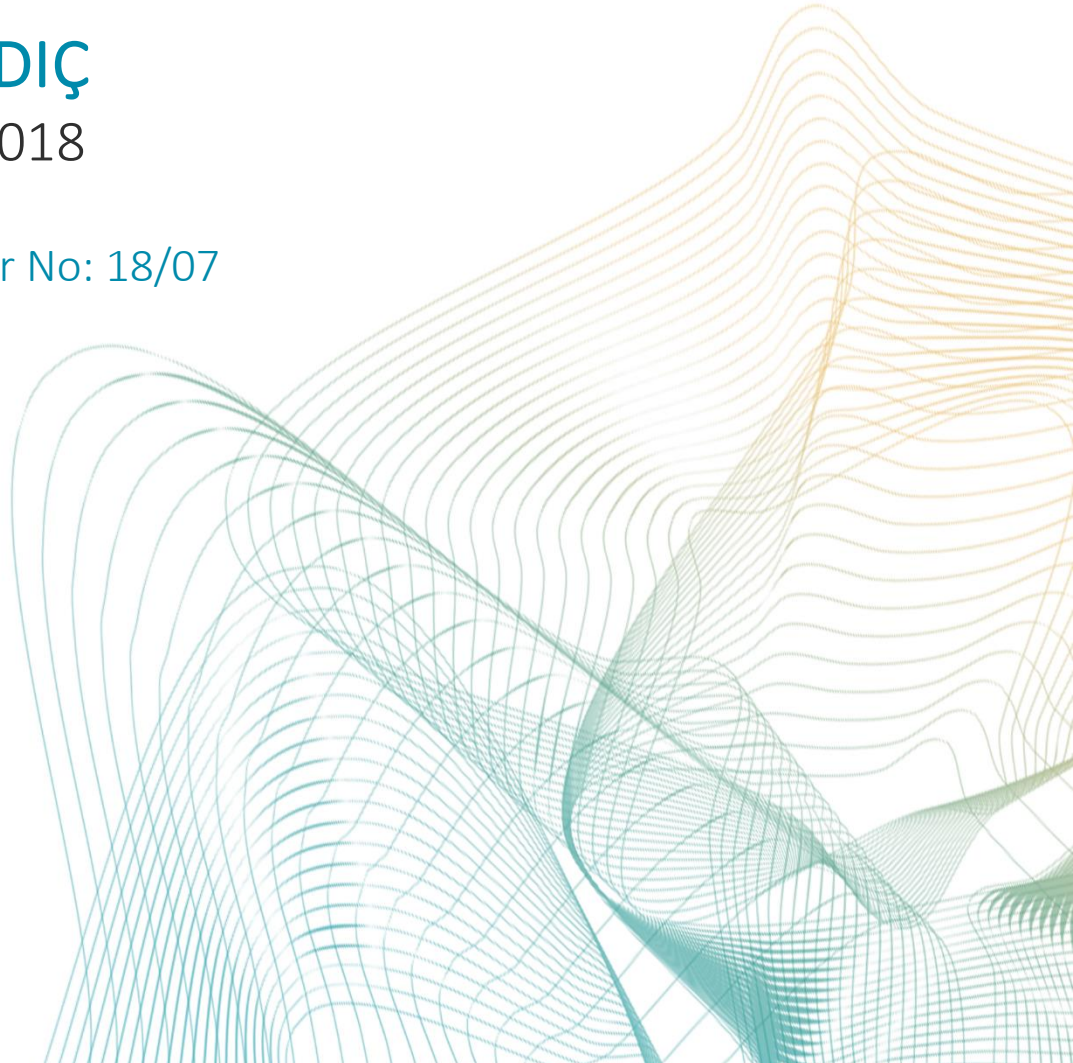


Multivariate Filter for Estimating Potential Output and Output Gap in Turkey

Selen ANDIÇ

February 2018

Working Paper No: 18/07



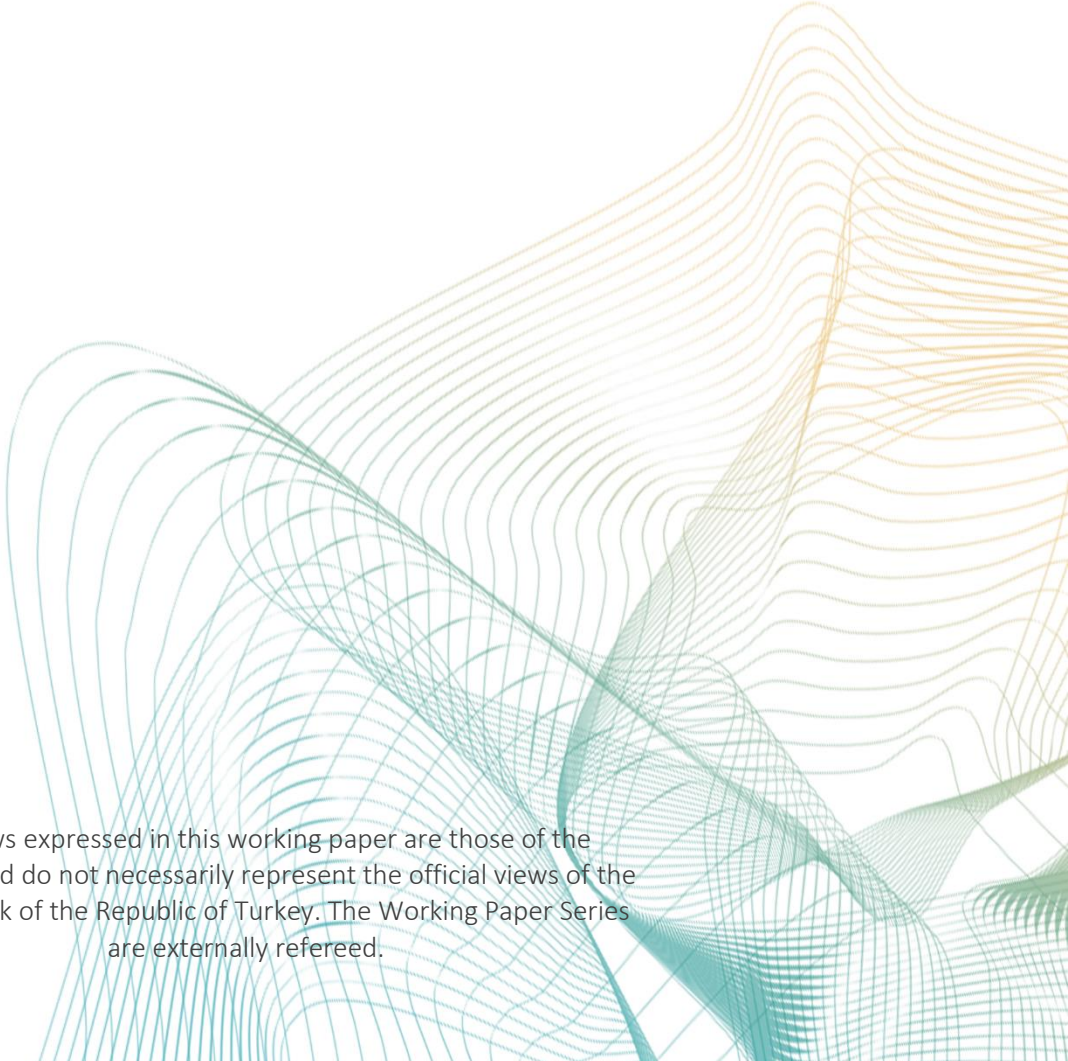
© Central Bank of the Republic of Turkey 2018

