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Potential Output and Output Gap Estimates for the Economy of Cyprus[1]

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Summary

This essay provides estimates for potential output and output gap for the economy of Cyprus using the production function approach suggested by the Economic Policy Committee (2001). These estimates are used by the European Union in the calculation of indicators for macroeconomic surveillance. In particular, they are used in the calculation of indicators of structural fiscal balance and in assessing the progress of countries in the Stability and Growth Pact, towards medium-term fiscal targets.

Potential output and output gap estimates are also used in the construction of structural macroeconomic models that are used for policy analysis and forecasting.

The estimates of output gap for Cyprus fluctuate more than those for the European Union as a whole (EU15) since Cyprus is a small open economy vulnerable to external shocks. The potential output growth of Cyprus is higher than that of the EU15 indicating that there is scope for further development.

The estimation of potential output and output gap was also carried out using a filtering technique (Hodrick-Prescott filter) and the results are very similar to those obtained from the production function method.

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[1] A draft of the essay was prepared for the meeting of the Output Gap Working Group organised by the Economic Policy Committee in Brussels on October 7, 2003.

CONTENTS

I. INTRODUCTION

The concepts of potential output and output gap play a significant role in assessing fiscal and monetary policies. In particular, potential output and output gap estimates are used by the European Union (EU) in the calculation of indicators for macroeconomic surveillance.

In the short-run, potential output is the level of output that can be produced in an economy without inducing inflationary pressures. In the long-run the level of potential output depends on the growth of the productive capacity of the economy, which in turn depends on total factor productivity and the growth rates of physical capital and of the potential labour force. Thus, potential output estimates provide an indicator of the aggregate supply capacity of the economy and the possibilities for non-inflationary growth. Potential output estimates are also used in the construction of structural macroeconomic models, which are used for policy analysis.

Output gap is the deviation of actual output from the potential. Output gap estimates are used in the calculation of the cyclically adjusted fiscal balance. In the context of the Stability and Growth Pact the cyclically adjusted fiscal balance[2] is used by the EU to assess the extent to which the member countries have achieved the medium-term fiscal goals. Output gap estimates provide also information about the position of an economy in the business cycle and therefore inflationary pressures can be prevented via counter-cyclical policies.

The various methods that have been proposed in the literature for estimating (unobservable) potential output and output gap can be divided into two categories: (i) statistical de-trending methods such as the Hodrick-Prescott (HP) filter or the deterministic trend method and (ii) economic approaches such as the production function approach.

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[2] Cyclically adjusted fiscal balance (is sometimes referred to as structural fiscal balance) is the fiscal balance that would prevail in the absence of either recession or expansion.

It was noted that the estimates of potential output and output gap are considerably uncertain because different estimation methods give different estimates (see e.g. Bagnoli and Cacciotti, 2003) and this might lead to misleading policy recommendations.

Due to the disagreement of the estimates resulting from the different methods and the absence of economic theory from the statistical method (HP filter) originally used by the EU member countries, the Economic Policy Committee (2001) decided to adopt an economic approach and in particular the production function method, see Dennis et al. (2002).

The purpose of this essay is the application of the production function method, proposed by Dennis et al. (2002), for the estimation of potential output and output gap for the Cyprus economy. For purposes of comparison of the results with those produced for EU member counties we follow closely the methodology analysed in Dennis et al. (2002).

II. HP FILTER VS PRODUCTION FUNCTION APPROACH

In this section we give an overview of the HP filter, which is the method that has been widely used in estimating potential output and output gap. Moreover, we state the main advantages and disadvantages of the HP filter and the production function approach.

The HP filter is a statistical technique for extracting the trend component of output by minimising the squared deviations of the trend from actual output and the square of the change in the growth rate of the trend. More specifically, let Y_t denote actual output (real GDP) and let Y_t^* denote the trend component of actual output, then the HP filter is defined as

$$\min_{Y_t^*} \sum_{t=1}^{T} (\ln Y_t - \ln Y_t^*)^2 + \lambda \sum_{t=2}^{T-1} [(\ln Y_{t+1}^* - \ln Y_t^*) - (\sum_{t=2}^{T-1} (\ln Y_t^* - \ln Y_{t-1}^*)]^2$$

where T is the sample size and λ is an exogenous de-trending parameter, which sets the degree of smoothness of the trend. The higher the value of λ the greater the weight attached to the smoothness of the trend.

