained by the fact that a lower value for $\lambda$ corresponds to using a smaller number of years in calculating moving averages. In literature the assumption of $\lambda = 100$ is fairly standard for annual data and $\lambda = 1600$ for quarterly data\(^9\).

The weighting of past and future observations brings problems to the utilisation of the Hodrick-Prescott filter at the ends of the sample, where the estimated trend follows closely the observed value of output. This issue is important, since in most cases our interest consists precisely in measuring potential output in recent years. To overcome this drawback, it is convenient to extend the sample period to include forecasts of future values for output.

Another limitation of the HP filter deals with the treatment of structural breaks which tend to be smoothed by the filter. As a result, the effect of a structural break tends to be distributed over several periods, instead of being felt in one period alone — as happens with the linear trend for instance, once the break period is identified. Furthermore, the HP filter tends to create spurious cycles i.e., it generates cycles even when these are not present in the original data\(^10\).

Nevertheless, this method has the advantage of ensuring that the estimated output gap (cyclical component) is stationary. As mentioned above, this was not the case of the linear trend.

### iii) Production function

The previously presented methods are statistical procedures aimed at identifying the trend of a time series. The major drawback of these methods is unequivocally the fact that they are simply statistical procedures, that fully disregard any information on eventual structural constraints binding the economy — namely the greater or smaller availability of production factors. Therefore, the potential output extrapolated by any of the above described approaches may be inconsistent with the behaviour of the capital stock, employment and productivity. The so-called production function approach intends to overcome these drawbacks by taking into account the greater or lower availability of productive factors.

According to this approach, potential output is the maximum output level consistent with stable inflation. Consequently, this concept should not be identified with maximum output level — in the technical sense — which corresponds to the full utilisation of productive factors.

For simplicity we assume that output is fairly explained by a Cobb-Douglas production function with constant returns to scale and technical progress\(^11\). Since technical progress can be non-stationary and not bound to be represented by a simple linear trend (which would complicate the estimation of the production function parameters), the production function parameter corresponding to the share of labour income in total national income is set equal to the sample mean by calibration. The residuals of the production function (technical progress) are then smoothed (using for instance the HP filter or a linear trend) to obtain a trend measure of total factor productivity. Potential output is found by substituting trend productivity, the capital stock and potential employment in the production function. In turn, potential employment can be given by an estimate for the NAIRU\(^12\).

Consider the following Cobb-Douglas production function with constant returns to scale and technical progress:

\[\text{GDP} = A K^{\alpha} L^{1-\alpha},\]

(8) See footnote 7.


(11)For an approach based on the C.E.S. production function see for instance Marques (1990).

(12)Non Accelerating Inflation Rate of Unemployment.
\[ Y_t = L_t^\alpha K_t^{1-\alpha} N_t \]

where \( Y_t \) stands for output, \( L_t \) is labour, \( K_t \) is the capital stock effectively used and \( N_t \) the technical progress.

Using lower case to represent the corresponding logarithms, the previous function can be written as follows:

\[ y_t = \alpha l_t + (1-\alpha)k_t + n_t \]

For a given value of \( \alpha \) we can calculate the technical progress \( n_t \) corresponding to the residuals of the production function. Smoothing \( n \) using a HP filter or a linear trend provides a measure of trend factor productivity, here noted by \( n^* \).

Potential employment is given by the expression

\[ L* = LF(1-NAIRU) \]

where \( LF \) stands for the labour force. The logarithm of potential output can be calculated from the following expression

\[ y^*_t = \alpha l^*_t + (1-\alpha)k^*_t + n^*_t \]

where \( k^* \) stands for the potential capital stock, which in practice corresponds to the observed capital stock.

The expression above evidences the role that different production factors play in determining potential output. First, the greater the capital stock, the highest is potential output. This means that high investment rates — specially if investment is channelled to expanding productive capacity — yield higher growth rates of potential output. Second, the higher potential employment — i.e., the lower the NAIRU — the higher is potential output. Finally, potential output is also higher the greater is trend technical progress.

Naturally, the production function approach is not free of limitations. As discussed above, potential output is dependent on the type of production function assumed, on the method of calculation of NAIRU and on the method of calculation of trend productivity. The choice of a point estimate for the NAIRU — which encompasses a certain level of uncertainty — and the utilisation of the HP filter or a linear trend in calculating \( n^* \) bring to this approach all kinds of limitations associated to these methods.