Address:
Central Bank of the Republic of Turkey
Head Office
Structural Economic Research Department
İstiklal Caddesi No: 10
Ulus, 06050 Ankara, Turkey

Phone:
+90 312 507 80 04

Facsimile:
+90 312 507 78 96

The views expressed in this working paper are those of the author(s) and do not necessarily represent the official views of the Central Bank of the Republic of Turkey. The Working Paper Series are externally refereed.



Multivariate Filter for Estimating Potential Output and Output Gap in Turkey

Selen Andıç*

Abstract

This paper estimates the potential output and output gap in Turkey using a multivariate filter. The filter employed links the output gap to slack in the labor market and changes in inflation. Additionally, it produces the output gap taking into account some macroeconomic variables. Though end-of-sample problem remains an issue, results show that the output gap estimates provided by the multivariate filter have a stronger relationship with inflation and are subject to smaller revisions compared to the Hodrick-Prescott filter.

Keywords: filter, potential growth, output gap, Turkey

Jel classification: C51, E32, O40

*Central Bank of the Republic of Turkey, Research and Monetary Policy Department, Istiklal Cad. No:10, 06100 Ulus, Ankara, Turkey. selen.baser@tcmb.gov.tr. The views expressed here are of the author and do not necessarily reflect those of the Central Bank of the Republic of Turkey. I would like to thank Çağrı Sarıkaya, Hande Küçük Yeşil and brown bag participants at the Central Bank of the Republic of Turkey for helpful discussions; Patrick Blagrove for sharing data; and the anonymous referees for their comments. All errors and omissions are my own.

1 Introduction

Potential output can be described as the maximum amount of output that can be produced without giving rise to inflation (Okun, 1962). Output gap is the percentage deviation of the actual output from the potential.

Estimation of potential output and output gap is important for policy-making. If the actual output is above (below) its potential, the output gap is positive (negative) and inflation rises (falls). Central banks, whose primary objective is to achieve price stability, closely monitor output gap developments. If the output gap is projected to exert pressure on inflation, central banks cool down the economy via increasing short-term interest rates. Potential output is also valuable from the perspective of non-monetary policymakers. The information on potential growth enables them to build medium to long-term policies, which can target convergence to the frontier economies.

There is a large literature on the potential output and output gap estimation. This study, similar to Benes et al. (2010), Blagrove et al. (2015), Alichì et al. (2015), Garcia-Saltos et al. (2016) and Pichette et al. (2015), belongs to the filtering branch of the mentioned literature. Filtering is easy to implement, yet it suffers from the end-sample bias (i.e., estimates towards the end of the sample, which the policymakers are most interested in, are the ones that are revised most significantly as new data become available). Another common technique to estimate the potential output is the production function approach. Basically, in this approach labor and capital are used as inputs. Depending on the type of the production function, total factor productivity is either estimated as a time-varying variable as in Klump et al. (2007) and Andıç (2016) or obtained as a residual as in Musso and Westermann (2005) and Husabø (2013). Though production function approach makes the drivers of growth visible, it may suffer from end-sample bias if the potentials of inputs and total factor productivity (TFP) are obtained via filtering. A third branch of the literature makes use of the sVAR and DSGE models to obtain the output gap estimates. However, these approaches are criticized for being sensitive to the specifications of the model. Specifically, DSGE model is hard to implement, though it allows for a deeper structural interpretation of the

potential output and output gap. Finally, some survey-based indicators, such as capacity utilization rates, perceived degree of insufficient demand as a constraint on businesses and the vacancy rate in offices, are considered to show the slack in the economy.¹ The revisions in output gap estimates under this method may be relatively moderate, especially when the indicators are not revised significantly and combined with simple averaging. Yet representativeness of the results for the whole economy is usually an issue with this approach.