HP filter is a simple statistical technique, the estimates can be obtained easily and can be replicated quickly. The main drawback of the method is the absence of economic theory, which makes the assessment of the results from the economic point of view and the recommendation of policies, difficult. The estimates of potential output and output gap are conditional on the choice of the de-trending parameter, λ, which is chosen arbitrarily. In addition, the estimates obtained using HP filter suffer from end-sample biases caused from the restriction that the sum of output gaps over the estimation period should be equal to zero. Since the estimation period does not always include completed business cycles the estimates of the trend might be too close or too far from actual output, due to the restriction imposed by the filter. The end sample bias can be considerable when the last observations in the sample are affected by demand shocks.

The lack of economic foundations in the case of the HP filter method has led to the development of the production function method, which gives an economic framework for estimating potential output. In this framework potential output and structural unemployment are clearly defined as the levels of output and unemployment respectively that are consistent with stable inflation. Thus, the estimates of potential output and output gap can be given economic interpretations and can be used in making medium-term growth projections. Moreover, macroeconomic policies can be consistently assessed within an economic framework. The production function method provides information about the contributions of the factor inputs and total factor productivity to potential growth.

Compared to the HP filter the production function method is more complicated and requires the use of data on capital stock, which might not be accurately measured. The choice of model specification in the production function approach is to some extent arbitrary and the particular model advocated by the Economic Policy Committee (2001) and analysed in Dennis et al. (2002) might not be appropriate for all countries due to peculiarities.

III. PRODUCTION FUNCTION APPROACH

The model used for the estimation of potential output and output gap for the Cyprus economy is the one suggested by Dennis et al. (2002).

The production function approach requires assumptions about the form of the production function of the economy and the process driving unemployment. Following Dennis et al. (2002), we assume that the production function has a Cobb-Douglas form, where total output (*Y*) is produced using labour (*L*) and capital (*K*)

$$Y = (U_L L E_L)^{\alpha} (U_K K E_K)^{1-\alpha} \qquad (1)$$

where U_L, E_L (U_K, E_K) represent the adjustments made to labour (capital) for the degree of utilisation and the level of efficiency respectively. The specification in (1) assumes constant returns to scale (CRS). Equation (1) can be re- written as

$$Y = (TFP) L^{\alpha} K^{1-\alpha} \qquad (2)$$

where $TFP = U_L^{\alpha} U_K^{1-\alpha} E_L^{\alpha} E_K^{1-\alpha}$ is total factor productivity, which by definition depends on the degree of utilisation and the level of efficiency (technology) of the factors of production.

The main reason for using a Cobb-Douglas production function is its simplicity and the fact that its parameters can directly be given economic interpretation as output elasticities with respect to factor inputs. Under the assumption of CRS and perfect competition, output elasticities with respect to labour and capital equal their respective factor shares. Hence, only α needs to be estimated and this can be done by using the wage share. Moreover, Dennis et al. (2002) argue that the assumption of CRS is consistent with empirical evidence.

Before estimating potential output we need to define the potential levels of factor inputs and the trend (i.e. potential) level of efficiency of the inputs.

The potential level of labour is defined as the level of employment which is consistent with non-accelerating inflation rate. In particular the potential level of labour (L_p) is given by

$$L_p = POPW \times PARTS \times (1 - NAIRU) \qquad (3)$$

where *POPW* is the population of working age, *PARTS* is the smoothed (HP filtered) participation rate and *NAIRU* is the non-accelerating inflation rate level of unemployment (i.e. structural unemployment).

The potential level of capital is achieved when the entire amount of capital stock in the economy is fully utilised. Dennis et al. (2002) argue that the use of a smoothed series for capital is not justified since capital stock is an indicator of the overall capacity and also due to the fact that the unsmoothed series for capital is rather stable[3] for the EU and the US. This is the case for Cyprus as well.

