



## CBT RESEARCH NOTES IN ECONOMICS

### A Production Function Method of Estimating the Output Gap<sup>1</sup>

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**Özet:** Bu çalışma, basit bir üretim fonksiyonunu temel olarak Türkiye için bir çıktı açığı göstergesi hesaplamaktadır. 2005-2008 döneminde çıktı açığında pozitif düzey olmuş ve 2007:Q4 dönemi tepe noktası olarak gözlenmiştir. 2009 yılında ise son küresel krizin etkisiyle üretim düzeyi, potansiyel düzeyinin altında yer almış ve çıktı açığı 2009:Q1 döneminde dip noktasına ulaşmıştır. Bu çalışmada ortaya konulan çıktı açığı hesaplamaları, yeni Keynesyen bir model ve Bayesçi yöntem kullanılarak Türkiye'de çıktı açığının hesaplandığı, Alp, Öğünç ve Sarıkaya (2012) çalışmasının bulguları ile karşılaştırılmıştır. Niceliksel olarak bazı farklılıklar gözlenmekle beraber; iki çalışmada da niteliksel olarak benzer çıktı açığı bulguları ortaya konmaktadır.

**Abstract:** This note estimates an output gap measure for Turkey using a production function approach relying on a simplistic representation of the production technology. There is a large positive swing in the output gap during 2005–2008 and output gap reached its peak in 2007:Q4. Output level fell below its potential dramatically as a result of the global economic crisis in 2009 hitting a trough in 2009:Q1 and negative output gap as a percentage difference from the potential output was around 12 percent. Output gap estimates in this note and the ones obtained in Alp, Öğünç, and Sarıkaya (2012), using Bayesian estimation of a New Keynesian model, exhibit a similar pattern qualitatively, whereas there are some differences in quantitative terms.

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## 1. Introduction

Reasonably accurate output gap estimates are necessary to conduct monetary policies since central bankers would like to know the size of the gap between actual and potential GDP, so as to determine whether the economy needs more or less monetary stimulus. This note presents a simple way of output gap calculation for Turkey based on the production function and the HP filtering.<sup>2</sup>

A production function states a relationship between inputs (like labor and capital) and output (goods and services combined). The production function approach models potential output as a function of potential labor and capital inputs, as well as of potential total factor productivity (TFP). Therefore, output gap measures how far the economy is from its full employment or potential level that depends on supply-side factors of the economy: the supply of labor and capital and their productivity.

## 2. Methodology and Data

Output gap is defined as the percentage difference between actual and potential output:

$$\text{Output gap} = 100 * \frac{\text{Actual output} - \text{Potential output}}{\text{Potential output}}. \quad (1)$$

Actual output is given by:

$$Y_t = A_t K_t^\alpha L_t^{1-\alpha}, \quad (2)$$

where  $Y_t$  represents real gross domestic product (GDP),  $A_t$  is TFP,  $K_t$  is real physical capital stock and  $L_t$  is employment at date  $t$ ;  $\alpha$  and  $(1-\alpha)$  are the elasticities of output with respect to capital and labor, respectively. Similarly, potential output is given by:

$$Y_t^* = A_t^* K_t^{*\alpha} L_t^{*(1-\alpha)}, \quad (3)$$

where  $Y_t^*$  represents potential GDP,  $A_t^*$  is potential TFP,  $K_t^*$  is potential physical capital stock and  $L_t^*$  is potential employment at date  $t$ .

Capital stock, employment, and real GDP data are from Saygılı and Cihan (2011). Saygılı and Cihan (2011) have seasonally adjusted quarterly data between 1988:Q1 and

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<sup>2</sup> For earlier studies on output gap estimation in Turkey with different methods, see Öğünç and Ece (2004), Kara, Öğünç, Öziale, and Sarıkaya (2007), Saygılı and Cihan (2008), Akçay and Ocakverdi (2011), Demiroğlu (2011), Öğünç and Sarıkaya (2011), Alp, Öğünç and Sarıkaya (2012) and the references therein.