This study rests on the work of Blagrove et al. (2015), which presents a modified version the multivariate (MV) filter presented in Benes et al. (2010). This filter includes some simple economic theory as it links the output gap to the slack in the labor market and changes in inflation. As the data requirements are minimal Blagrove et al. (2015) apply the filter to a range of countries, including Turkey. Concentrating on one developed, Canada, and one developing country, Brazil, they show that the MV filter produces more robust real-time estimates of potential output and output gap relative to estimates from the Hodrick-Prescott (HP) filter. However, they note that uncertainty in these estimates is still present. Though this paper mainly draws on Blagrove et al. (2015), it differs from that regarding its estimation technique and model specification. In particular, Blagrove et al. (2015) use a small sample of annual data and apply Bayesian estimation. On the other hand, this study employs a relatively larger sample as it uses quarterly data, and use maximum likelihood estimation. Also, Blagrove et al. (2015) model output gap as an autoregressive process. However, slack in the economy is determined by the domestic and foreign conditions. This paper adds some macroeconomic variables to capture these conditions when explaining the output gap.²

Quite a number of papers have utilized filtering method to obtain the potential output and output gap in Turkey.³ Özbek and Özlale (2005), Kara et al. (2007),

¹For instance, see Rodriguez et al. (2006). Also, see ECB (2015b) for a combination of survey-based indicator and filtering approach.

²Another difference in the model specification is the use of steady-state variables in potential growth and NAIRU equations. Steady-state expressions, which are indeed unknown and in the end calibrated as the average of past values, are simply dropped in this study.

³A nice paper which uses production function method to estimate the potential output and output gap in Turkey is Üngör (2012). Erdoğan et al. (2013) produce a slack indicator for the Turkish economy using survey variables, which are combined in a dynamic factor model setting.

Metin Özcan et al. (2007), Ögünç and Sarıkaya (2011) and Alp et al. (2012) are some examples. However, some of these either do not incorporate any economic theory, or includes it only partially by just adding a Phillips curve to estimations. Hence, this paper contributes to the existing literature, mainly because it is the first one that produces potential output and output gap estimates for Turkey taking into account both the inflation and labor market dynamics in a multivariate filter augmented with macro variables.

The output gap estimates obtained in this paper seem to be robust under reasonable calibration values. They are found to be more related with inflation and have smaller revisions compared to the ones coming from the HP filter. Yet it is shown that the output gap estimates of the MV filter suffer from the end of sample bias. Turkish Statistical Institute (TurkStat) has recently switched to a new set of standards for measuring GDP to provide compliance with the System of National Accounts (SNA2008) and European System of Accounts (ESA2010). The adoption of these guidelines implied major changes in the classification, definition, and coverage of the national accounts.⁴ The new implementation created a notable change in the GDP series. This paper presents the output gap and potential growth estimates using both old and new GDP data. Results show that new series implies a more volatile output gap and higher potential growth compared to the old series.

The remainder of this paper is organized as follows. Section 2 introduces the model and data. Section 3 discusses the results by making a comparison between the estimates before and after the revision in the national accounts. Section 4 presents robustness checks. Finally, Section 5 concludes.

Saraçoğlu et al. (2014) obtain output gap from an sVAR. Finally, output gap estimates in a DSGE setting for the Turkish economy is relatively an untouched area.

⁴Details can be found at http://www.turkstat.gov.tr//duyurular/duyuru_2305.pdf.

2 Model and Data

The model is made of three blocks: output, unemployment and inflation. The output block has the following equations:

$$Y_t = \bar{Y}_t + y_t \quad (1)$$

$$\bar{Y}_t = \bar{Y}_{t-1} + G_{t-1}^{\bar{Y}} + \varepsilon_t^{\bar{Y}} \quad (2)$$

$$G_t^{\bar{Y}} = G_{t-1}^{\bar{Y}} + \varepsilon_t^{G^{\bar{Y}}} \quad (3)$$

$$y_t = \delta y_{t-1} + \lambda r_{t-1} + \beta_1 rer_{t-1} + \beta_2 rer_{t-1} D10 + \beta_3 y_t^f + \beta_4 D08Q1 + \varepsilon_t^y \quad (4)$$

Y_t is the real GDP in log terms. \bar{Y}_t is the potential GDP and y_t is the output gap. Potential GDP is a function of its past and quarterly potential growth $G_t^{\bar{Y}}$, which follows a random walk.⁵

GDP is composed of domestic and foreign demand. The same argument goes for the output gap, as well. Hence, the output gap is modeled, parsimoniously, as a function of variables which explain these components. Income is effective on how much to consume and save. Consumption and investment decisions are affected by the interest rate and exchange rate developments. Foreign demand not only takes into account the exchange rate changes but also its income when buying goods from abroad. Accordingly, as shown in equation (4), output gap is written as a function of its past, real interest rate r_{t-1} , quarterly change in real effective exchange rate rer_{t-1} and export-weighted global growth y_t^f .⁶ Increase in the real exchange rate means real appreciation. $D10$ is a dummy variable that takes the value of 1 since 2010 and 0 otherwise. Hence, equation (4) allows for a change in the effect of real exchange rate on the output gap before and after 2010. A

⁵Note that equations (1)-(4) imply that Y_t is $I(2)$. This type of modelling relies on the idea that potential growth of developing countries may not be constant since, during their development process, the contribution of labor, capital and productivity will change. This is also pointed by Clark (1987) in his pioneering work for US as follows: *"In addition, it seemed inappropriate to assume a constant growth rate [in potential growth] in advance, given the decline of U.S. productivity growth in the 1970s and reduction of labor force growth in the 1980s, both of which should have shifted the underlying growth of output."* $I(2)$ modelling of GDP is still common for the developed countries as we see in ECB (2015a) and Melolinna and Toth (2016).

⁶See Eren (2013) for the details of the export-weighted global demand index for Turkey.

detailed description of the variables used in this study is presented in Table 1.

δ is expected to be between $(0, 1)$, as higher income today can yield higher consumption in future through savings. λ is expected to be negative since when the interest rate increases, the cost of borrowing increases (or the opportunity cost of spending rises), hence domestic demand decreases pushing the economy below its potential. β_3 is expected to be positive because an increase in foreign income can lead to a rise in its imports, i.e., exports of the domestic country. However, the signs of β_1 and β_2 are ambiguous. Traditionally, exchange rate depreciations are considered to increase the output through improved net exports. Yet depreciation can have deteriorating effects on the supply-side of the economy as well as expectations of the agents, hence a fall in output. Finally, $D08Q1$ is a dummy variable taking the value of 1 in the first quarter of 2008 and 0 otherwise.