The trend or potential level of efficiency of factor inputs is measured by the HP filtered Solow residual denoted by *TFPS*. After having normalised the full utilisation of inputs to unity the expression for *TFP* becomes

$$TFP = E_L^{\alpha} E_K^{1-\alpha} = YL^{-\alpha} K^{\alpha-1} .$$

Potential output is then given by

$$Y_p = (TFPS) L_p^{\alpha} K^{1-\alpha} .$$

For all the variables mentioned above we have either available data or the variables can be calculated, except for *NAIRU*. Thus, we need to adopt a model, which can be used in the estimation of *NAIRU*.

First we assume that the unemployment rate can be decomposed into two unobservable components, the cyclical (C_t) and the trend (T_t) component,

$$U_t = C_t + T_t . \qquad (4)$$

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[3] Since net investment in each period constitutes a small fraction of capital stock, its volatility does not seem to affect capital.

Next we make assumptions about the statistical properties of the unobservable components. Again following Dennis et al. (2002) we assume that the cyclical component is a stationary, second order autocorrelated process with zero mean,

$$C_t = \phi_1 C_{t-1} + \phi_2 C_{t-2} + v_t \tag{5}$$

where $\phi_1 + \phi_2 < 1$, by the stationarity assumption and v_t is an independent and identically distributed (i.i.d.) error process.

The trend component, T_t, is assumed to follow a random walk with drift, where the drift term, μ_t, itself follows a random walk. These are given by equations (6) and (7) below.

$$T_t = \mu_t + T_{t-1} + z_t \tag{6}$$

and

$$\mu_t = \mu_{t-1} + a_t \tag{7}$$

where z_t and a_t are i.i.d.

Since C_t and T_t are unobservable, they can be estimated by application of the Kalman filter. Kalman filtering is a technique used for the estimation of unobservable quantities (called state variables) from observed series, subject to certain specifications of the processes involved and initial conditions. For more details on the Kalman filter technique, see e.g. Harvey (1989). In this case the observed series is the unemployment rate.

IV. DATA

The data were obtained from the Statistical Service of Cyprus. GDP at constant 1995 prices, gainfully employed population and net capital stock[4] at constant 1995 prices were used for actual output (*Y*), actual employment/labour (*L*) and capital (*K*) respectively. The available data for capital stock cover the period

[4] The capital stock was calculated using the perpetual inventory method.

1985-2001 which restricts the period for which estimates of potential output and output gap can be obtained, to 1985-2001.

The population of working age (*POPW*) used in the estimation consists of the population aged 15-64. Participation rate was calculated as the ratio of economically active population (corrected for the number of people carrying out their compulsory military service) over the population of working age. Participation rate was calculated and smoothed (using HP filter) for the period 1975-2001.

Under the assumption of constant returns to scale and perfect competition the output elasticity of labour (α) and capital (1-α) can be calculated from the mean labour share for the period 1985-2001. The labour share for each year is defined as the sum of the compensation of employees and imputed wages and salaries of the self-employed, expressed as a proportion of GDP of that year. α for the period 1985-2001 equals 0.59 thus (1-α) = 0.41.

Finally NAIRU was estimated by applying the Kalman filter to the unemployment rate using the specifications in equations (4)-(7).