2011:Q2. This sample period is extended to 2014:Q4 to avoid end-sample biases, which reflect the symmetric trending objective of the method across the whole sample and the different constraints that apply within the sample and at its edges.<sup>3</sup>

The next step is calculating TFP series using capital stock, employment, and real GDP data:

$$A_t = Y_t / (K_t^\alpha L_t^{1-\alpha}), \quad (4)$$

where  $\alpha = 0.5$  is used following Saygılı and Cihan (2011).<sup>4</sup> Then, using a growth accounting method, the contributions of capital, labor, and TFP into real GDP growth are calculated.<sup>5</sup> It is assumed that these calculated contributions for the period 2002:Q1-2011:Q2 will be valid through 2014:Q4. Next, using the forecasts for quarter-on-quarter growth rates of GDP, consistent with the official forecasts, the real GDP series are extended to 2014:Q4. After that, the growth contributions of capital, labor, and TFP for the period 2011:Q3-2014:Q4 are used to extend these series until the last quarter of 2014. Now, capital, labor, TFP, and real GDP series for the period 1988:Q1-2014:Q4 are available to be used for calculations.

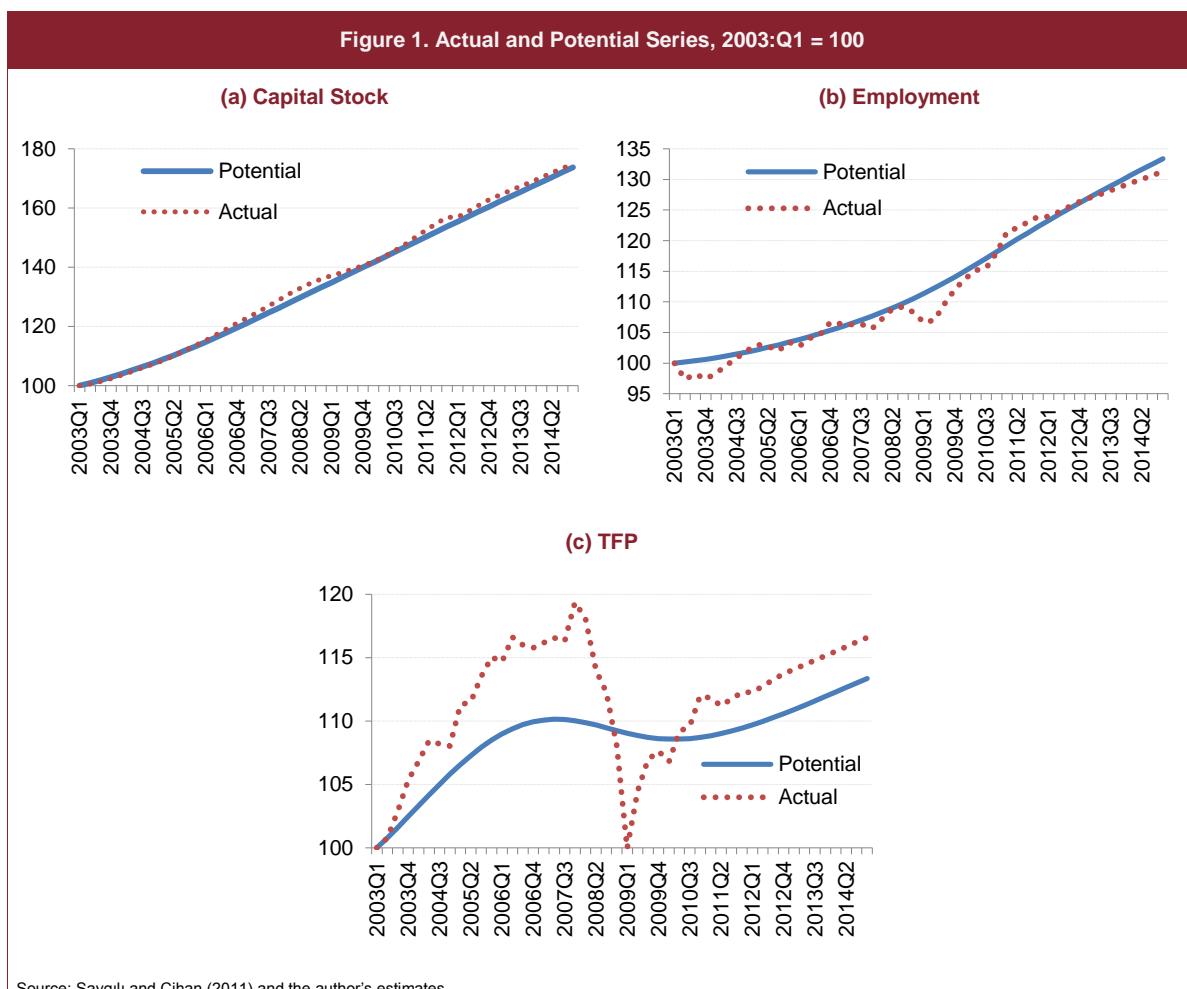
Potential output cannot be measured directly and therefore must be estimated. The HP filter is applied, using the standard value of 1600 for the smoothing parameter, to actual capital, labor, and TFP series separately. Then, the trends underlying the series of actual labor as potential labor input, actual capital as potential capital input, and actual TFP for potential TFP are used. Figure 1 provides actual and potential data for capital, labor, and TFP for the period 2003:Q1-2014:Q4.