It might be argued why the macro variables in equation (4) are not used in gap forms. There are mainly two reasons for this. First, how should we define the gap form? In the context of this paper, an appropriate way would be introducing additional equations that estimate the gaps of these variables. However, there is not enough data for that. Second, as the filtered gaps suffer from the end-sample problem use of, for instance, HP filtered, gap estimates of the macro variables could have amplified the uncertainty around the output gap estimate in equation (4).

In the block of unemployment, the slack in the labor market, u_t , is defined as the log difference between trend unemployment -NAIRU- and actual unemployment, namely \bar{U}_t and U_t . $G_t^{\bar{U}}$ is the change in the trend and assumed to follow a random walk. Last, using the Okun's law, unemployment gap is linked to the output gap:

$$U_t = \bar{U}_t - u_t \quad (5)$$

$$\bar{U}_t = \bar{U}_{t-1} + G_{t-1}^{\bar{U}} + \varepsilon_t^{\bar{U}} \quad (6)$$

$$G_t^{\bar{U}} = G_{t-1}^{\bar{U}} + \varepsilon_t^{G^{\bar{U}}} \quad (7)$$

$$u_t = \alpha u_{t-1} + \phi y_{t-1} + \varepsilon_t^u \quad (8)$$

where, α is expected to be $(0, 1)$ and ϕ is expected to be positive. The final block is a traditional Phillips curve defining the inflation dynamics:

$$\pi_t = \theta_0 + \theta_1 \pi_{t-1} + \theta_2 y_{t-1} + \theta_3 pm_t^{TL} + \theta_4 D06Q3 + \theta_5 D07Q4 + \theta_6 D08Q4 + \theta_7 D09Q3 + \varepsilon_t^\pi \quad (9)$$

where π_t is the quarterly change in the consumer prices excluding unprocessed food, alcoholic beverages, and tobacco. It is the core D index newly published by the TurkStat.⁷ As the share of imported inputs is high in Turkey, the import prices are effective on the inflation dynamics. pm_t^{TL} , quarter over quarter change in import prices denominated in Turkish Lira, is added to equation (9) to capture this effect.⁸ Clearly, θ_1 , θ_2 , and θ_3 are all expected to be greater than zero. The rest is time dummies with a value of 1 at Q3 of 2006, Q4 of 2007, Q4 of 2008 and Q3 of 2009, and 0 otherwise.⁹

The sample length is constrained by the break in the Household Labor Force Survey in 2005. Therefore, the data set covers 2005Q1-2016Q4 period. It is also more convenient to start data from 2005 as the preceding periods either correspond to a disinflationary period under inflation targeting or a different monetary policy

⁷It is the preferred price index instead of CPI due to the following reason: as shown in Ögünc (2010) unprocessed food and tobacco prices have the highest unexpected volatility among the sub-components of CPI in Turkey. It is quite problematic to model the evolution of inflation dynamics when there is high volatility as it either makes modeling impossible or causes selection of irrelevant variables in the model. Also, these sub-components are beyond the control of monetary policy. This is recognized in the Inflation Report of the Central Bank of Turkey, and for this reason, since 2010, CBT publishes forecasts for the D index, as well. Therefore, it is the D index which the monetary policy is effective on through the output gap and other transmission channels.

⁸Imported inputs play a significant role in manufacturing production in Turkey. Indeed, in Andıç et al. (2015), it is shown that 60% percent of the marginal cost of production is foreign, while 40% percent of it is domestic. Imports are in foreign currency. Therefore, change in the nominal exchange rate and change in import prices (which is equivalent to say a change in TL denominated import prices) affect production costs, hence the overall price level. Indeed, Kara and Ögünc (2012) show that a 10 percent shock to Turkish lira denominated import prices leads to about 1.5 percentage points increase in core (D index) inflation at the end of twelve months. Therefore, import prices should be included as an explanatory variable when modeling inflation in Turkey.

⁹The dummies are included to provide concavity in the maximum likelihood function. Without them, the model does not converge. They are chosen by carefully examining the residuals of the IS and Phillips curve equations. It is noteworthy that 2 of the dummies in the model coincide with the global recession period - a period hard to model thoroughly with any macro variables.

strategy in Turkey.

3 Results

3.1 Parameter and gap estimates

The estimated parameters of the model have the expected signs and are significant at the conventional levels (Table 2). Parameters δ , λ and α are calibrated at values 0.5, -0.001 and 0.8, respectively.¹⁰ Results show that the effect of one percentage point increase in the quarterly growth of foreign demand closes the output gap (i.e., push the economy towards/above its potential) by 1.2 percentage points. The calibration value for λ indicates that a 100 basis points rise in the real interest rate opens the output gap (i.e., pull the economy towards/under its potential) by 0.1 percentage points.

Traditionally, when the exchange rate depreciates, exports can rise while imports fall leading to a rise in net exports and a smaller slack in the economy. However, the exchange depreciation can increase the cost of production, as well as it can disturb the balance sheet of firms and expectations of the agents in the economy. In such a situation, the domestic demand may deteriorate and cause the output to fall behind its potential. Previous studies on the responsiveness of total real exports to the real exchange rate in Turkey find no significant relationship between the two.¹¹ This study points out that the effect of real exchange rate on the output gap in Turkey can be episodic or blurred by the global financial crisis as the coefficients before and after 2010 have opposite signs.¹² In particular, one

¹⁰Residual standard errors of the model are also calibrated. Details are presented in Appendix 1. Without constraints on residuals no meaningful results could be obtained: the model never converged, and the output gap was flat. Then, the model was run under different calibration values for the residuals and without constraints on δ , λ and α . This way, estimates of these parameters were obtained, which were similar in general. However, most of the time their standard errors could not be solved and the model did not converge, though the output gap had a more sensible shape. Hence, δ , λ and α are calibrated at values close to the estimates obtained from these "residual-calibrated but parameter-set-free" estimations. The major reason for the need of calibration is considered to be the small sample size.