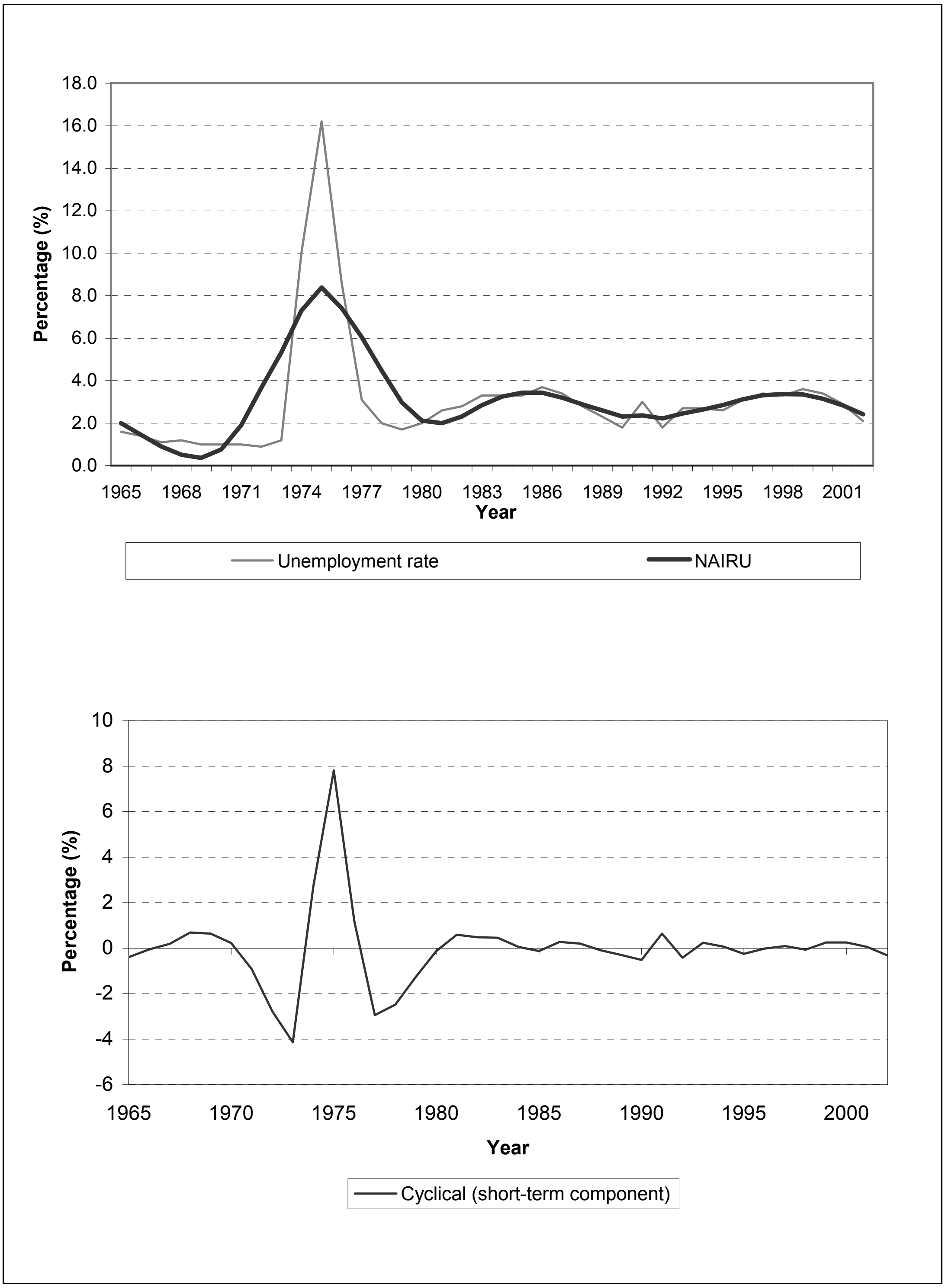
V. ESTIMATION RESULTS

V.1. NAIRU and Cyclical Unemployment

The results from the application of the Kalman filter to the unemployment rate series are shown in Figure 1.

The deviations of the cyclical component of unemployment from zero have cyclical behaviour and have become smaller in recent years. The peak in the unemployment rate that occurred in 1975 due to the Turkish invasion, is captured by both the cyclical and structural (trend) components. The estimates of the trend and cyclical components for a sub-sample are presented in Table 1. The estimates for the whole sample are presented in Table A3 in the Appendix.

Figure 1: Breakdown of Unemployment Rate into its Trend (NAIRU) and Cyclical Components



The estimates of the autoregressive coefficients for the cyclical component are shown in Table A1 in the Appendix and are highly significant. The hypothesis of a unit root $\phi_1 + \phi_2 = 1$ in C_t, is tested by performing an Augmented Dickey Fuller (ADF) test in order to verify that the data for cyclical unemployment were generated according to assumptions about equation (5). According to the ADF statistic the stationarity of the process is supported by the data (see Table A2 in the Appendix).