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<sup>3</sup> This flaw is particularly severe when the focus of attention is directed at the most recent observations in the sample in an effort to draw conclusions for policy implementation and make projections for the immediate future (see, for example, Cerra and Saxena (2000)).

<sup>4</sup> See Altuğ, Filiztekin, and Pamuk (2008); and Ismihan and Metin-Özcan (2009) on the value of capital income share in Turkey. Chen, Gupta, Therrien, Levanon, and van Ark (2010), among many other studies, use 0.5 as the labor share for emerging and developing economies, because capital is relatively scarce in most of those remaining economies, and thus its return is high, while labor is cheap compared to advanced countries, leading to a lower labor share.

<sup>5</sup> This growth accounting exercise is carried out with annual data (with human capital input) as well. The results are available upon request.



Actual TFP growth exceeds the estimated potential TFP growth by a wide margin between 2003 and 2008. This substantial acceleration of the actual TFP growth could be likely to have been driven by a supply-side impetus such as the increased role of FDI in economic activity.<sup>6</sup> In addition, Ismihan and Metin-Özcan (2009) list four factors that could have been responsible for the speed-up in TFP: (i) successful reduction of the inflation rate, fiscal discipline, and the resultant stable macroeconomic environment; (ii) institutional reforms to the central bank and public-sector spending and structural reforms to the financial sector; (iii) the relatively stable political and external environment; and (iv) the prospect of

<sup>6</sup> Sayek (2007) provides some observations regarding foreign direct investment (FDI) flows to Turkey and notes the regulatory changes implemented with the FDI Act (Law No. 4875) that entered into force as of June 2003. With this legislative change, investment climate has been made more favorable for the entries of foreign firms. For example, until the regulatory changes in 2003 foreigners were not allowed to invest in real estate. As the new FDI Act allows foreigners to acquire property in Turkey, FDI inflows in real estate increased sharply. Sharp increase in FDI inflows is attributable to acquisitions by multinational companies of large stakes in major Turkish companies, especially in finance, telecommunications, and as a result of privatization and private sector takeovers.

possible EU membership.<sup>7</sup> Finally, potential employment ( $L_t^*$ ) and potential capital ( $K_t^*$ ) inputs and potential TFP ( $A_t^*$ ) in equation (3) are used to estimate potential output.

### 3. Output Gap

Figure 2(a) presents quarter-on-quarter growth rates for potential output and Figure 2(b) displays the output gap estimates based on the production function for the period 2003:Q1-2014:Q4. There is a large positive swing in the output gap during 2005–2008. Output gap reached its peak in 2007:Q4 and output level fell below its potential dramatically as a result of the global economic crisis in 2009. Output level hit a trough in 2009:Q1 and negative output gap as a percentage difference from the potential output was around 12 percent.<sup>8</sup> After the crisis, Turkish economy has entered a rapid recovery period. In the succeeding period output gap has started to decline compared to the year of 2009, the negative gap closed indicating the contribution of output gap to disinflation process has been diminishing compared to the global crisis era. These output gap estimates point out similar expansion and recession periods and are close to previous studies by Saygılı and Cihan (2008), Öğünç, and Sarıkaya (2011), and Alp, Öğünç, and Sarıkaya (2012).