¹¹For instance see Atabek et al. (2014), Çulha and Kalafatçılar (2014) and Berument et al. (2014).

¹²This finding is consistent with Dincer and Kandil (2011). In their study, they argue that

percentage point decrease in the real exchange rate, i.e., depreciation, is estimated to open the output gap by 0.18 percentage points before 2010. Yet, $\widehat{\beta}_2$ is found to be negative, which means that one percentage point depreciation in rer_{t-1} closes the output gap by 0.05 percentage points in the period after the financial crisis.

Output gap estimates, after (trend) smoothing, are presented in Graph 1. Results show that the Turkish economy was operating above its potential just before the global financial turmoil. However, upon the fall in the consumer and investor confidence, outflow in capital, decrease in use of credits and recede in global trade, the output gap turned out to be negative in 2009. Graph 1 also shows the output gap estimates of the HP filter and a simple multivariate filter, which excludes the macroeconomic variables employed in equation (4). All the results look similar at first sight. Yet the HP filtered output gap is more volatile than the MV filtered gaps, and as it will be shown in section 4, it is subject to greater revisions. In the simple MV filter, the economy is estimated to be below but closer to its potential around 2009 compared to the MV filter with macro variables. The triggering reason for this difference is the ruling out of information coming from the foreign demand, y_t^f , which collapsed in the global financial crisis. The more recent estimates of the output gap indicate that there might be slack in the Turkish economy upon the rising domestic and geopolitical uncertainties, as well as the tightening in the financial conditions in the second half of 2016. Though, this finding should be taken with caution due to the end of sample uncertainty.

The estimate of the unemployment gap is shown in Graph 2 alongside with the output gap. The goods market leads the labor market by one quarter. The unemployment is estimated to be below the NAIRU before the global financial crisis. Then, the unemployment rises above its trend. The more recent estimates indicate a widening slack in the labor market, as the economic activity has fallen behind its potential. Graph 3 shows the output gap estimates and inflation. The Phillips curve equation, equation (9), implies that if the output gap closes by

while an unexpected depreciation in real exchange rate led to a rise in exports in the 1996-2001 period, it had a contractionary effect in the 2002-2008 period. When this is evaluated together with the effects of an unexpected appreciation, they conclude that volatility in the exchange rate is detrimental for exports in the post-2002 era and improvement in the quality and accessing new markets can be helpful in boosting exports.

one percentage point, inflation edges up by 0.1 percentage points.¹³ The past inflation is influential on current inflation, as $\hat{\theta}_1$ is approximately 0.42. Finally, one percentage point rise in the quarterly change in import prices is estimated to increase the quarterly inflation by 0.06 percentage points.

3.2 Potential growth

Results suggest that while potential growth fell significantly during the global financial crisis, it improved in 2011-2013 period before its recent slow down (Graph 4).

MV filter defines potential output as the level of output consistent with stable inflation. Hence, potential growth obtained from this filter can be interpreted as the "constant inflation rate of growth" if the output gap is zero. That is to say, an increase in output that is equivalent to the magnitude of potential growth can be inflationary if the output gap is positive.

Potential output is a supply-side concept. Therefore, the reasons for the changes in potential growth are examined through the lens of a production function. The most widely used production function is Cobb-Douglas. However, assuming only two factors of production, i.e., labor and capital, employing such a function imposes two important assumptions. First, the elasticity of substitution between labor and capital is assumed to be 1. Second, inputs' shares in national income are assumed to be constant. Yet it should be kept in mind that neither of these assumptions has to hold. For instance, Klump et al. (2007) show that labor and capital are complements, i.e., elasticity is smaller than 1, in the US and the euro area, and labor share in national income is non-stationary in latter. Moreover, productivity is measured as a residual term in Cobb-Douglas function. However, in the short-run, a residual can hardly be an indicator of productivity "only" as it will also reflect an unexplained part of output once the inputs are accounted for.

Given these limitations, when the potential growth obtained from the MV filter

¹³These findings remain broadly the same when the analysis is done with the GDP data excluding agriculture. The results are available upon request.

is decomposed into its sources via Cobb-Douglas, it is seen that the greatest contribution comes from capital, which is followed by labor (Graph 5). Looking at the last ten years, it can be noticed that productivity growth does not help too much to reach higher levels of economic growth in Turkey. Even when the global recession period is excluded, the contribution of TFP to potential growth is still low on average.

3.3 Revision in national accounts: then and now

In December 2016, TurkStat has switched from ESA95 to ESA2010 methodology in the implementation of the system of national accounts in Turkey. After this revision, not only the level of GDP has increased in real and nominal terms, but also the growth rates have scaled up after 2009. While the old GDP series measured the average growth rate as 5.2 percent from 2010 to 2015, the new series has shown that it was indeed 7.4 percent. The main reason for this rise is the up-shift in the construction investments, which resulted from the improvement in data sources. According to the TurkStat, new data sources rest more on official recordings and are more representative of the whole economy.

This major revision has evoked the following question: what has happened to the output gap and potential growth? As shown in Graph 6, there is no systematic upward or downward change in the output gap estimates.¹⁴ For some quarters, such as 2008Q1 and 2011Q3, the new series implies a more positive output gap compared to the old series, and for some others, such as 2014Q1 through 2014Q3, it signals the reverse. Overall, out of 44 data points, 23 (21) are revised downwards (upwards). However, volatility in the output gap is higher in the new series. According to the 1998 based series, the Turkish economy seems to have gradually increasing inflationary pressures before the global recession. The period after 2013 is also marked by a positive output gap, which tends to close over time. Yet the new series does not quite speak of persistence. These observations point to something important for the policy-makers; evaluate the gap in the economic activity *jointly* with the GDP-free-slack-informative indicators.

¹⁴The MV estimation results with the 1998 based GDP series is presented in Appendix 2.