3. RESULTS FOR PORTUGAL

This section presents the results of the application of the methods described above. Two alternative series were used for output. First we used a series resulting from patching three distinct series: that covering the period 1958-1987 was drawn from Santos, Dias and Cunha (1992); the series for the period 1988-1994 corresponds to the National Accounts of the Instituto Nacional de Estatística; finally, for the period 1995-1998 we used the most recent estimates and forecasts of the Banco de Portugal (see the 1997 Annual Report of the Banco de Portugal, as well as the article “The Portuguese economy in 1998” in this bulletin). The second alternative consisted of using the “Historical Series for the Portuguese Economy” in Pinheiro et al. (1997) for the period 1958-1995\(^{(13)} \), and the most recent estimates of the Banco de Portugal for the period 1996-1998. Hereafter these series shall be denoted National Accounts (NA) and Historical Series (HS), respectively. We use two distinct series because their real growth rates exhibit a non-negligible difference. Indeed, the Historical Series reveal a stronger growth in the period after 1974.

The application of the above described techniques of estimation of the output gap was applied to these annual series, but also to quarterly ones. We follow to present the main findings.

i) Annual data

The Portuguese economy grew substantially more in the period 1958-1973 than in the period 1974-1998. The estimation of a log-linear trend for the period as a whole would lead to the estimation of a relatively high potential growth rate when compared to the growth observed in the last 20 years. To overcome this situation, we considered a log-linear model with a structural brake in 1974.

Chart 1 presents the estimates for potential output growth obtained for the Historical Series, as well as the observed growth rates. The estimation of a log-linear regression leads to an average growth of 6.0 per cent up to 1973 and 3.5 per cent

\(^{(13)}\)The series used in this research encompass some revisions meanwhile made to the series of Pinheiro et al. (1997) up to 1993, and an extension to cover 1994 and 1995.
thereafter. The potential growth rate obtained from the Hodrick-Prescott filter is also depicted in the chart. At the end of the sample period, this estimate is slightly lower than that yielded by the log-linear regression.

Chart 2 exhibits the corresponding estimates based on the National Accounts. The estimation of a log-linear regression leads to an average growth of 6.6 per cent up to 1973, and 2.9 per cent afterwards. The potential output growth rate delivered by the Hodrick-Prescott filter is virtually identical to that yielded by the log-linear regression in the last 20 years. At the end of the period under scrutiny the Hodrick-Prescott series stands slightly above the log-linear regression with a growth rate of 3.1 per cent.

Note that we get the same potential output growth for both series at the end of the sample period if the Hodrick-Prescott method is used.

The output gap estimates for each one of these series and for each method are plotted in charts 3 and 4. These charts present quite similar behaviours. In general, and regarding the most recent period, we may conclude that the 1993 recession led observed output to a level below potential output. From 1996 onwards, however, the growth of the Portuguese economy has made the output gap less negative. In 1998, the estimated level for output stands very close to its potential value. According to the National Accounts, the output gap switched from negative in 1997 (-0.6 per cent) to positive in 1998 (about +0.4 per cent). For the Historical Series the output gap became null in 1998 according to the HP filter (-0.9 per cent in 1997); however, according to the linear trend the output gap still remains marginally negative in 1998 and 1999. In any of these cases, the conclusion is that in 1998 output is very close to its potential value – i.e., the output gap is virtually null.

Charts 3 and 4 provide us with two additional remarks. The first is that in the 1960s (the first 10 years of the sample) there are no visible cycles – or, if existing, they were clearly inexpressive and short. On the contrary, from the early 1970s onwards, cycles are clearly defined and are more or less lengthy – the last of which is estimated to have lasted about 10 years. The second remark is that the 1993 recession was less sharp and shorter than those recorded in 1975 and in 1983-84. The
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output gap estimated for the period following to the last recession is clearly less negative than that obtained in previous recession periods.

**ii) Quarterly data**

We now analyse the results obtained from using quarterly data. Since these series have the same implicit growth rates of the corresponding annual series, qualitative changes from the above presented conclusions should not be expected — except for those eventually resulting from the different sample period considered\(^{(14)}\) or the utilisation of the production function method in calculating potential output.

To calculate potential output according to the production function method we assumed \(\alpha = 0.535\), which corresponds to the average share of wage income in national income in the period 1980-1996. In general, the greater difficulty deals with the estimation of potential employment \(L^*\), given the usual uncertainty regarding the true value of NAIRU. However, in the Portuguese case, there is not only a large consensus among researchers that the NAIRU has remained virtually stable over the last 15 years, but also estimates themselves are quite close to each other. Indeed, most estimates stand between 5.5 and 6 per cent, as table 1 shows.

We chose to use 5.75 per cent as the value for NAIRU in estimating potential output. Total labour force was assumed to grow 1 per cent in 1998 and 1999, which compares with 0.7 per cent in 1996 and 1.3 per cent in 1997. As regards trend technical progress \(n^*\), we admitted for 1998 and 1999 a quarterly growth rate equal to the trend rate recorded at the end of the sample period (the last quarter of 1997). The capital stock effectively in use was calculated multiplying the observed capital stock by the rate of productive capacity utilisation (previously divided by its mean value), according to the values disclosed in the Monthly Manufacturing Industry Survey of the Instituto Nacional de Estatística. To reduce slightly the noise present in the potential output measures, GDP and labour force series were adjusted from their irregular component.