Figure 2(c) compares the output gap estimated in this note with the findings of a recent study for the period 2003:Q1-2011:Q3. Alp, Öğünç, and Sarıkaya (2012) estimate an output gap measure for Turkey in a Bayesian framework considering a stylized New Keynesian small open economy model that describes the joint determination of output gap, its domestic and external components along with inflation. Figure 2(c) reveals that, the output gap estimates in this note and the ones obtained in Alp, Öğünç, and Sarıkaya (2012) exhibit a similar pattern qualitatively, whereas there are some differences in quantitative terms. For example, it is estimated that output level hit a trough in 2009:Q1 and negative output gap as a percentage difference from the potential output was 11.84 percent. The corresponding figure in Alp, Öğünç, and Sarıkaya (2012) is 11.71 percent. Some noticeable differences are observed for 2011. Alp, Öğünç, and Sarıkaya (2012) estimate that output gap was 0.43 for the first quarter of 2011; 0.06 for the second and 0.09 for the third quarter of 2011. On the other hand, this note estimates that output gap was 1.60 for the first quarter of 2011; 0.96 for the second and 1.37 for the third quarter of 2011.

<sup>7</sup> Since 2001, Turkey has put in place a very intense and ambitious structural reform agenda, coupled with sound monetary and fiscal policies, to establish macroeconomic and financial stability and to improve the business environment. Central Bank independence that was granted by Law in 2001 was one of the milestones of this agenda. The introduction of free-floating exchange rate regime in 2001 and inflation-targeting regime in 2002 were other key steps (see OECD (2006) for a review).

<sup>8</sup> An alternative way in the literature to calculate potential output is assuming that potential capital equals the actual total capital stock (see, for example, Konuki (2008)). Output gap is also calculated with actual physical capital series as potential capital stock. The results are very similar.