A unit root test for the unemployment rate series was also carried out (see Table A2). The test indicates that the null hypothesis of a unit root is not supported by the data, hence the assumption that the trend component follows a random walk with a random time varying drift might be considered as superfluous. This raises the question of whether in the future we should attempt to obtain a specification for the process generating T_t that is more appropriate for Cyprus' labour market.

Table 1: Breakdown of Actual Unemployment Rate into its Trend (NAIRU) and Cyclical Components

Year	1965	1970	1975	1980	1985	1990	1995	2000
Trend Component	2.0	0.8	8.4	2.1	3.4	2.3	2.9	3.2
Cyclical Component	-0.4	0.2	7.8	-0.1	-0.1	-0.5	-0.3	0.2
Observed Unemployment Rate	1.6	1.0	16.2	2.0	3.3	1.8	2.6	3.4

NB: the trend and cyclical components are estimated by the Kalman filter algorithm using equations (4)-(7).

V.2. Potential Output and Output Gap

Next we present and comment on the estimates of output gap and growth rate of potential output, obtained by using the production function (PF) approach. In order to have a comparable reference for the estimates, potential output and output gap were estimated using the HP filter too. The HP filter[5] was applied to the series of GDP at constant 1995 prices for the period 1975-2002 and the extracted trend component was interpreted as the level of potential output. The values of estimated potential output and output gap from both methods, for the period 1985-2001 are presented in Table A4 in the Appendix.

[5] The de-trending parameter λ of the HP filter was set equal to 7 since the frequency of the data is annual.

Table 2 shows the output gap estimates as percentage of potential output for the period 1985-2001, together with the growth rate in potential output. Output gap estimates from the two methods move closely in the sense that expansions and contractions of the gaps occur at the same periods for the two methods. The averages of potential growth for the period 1985-2001 from the two methods are very close. It has to be pointed out however, that the end point bias problem is evident in the estimates of the output gap using the HP filter when we compare them with the estimates using the PF method. This can be seen below and in Figure A1 in the Appendix. Table 2 also shows the contributions of labour, capital and TFP to potential growth (calculated using the PF method).