Graph 7 outlines the change in the potential growth. The main takeaway is; potential growth has increased. The supply-side story of potential growth is the same; the largest contribution used to come from capital and labor, respectively (Graph 8). So, what explains the hike in potential growth? First, the capital accumulation. With the increase in construction investments after the revision in national accounts, capital stock has scaled up. It now grows stronger and adds more to potential growth. Second, the contribution of TFP growth has improved.¹⁵

4 Robustness Checks

Output gap is an unobserved variable. Therefore, the precision of output gap estimates cannot be known. However, the estimated series can be compared with respect to some criteria. Hence, the relative performance of the estimated series can be assessed. In this section, the robustness of the obtained results is checked in three ways. First, the output gap estimates obtained under different reasonable calibration values are presented. Second, the relationship between the MV filtered output gap estimates and inflation is compared to that between the HP filtered estimates and inflation. Third, amount of revision in the output gap estimates produced with the multivariate filter is compared with the HP filter when the sample is recursively extended.

How sensitive are the output gap estimates to the calibration values? To answer this question, output gap is estimated under various calibration values for δ , λ and α . Graph 9 shows that the produced series are mainly in line with each other. The most different output gap series seems to be the one when δ , the effect of y_{t-1} on y_t , is evaluated at 0.7. However, this estimation has the lowest log likelihood (Table 3).

MV filter relates the output gap to changes in inflation, whereas the HP filter drives output gap just relying on the GDP data. Therefore, it is expected that

¹⁵Using the 1998 based GDP series, Blagrove et al. (2015) present potential growth and output gap estimates for Turkey. When the same series is employed, findings of this paper is mainly in line with Blagrove et al. (2015), as shown in Appendix 2.

the MV filter has a stronger relationship with the inflation compared to the HP filter. The correlation between the output gap and inflation is 0.69 with the MV filtered output gap estimates and 0.60 with the HP filtered ones (Table 4). If the crisis period is excluded, the strength of the relation falls, though still stronger with the MV filter.

Output gap estimates are revised as new data become available. Yet the policymakers would like to know the "precise" slack in the economy. Hence, the smaller the revision, the better. Graph 10 and 11 present the quasireal-time estimates of the HP and MV filter as the sample is extended. These estimates are obtained from recursive estimations using the last vintage of the GDP series.¹⁶ By visual inspection, the estimates coming from the multivariate filter seem to be less prone to revision than are estimates derived from an HP filter towards the sample end. The amount of revision can be measured quantitatively, as well. In this respect, two different criteria are used. First criterion assumes that the last output gap estimate is the "true" estimate and computes the revision in the output gap series, for instance, at 2014Q1, as:

$$\left| \frac{\sum_{t=2014Q1}^{2016Q4} (y_{2014Q1,t} - y_{2014Q1,2016Q4})}{11} \right| \quad (10)$$

where $y_{2014Q1,t}$ means the observation at 2014Q1 of the output gap series ending at time t . The denominator is the number of observations from 2014Q1 to 2016Q4. The second criterion takes into account the revision in each recursive output gap estimate and calculates the overall revision, say at 2014Q1, as:

¹⁶A more comprehensive analysis on total revision can only be done with the real-time estimates of the output gap. To this aim, real-time GDP data are required. However, as of early 2017, there are only two vintages of the GDP series after the revision in the system of national accounts in Turkey. The first vintage is from 1998Q1 to 2016Q3, the second is from 1998Q1 to 2016Q4. Hence, a quasireal-time exercise is the only possible option with the available data.

$$\left| \frac{\sum_{t=2014Q1}^{2016Q4} y_{2014Q1,t+1} - y_{2014Q1,t}}{11} \right| \quad (11)$$

As shown in Graph 12 and 13, both criteria imply that revision in the output gap coming from the MV filter is smaller than the HP filter.¹⁷ This is because more identifying information is used in the former compared to the latter. However, the upward trends in those graphs indicate that both filters suffer from the end-sample bias. That is, the most recent estimates are the ones that are revised most significantly.

Why are the output gap estimates revised? One reason is the revision in the actual GDP series with the new data. However, this cannot be an answer in this analysis since only the last vintage of data is used. In the context of this paper, revision can be due to two reasons. First, the effect of new data points to the estimated parameters of the model can lead to a change in the output gap estimates. Second, use of full sample information compared to partial one can cause an update in the estimated series. The latter reason occurs due to smoothing process in filtering. Graph 14 shows recursive estimates of the output gap with the non-smoothed trend.¹⁸ Immediately noticed is the stability in the non-smoothed estimates. That is, the addition of new information does not induce a major change in the estimated parameters of the model. Therefore, it is the smoothing in the potential output that causes revisions in the output gap displayed in Graph 11.¹⁹ If so, then why do we smooth out the potential output? The reason may

¹⁷This finding holds when the MV filter is calibrated at different values, as well. Those results are available upon request. Also, the results are valid if the first criterion is calculated using root mean squared error.

¹⁸To be precise, non-smoothed output gap estimates are obtained by predicting the potential output at each period using the previous and contemporaneous data by the Kalman filter. On the other hand, smoothed estimates are produced when the potential output is predicted using all the sample information at each period.

¹⁹In the context of Orphanides and van Norden (2002), this suggests that the difference between quasifinal and quasireal output gap estimates accounts for the revision in Turkey. Similarly, they argue that adding a Phillips curve relation to different unobserved components models for the US GDP, does not enhance the reliability of the output gap estimates as the mentioned difference is particularly large for the period between 1995:1-2000:1.

be lying in the belief that shocks to the economy are shocks to aggregate demand primarily, with supply conditions largely unaffected, so an economy's capacity to produce does not change significantly from today to tomorrow.

5 Conclusion

In this paper, using the multivariate filter, estimates of the potential output and output gap are presented for Turkey. The filter embeds some basic economic theory as it derives the output gap taking into account inflation and unemployment. Results show that the deepest economic slack was experienced in 2009. After that, the Turkish economy has had inflationary and disinflationary cycles.