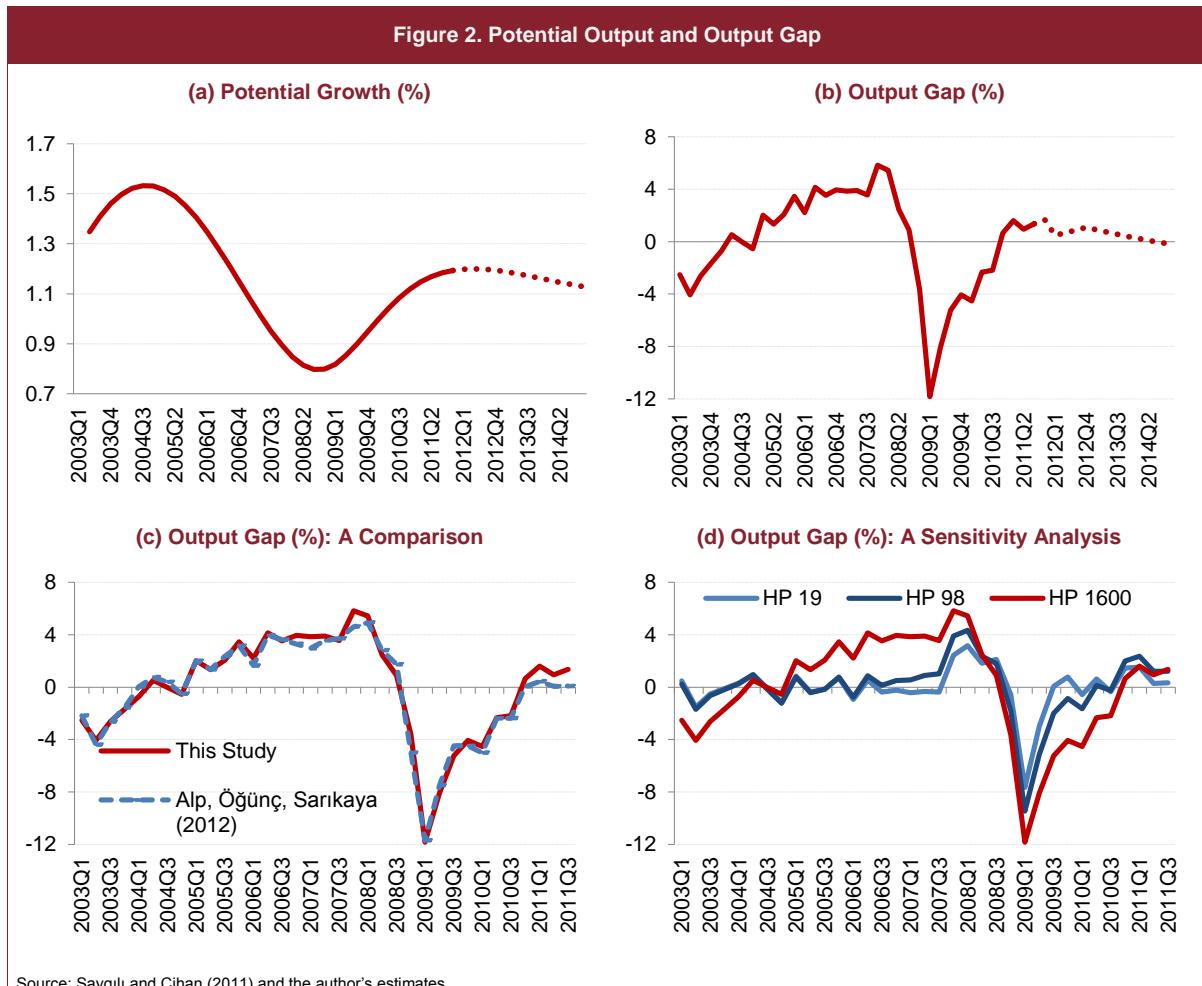


Figure 2(d) provides alternative estimates of output gap using different smoothing parameter for the HP filter since a possible shortcoming of using the HP filter is the difficulty in identifying the appropriate smoothing parameter, which is generally overlooked by using arbitrary values popularized by the real business cycle literature. Alp, Başkaya, Kılınç, and Yüksel (2011) estimate the optimal smoothing parameter for the HP filter for Turkey using quarterly real GDP data between 1987 and 2007. They come up with two alternative estimates (compared to 1600, which is the benchmark smoothing parameter used in this note): 19 and 98. Therefore, the calculations are replicated to see the sensitivity of the results with respect to the smoothing parameter. It is observed that the qualitative nature of the results is similar. However, the smaller the value of the smoothing parameter, the closer the output gap to zero. If 19 (98) is used as the value of the smoothing parameter, then output level hit a trough in 2009:Q1 and output gap was -7.66 (-9.47) percent.

#### 4. Concluding Remarks

This note presents a simple production function approach to estimate the output gap. The idea is, using minimum available information on the supply side of the economy, to infer useful information for measuring the output gap for the Turkish economy. In this regard, this study departs from traditional production function approach in which labour variable (rather than employment) is estimated by taking into account labour supply (usually linked to working-age population growth, participation rate and working hours) and NAIRU (or structural unemployment rate), and capital stock variable is used as actual values or corrected by using capacity utilization rates.<sup>9,10</sup>

Any method of estimating potential output depends on numerous assumptions that are subject to uncertainty and error. The approach in this note relies on a simplistic representation of the production technology omitting the direct information regarding the related supply-side factors such as capacity utilization, hours worked, labor force participation rate, technology adoption, regulation, human capital accumulation, etc. in addition to the alternative filtering methods. However, the obtained results are fairly comparable with the ones obtained in more complicated studies suggesting that the approach used in this note could be useful as an alternative method of output gap estimation for Turkey.

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<sup>9</sup> Saygılı and Cihan (2008) study such a production function approach and report potential and actual growth rates between 1987 and 2007. The potential output estimates, using annual capital and employment data, obtained in this note are compared with the ones obtained in Saygılı and Cihan (2008), who use capacity utilization rates, average working hours, and NAIRU figures to calculate potential output. The results are very similar.

<sup>10</sup> The simplicity of the production function ingredients may bring up questions on the validity of the approach. For example, using of employment instead of labour supply may yield similar potential output results if these variables have exhibit similar trends during the sample period (as the comparison of results of this study and the study by Saygılı and Cihan (2008) reveals). In this regard, it should be noted that reliability of output gap measures obtained by using employment variable instead of labour supply could be highly sensitive to changes in the relation of employment to labour supply. Therefore, any structural or medium-long term changes in labour participation rates, population growth, structural unemployment rate, or average working hours could to lead different output gap estimates. For the sake of simplicity, this note does not deal with these issues.

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