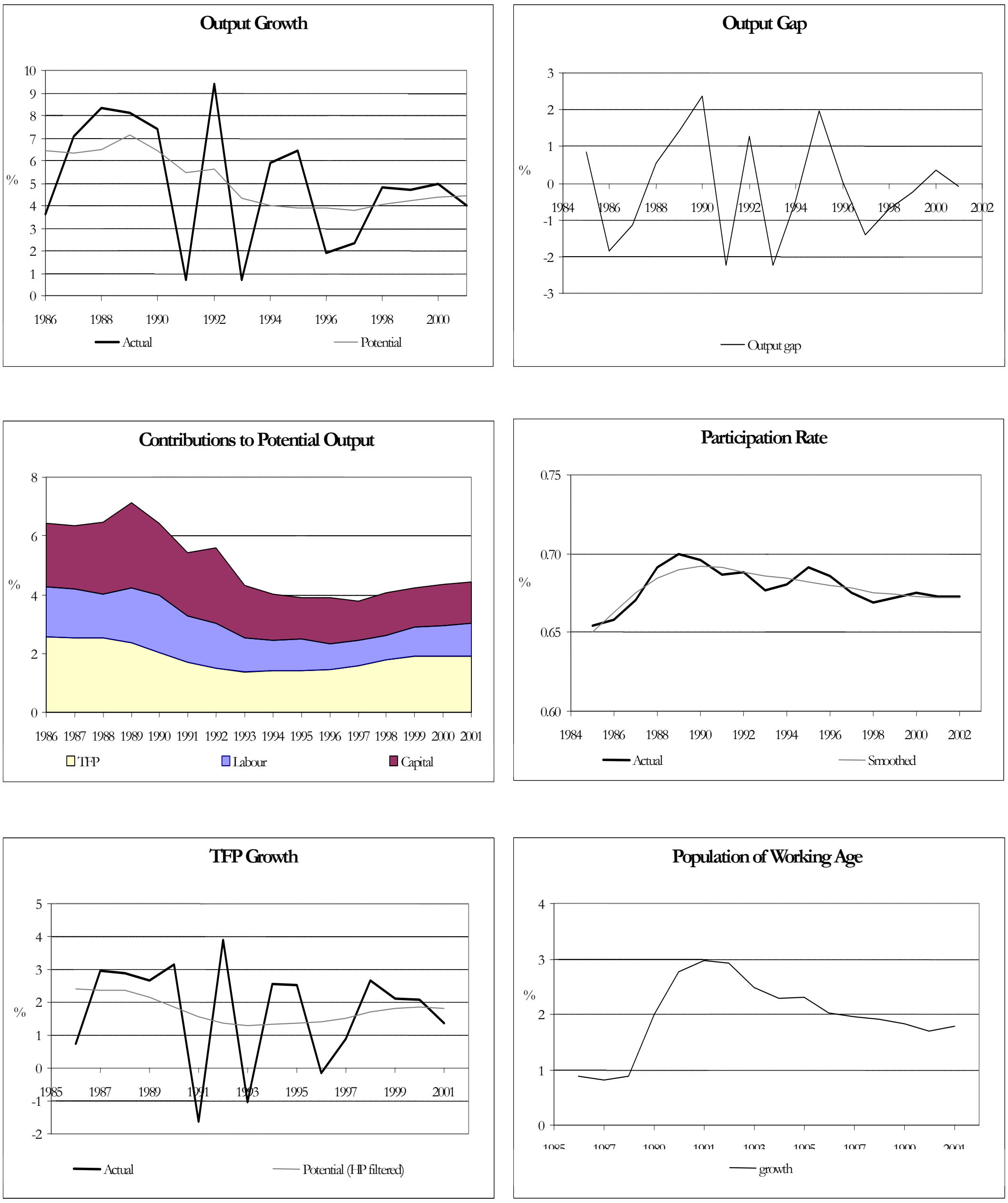
Table 2: Output Gap, Potential Growth and Contributions to Potential Growth

Year	Output Gaps (% of Potential Output)		Potential Growth (annual % change)		Contributions to Potential Growth*		
	HP	PF	HP	PF	Labour	Capital	TFP
1985	0.32	0.84	-	-	-	-	-
1986	-2.17	-1.85	6.23	6.43	1.68	2.17	2.58
1987	-1.7	-1.15	6.59	6.35	1.67	2.15	2.52
1988	-0.27	0.55	6.76	6.48	1.49	2.46	2.54
1989	1.18	1.44	6.54	7.15	1.86	2.93	2.36
1990	2.52	2.36	6	6.44	1.95	2.44	2.04
1991	-2.01	-2.24	5.36	5.44	1.61	2.15	1.68
1992	2.1	1.26	4.99	5.61	1.53	2.57	1.51
1993	-1.67	-2.24	4.56	4.31	1.13	1.8	1.37
1994	-0.24	-0.46	4.38	4.01	1.05	1.56	1.4
1995	1.95	1.97	4.17	3.91	1.04	1.44	1.43
1996	-0.02	0.01	3.9	3.89	0.84	1.59	1.46
1997	-1.52	-1.41	3.86	3.77	0.85	1.33	1.59
1998	-0.77	-0.73	4	4.08	0.82	1.48	1.78
1999	-0.16	-0.24	4.09	4.22	1	1.32	1.9
2000	0.75	0.35	4.03	4.36	1.02	1.42	1.92
2001	0.92	-0.07	3.83	4.44	1.14	1.42	1.89
Average	-0.05	-0.1	4.96	5.06	1.29	1.89	1.87

* Labour and Capital contributions are labour and capital growth rates multiplied by the respective factor shares. Labour, Capital and TFP contributions add up to Potential Growth calculated using the PF method and any discrepancies are due to rounding.