Charts 5 and 6 exhibit the results for the output gap calculated according to the three methods,

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(14) An additional limitation of the linear trend and HP filter approaches deals with the fact that results may be sensitive to the size of the sample period. Recall that in both cases residuals (i.e., the cyclical component) have zero mean independently of the length of the sample period, and regardless of the economy being or not at the same stage of the cycle at the beginning and the end of the period. This property alone may generate spurious cycles — since in any sample period (the smallest it can be) there is always at least one positive gap period and one negative gap period that compensate each other.

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**Table 1**

<table>
<thead>
<tr>
<th>Methodology</th>
<th>NAIRU</th>
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<tr>
<td>Luz and Pinheiro (1993)</td>
<td>Okun’s law 5.5</td>
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<td></td>
<td>Wage equation 6.0</td>
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<td>Marques and Botas (1997)</td>
<td>Wage equation 5.4</td>
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<td>Modesto (1997)</td>
<td>Beverage curve 6.0-6.5</td>
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<td>Gaspar and Luz (1997)</td>
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<td></td>
<td>Wage equation 5.75</td>
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<tr>
<td>Barbosa et al (1998)</td>
<td>Okun’s law 5.8</td>
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<td>Wage equation 5.6</td>
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based respectively on the Historical Series and on the National Accounts. In general, the output gap given by the production function\(^{(15)}\) follows closely the output gap yielded by the HP filter.

The application of the three methodologies points towards a change in the sign of the output gap over the course of 1997, when using the National Accounts series. The same happens when applying the HP filter and the production function to the Historical Series. However, the adjustment of a linear trend of the Historical Series leads to a negative output gap at the end of the sample.

The idea presented above for the annual data, according to which the 1993 recession was less sharp and shorter than that recorded in 1983-1984 is confirmed by the quarterly data.

\(^{(15)}\)Charts 5, 6, 7 and 8 present the result of the production function approach where potential technical progress is measured by the application of the HP filter to the series of observed technical progress. However, the results found when trend technical progress is measured through a linear trend are not qualitatively distinct from those presented.
methods, as well as the observed/estimated GDP growth rate. Analysing in detail the end of the sample period we see that GDP has grown above potential output since 1996, regardless of the method of calculation — exception made for the last year under scrutiny (1999). Indeed, in 1999, due to the slowdown assumed for GDP, its growth rate becomes closer to that of potential output — specially when measured by the HP filter or by the production function.

4. CONCLUSIONS

This article presents estimates for potential output for the Portuguese economy, calculated according to the most commonly used methods: the log-linear trend method, the Hodrick-Prescott filter and the production function approach. Estimates were obtained for annual data (period 1958-1999) and for quarterly data (period 1983:1 — 1999:4). The main conclusion is that results for potential output — and consequently for the output gap — do not differ substantially, independently of the series and the calculation methods used. One can also conclude that output has grown above potential output in the last three years; moreover, regardless of the calculation method and the sample period considered, the value of observed output in 1998 is estimated to be very close to potential output.

Naturally these conclusions should be interpreted with caution. The limitations of all methods — specially the uncertainty regarding the true value of NAIRU — suggest that the kind of analysis carried out in this research should be completed with the observation of variables bound to provide some indications on the level of productive factor utilisation. An analysis of the labour market situation — comprising the analysis of the unemployment rate and wage behaviour — and the scrutiny of the level of productive capacity utilisation in manufacturing industry, at each moment, should be carried out regardless of the greater or lower credibility the present potential output estimates might gather.

Furthermore, the Portuguese economy, as in the case of the remaining countries in the euro area, is possibly undergoing a change of regime due to the introduction of the single currency. It may be the case that the positive effects resulting from the suppression of exchange rate risks and conversion costs between the participating currencies, from the clear objective of promotion of price stability in the euro area, and from the reduction of public deficits in the context of the Stability and Growth Pact, lead to the creation of a favourable environment for a progressive rise in potential output, greatly as a result of stronger investment growth — induced by lower interest rates and lower uncertainty(16). If this suspicion is confirmed, this change of regime shall allow for a stronger growth of the Portuguese economy exempt of the risks of significant pressures on prices.

REFERENCES

Barbosa et al., 1998, O impacto do euro na economia portuguesa, Ministério das Finanças.

(16) Barbosa et al (1998) presents estimates for the impact of some of the mentioned effects on output growth.