The MV filter is also run with the 1998 based GDP series. Findings suggest that the output gap used to be less volatile and potential growth used to be lower with the old series. A simple growth accounting exercise reveals that the rise in potential growth implied by the new series hinges on the higher capital stock and improvement in productivity growth.

The output gap estimates are found to be robust at different calibration values. MV filtered output gap is shown to have a stronger relationship with the inflation compared to the HP filtered one. Moreover, with incremental extensions in the sample size, the revisions in the estimates of the MV filter are shown to be smaller relative to the HP filter. Yet it should be noted that end-of-sample problem remains an issue. The findings in this study imply that the multivariate filter is a useful tool to assess the potential output and output gap in Turkey. To alleviate the above-mentioned bias and to guard against cases like major revisions in the national accounts, it is recommended that the most recent estimates be evaluated together with other indicators of economic slack when guiding the policy. A similar approach should be adopted in the design of policies resting on the potential growth since combining potential output estimates derived under different methodologies can incorporate a wider set of information.

The future work can extend this paper in two directions. First, the output gap equation can be augmented with other macroeconomic variables such as

fiscal stance. Second, a fourth block linking the credit market dynamics to the real economy can be added to the model. Leaving aside filtering, research directed at estimating potential output and output gap in a more structural and micro-founded framework for Turkey will fill a gap in the literature. However, the most valuable efforts will be the ones directed at improving the reliability of the real-time estimates.

References

- Alichi, A., B. Olivier, S. Domit, E. F. Corugedo, D. Laxton, K. Tanyeri, H. Wang, and F. Zhang (2015). Multivariate filter estimation of potential output for the Euro Area and the United States. IMF Working Paper 15/253.
- Alp, H., F. Ögünç, and Ç. Sarkaya (2012). Monetary policy and output gap: mind the composition. CBT Research Notes in Economics No:12/07.
- Andıç, S. (2016). On estimation of the normalized CES production function for Turkey. Central Bank of Turkey Working Paper No:16/13.
- Andıç, S., H. Küçük, and F. Ögünç (2015). Inflation dynamics in Turkey: In pursuit of a domestic cost measure. *Emerging Markets Finance and Trade* 51(2), 418–431.
- Atabek, A., O. Y. Çulha, and M. K. Kalafatçılar (2014). Sensitivity of exports to sectoral exchange rates (in Turkish). CBT Research Notes in Economics No:2014-21.
- Benes, J., K. Clinton, R. Garcia-Saltos, M. Jonson, D. Laxton, P. Manchev, and T. Matheson (2010). Estimating potential output with a multivariate filter. IMF Working Paper 10/285.
- Berument, M. H., N. N. Dincer, and Z. Mustafaoglu (2014). External income shocks and Turkish exports: a sectoral analysis. *Economic Modelling* 37, 476–484.
- Blagrove, P., R. Garcia-Saltos, D. Laxton, and F. Zhang (2015). A simple multivariate filter for estimating potential output. IMF Working Paper

15/79.

- Clark, P. K. (1987). The cyclical component of U.S. economic activity. *Quarterly Journal of Economics* 102(4), 797–814.
- Çulha, O. Y. and M. K. Kalafatçılar (2014). An analysis on the elasticity of exports to income and price: importance of regional differences (in Turkish). CBT Research Notes in Economics No:2014-05.
- Dincer, N. and M. Kandil (2011). The effects of exchange rate fluctuations on exports: a sectoral analysis for Turkey. *Journal of International Trade and Economic Development* 20(6), 810–837.
- ECB (2015a). A survey-based measure of slack. in the ECFIN workshop Assessment of the real time reliability of different output gap calculation methods.
- ECB (2015b). A survey-based measure of slack for the Euro Area. Box 6, Economic Bulletin 6/2015.
- Erdoğan, E. C., S. Kösem, and Ç. Sarıkaya (2013). Do we really need filters in estimating output gap?: evidence from Turkey. CBT Research Notes in Economics No:2013-33.
- Eren, O. (2013). The export growth and 2013-2030 current account deficit projections of Turkey by using market size and market share components. CBT Research Notes in Economics No:2013-05.
- Garcia-Saltos, R., I. R. Teodoru, and F. Zhang (2016). Potential output growth estimates for Central America and the Dominican Republic. IMF Working Paper 16/250.
- Husabø, E. (2013). Lower potential growth in the Euro area after the crisis. Norges Bank Economic Commentaries No:7.
- IMF (2016). Potential output. Country Report 16/105 Turkey Selected Issues, International Monetary Fund Washington DC, USA.
- Kara, H. and F. Ögünç (2012). Effect of exchange rate and import prices on domestic prices (in Turkish). *İktisat İşletme ve Finans* 27(317), 09–28.

- Kara, H., F. Ögünç, Ü. Özlale, and Ç. Sarıkaya (2007). Estimating the output gap in a changing economy. *Southern Economic Journal* 74(1), 269–289.
- Klump, R., P. McAdam, and A. Willman (2007). The long-term sucCESs of the neoclassical growth model. *Oxford Review of Economic Policy* 23(1), 94–114.
- Melolinna, M. and M. Toth (2016). Output gaps, inflation and financial cycles in the United Kingdom. Bank of England Staff Working Paper No. 585.
- Metin Özcan, K., Ü. Özlale, and Ç. Sarıkaya (2007). Sources of growth and the output gap in Turkish economy. In J. B. Nugent and M. H. Pesaran (Eds.), *Contributions to economic analysis Vol. 278*, pp. 239–269. Elsevier B. V.
- Musso, A. and T. Westermann (2005). Assessing potential output growth in the Euro area a growth accounting perspective. European Central Bank Occasional Paper Series No:22.
- Ögünç, F. (2010). Volatility in unprocessed food inflation in Turkey. (in Turkish) CBT Research Notes in Economics No:10/05.
- Ögünç, F. and Ç. Sarıkaya (2011). Invisible but not imperceptible: output gap in Turkey. (in Turkish) Central Bank Review, 11(2), 15.
- Okun, A. M. (1962). Potential GNP: its measurement and significance. in Proceedings of the Business and Economic Statistics Section of the American Statistical Association.
- Orphanides, A. and S. van Norden (2002). The unreliability of output-gap estimates in real time. *The Review of Economics and Statistics* 84(4), 569–583.
- Özbek, L. and Ü. Özlale (2005). Employing the extended Kalman filter in measuring the output gap. *Journal of Economic Dynamics and Control* 29, 1611–1622.
- Pichette, L., P. St-Amant, B. Tomlin, and K. Anoma (2015). Measuring potential output at the Bank of Canada: the extended multivariate filter and the integrated framework. Bank of Canada Discussion Paper 2015-1.