Figure 2 shows output gap and potential growth obtained using the PF method, together with the factor contributions presented in Table 2. In addition, the growth of the determinants of potential labour (participation rate and population

Figure 2: Output Gap and Determinants

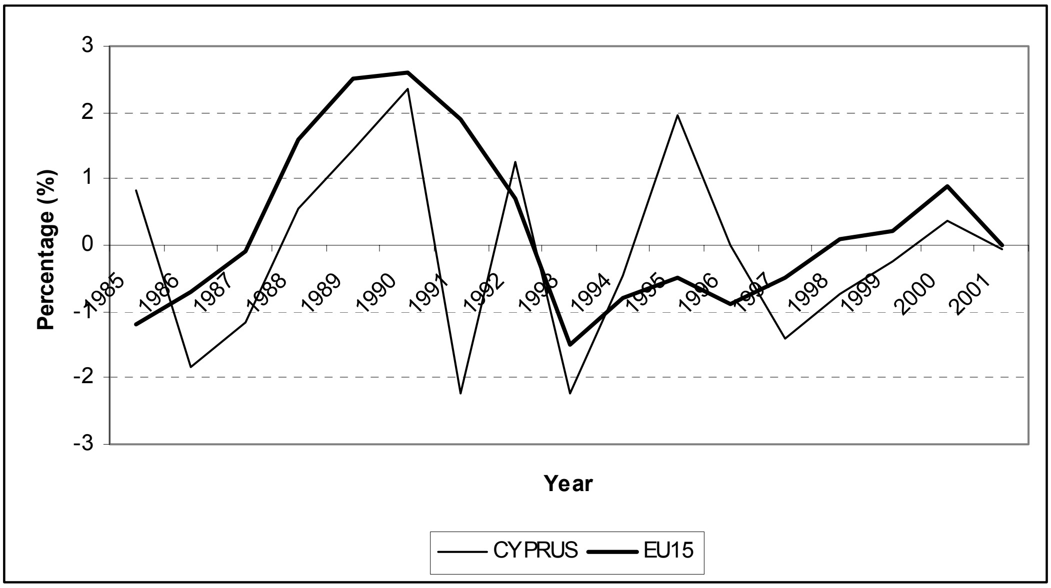


of working age) are also presented (NAIRU is shown in Figure 1). Actual and potential TFP growth are also shown in Figure 2. Actual TFP growth is rather volatile and becomes negative for some years. TFP growth for the European Union (EU15) is always positive for the same period (see Dennis et al., 2002).

Next we compare the results for Cyprus to those for EU15, which were obtained using very similar methodology, see Dennis et al. (2002).

The potential growth of Cyprus is higher than that of EU15 for all years. In particular the average potential growth for the period 1985-2001 is about 5% (from both methods) and the corresponding percentage for EU15 is 2.3% (from both methods). However, EU15 consists of economies most of which are at a more advanced stage of development than Cyprus. Thus, the higher potential growth rate for Cyprus indicates that there is still scope for further development. The contribution of labour as a percentage of potential growth is higher for Cyprus until 1997. The capital contribution to potential growth is also higher for Cyprus for most of the years. This of course results in lower TFP contribution to potential growth for Cyprus compared to EU15.

Figure 3: Output gaps for Cyprus and EU15



Output gaps as a percentage of GDP tend to fluctuate more for Cyprus than for EU15 since Cyprus is a small open economy hence vulnerable to shocks. Some of the peaks and troughs occur at the same point in time but the deviations of actual from potential last longer for EU15 than for Cyprus (see Figure 3).

VI. CONCLUDING REMARKS

The purpose of this essay was to provide estimates for potential output and output gap for the Cyprus economy using the production function approach, which was proposed by the Economic Policy Committee (2001) and was developed in Dennis et al. (2002).

Output gap estimates together with certain output elasticities with respect to main tax categories and public expenditures are used in the calculation of structural fiscal balance indicators (see Economic Policy Committee, 2001). These indicators are used in EU surveillance procedures mainly for the purposes of the Stability and Growth Pact.

Potential output and output gap estimates can also be used in the construction of structural macroeconomic models which are used for forecasting and policy analysis.

An extension to the current analysis would be the inclusion of the Phillips curve in the Kalman filter procedure for estimating NAIRU. The inclusion of a Phillips curve helps identify the cyclical component and make the decomposition of unemployment economically meaningful.

Another addition in the analysis would be to extend the estimates to the medium-term using projections (ARIMA models) for the determinants of potential output. This will give us an indication about possible developments provided that recent and current trends will not change.

Finally the aim is the calculation of structural fiscal balance indicators for Cyprus, that will be used for assessing macroeconomic policies and for purposes of budgetary surveillance by the EU.

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APPENDIX

Table A1: Estimates of the Autoregressive Coefficients of the Cyclical Component

AR coefficients	Estimates	Standard Error	P-value
ϕ_1	0.66	0.13	0.00
ϕ_2	-0.64	0.09	0.00

Table A2: ADF test statistics

Variable	Order	Test Statistic	95% Critical Value
U_t	ADF(3)	-3.44	-2.95
C_t	ADF(1)	-7.84	-2.95

NB: The order of ADF regression for U_t was chosen according to the Akaike Information Criterion

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Table A3: Breakdown of Actual Unemployment Rate into its Trend (NAIRU) and Cyclical Components

Year	Unemployment Rate	Trend Component	Cyclical Component
1965	1.6	2.0	-0.4
1966	1.4	1.5	-0.1
1967	1.1	0.9	0.2
1968	1.2	0.5	0.7
1969	1.0	0.4	0.6
1970	1.0	0.8	0.2
1971	1.0	1.9	-0.9
1972	0.9	3.7	-2.8
1973	1.2	5.3	-4.1
1974	10.0	7.3	2.7
1975	16.2	8.4	7.8
1976	8.6	7.4	1.2
1977	3.1	6.0	-2.9
1978	2.0	4.5	-2.5
1979	1.7	3.0	-1.3
1980	2.0	2.1	-0.1
1981	2.6	2.0	0.6
1982	2.8	2.3	0.5
1983	3.3	2.8	0.5
1984	3.3	3.2	0.1
1985	3.3	3.4	-0.1
1986	3.7	3.4	-0.1
1987	3.4	3.2	0.2
1988	2.8	2.9	-0.1
1989	2.3	2.6	-0.3
1990	1.8	2.3	-0.5
1991	3.0	2.4	0.6
1992	1.8	2.2	-0.4
1993	2.7	2.5	0.2
1994	2.7	2.6	0.1
1995	2.6	2.9	-0.3
1996	3.1	3.1	0.0
1997	3.4	3.3	0.1
1998	3.3	3.4	-0.1
1999	3.6	3.4	0.2
2000	3.4	3.2	0.2
2001	2.9	2.8	0.1

Table A4: Potential Output and Output Gap using the Production Function Method and HP Filter

Year	Real GDP (1995 constant prices)	Potential Output		Output Gap (% of Potential Output)	
		PF	HP	PF	HP
1985	2303.7	2284.6	2296.4	0.84	0.32
1986	2386.6	2431.5	2439.5	-1.85	-2.17
1987	2556.0	2585.8	2600.3	-1.15	-1.7
1988	2768.5	2753.4	2776.1	0.55	-0.27
1989	2992.7	2950.2	2957.7	1.44	1.18
1990	3214.2	3140.1	3135.1	2.36	2.52
1991	3236.8	3311	3303.2	-2.24	-2.01
1992	3540.9	3496.7	3468.1	1.26	2.1
1993	3565.7	3647.6	3626.4	-2.24	-1.67
1994	3776.2	3793.8	3785.3	-0.46	-0.24
1995	4020	3942.2	3943.1	1.97	1.95
1996	4096.3	4095.8	4097	0.01	-0.02
1997	4190.5	4250.2	4255.1	-1.41	-1.52
1998	4391.3	4423.5	4425.3	-0.73	-0.77
1999	4598.7	4610	4606.3	-0.24	-0.16
2000	4828.0	4811	4792.1	0.35	0.75
2001	5021.1	5024.8	4975.4	-0.07	0.92

Figure A1: Output Gap estimates using the HP and PF approaches