- Rodriguez, N., J. L. Torres, and A. Velasco (2006). Estimating an output gap indicator using business surveys and real data. Bank of Colombia Working Paper No:392.
- Saraçođlu, B., Ö. Yiđit, and A. Koçak, N (2014). Alternative methods of estimating the output gap for Turkey (in Turkish). *Business and Economics Research Journal* 5(3), 44–64.
- Üngör, M. (2012). A production function method of estimating the output gap. CBT Research Notes in Economics No:2012-19.

Table 1: Data descriptions

Variable	Description	Use	Source
Y_t	GDP	log, SA, level	TurkStat
r_t	real interest rate	difference between interest on commercial credits in TL and 12m annual inflation expectations, level	Central Bank of Turkey
rer_t	real effective exchange rate	quarterly percentage change	Central Bank of Turkey
y_t^f	export-weighted foreign demand	SA, quarterly percentage change	Eren (2013)
U_t	Unemployment rate	log, SA, level	TurkStat
π_t	core price index D	SA, quarterly percentage change	TurkStat, author's calculations
pm_t^{TL}	import prices in TL	quarterly percentage change	TurkStat

Table 2: Model estimation, 2005Q1-2016Q4

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
\bar{Y}_t	1								
y_t	1								
\bar{Y}_{t-1}		1							
$G_t^{\bar{Y}}$		1							
$G_{t-1}^{\bar{Y}}$			1						
y_{t-1}				0.5				0.76*** (6.5e-06)	11.06*** (3.72)
r_{t-1}				-0.001					
rer_{t-1}				0.0018** (0.0009)					
$rer_{t-1}D10$				-0.0024** (0.0012)					
y_t^f				0.012*** (0.004)					
D08Q1				0.042** (0.017)					
\bar{U}_t					1				
u_t					-1				
\bar{U}_{t-1}						1			
$G_t^{\bar{U}}$						1			
$G_{t-1}^{\bar{U}}$							1		
u_{t-1}								0.8	
π_{t-1}									0.42*** (0.10)
pm_t^{TL}									0.06*** (0.012)
D06Q3									1.16*** (0.41)
D07Q4									1.30*** (0.42)
D08Q4									-1.02** (0.45)
D09Q3									1.41*** (0.45)
constant									0.91*** (0.22)

Notes: The first row shows the equation numbers. Dependent variable of each equation is different. Standard errors in paranthesis. ***/**/* show the significance at 10, 5 and 1 percent, respectively.

Table 3: Robustness checks at different calibration values

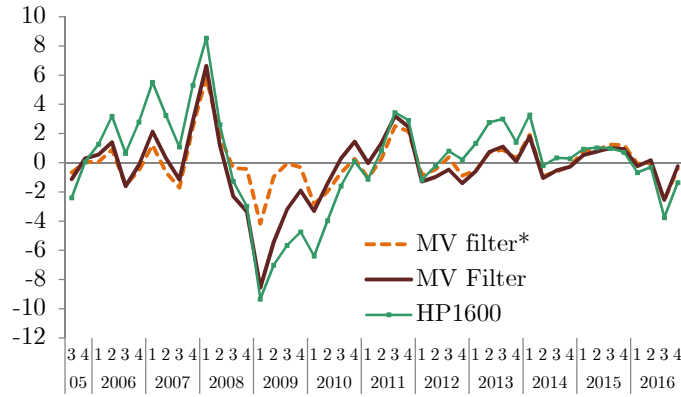
δ	λ	α	Log Likelihood	AIC	BIC
0.7	-0.001	0.8	150.0	-264.0	-231.1
0.6	-0.0007	0.9	150.4	-264.8	-231.9
0.6	-0.001	0.9	150.8	-265.5	-232.6
0.5	-0.0012	0.9	151.2	-266.3	-233.4
0.5	-0.001	0.9	151.2	-266.4	-233.5
0.5	-0.001	0.8	152.2	-268.3	-235.4

Notes: Last row is the baseline specification.

Table 4: Correlation between inflation and output gap

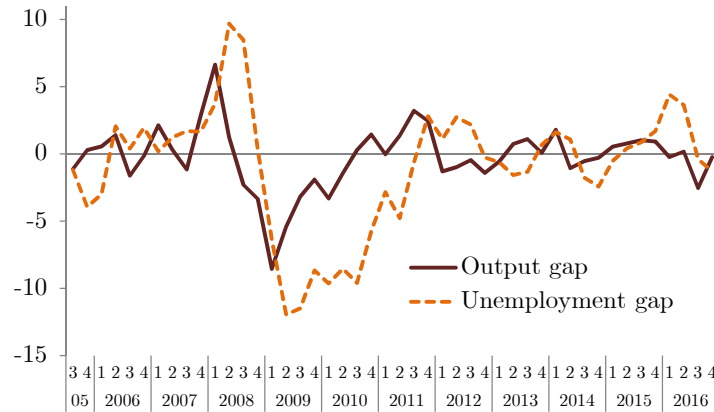
	2005Q3-2016Q4		2012Q1-2016Q4	
	MV filter	HP filter	MV filter	HP filter
$\text{cor}(\pi_t, y_{t-2})$	0.40	0.37	0.07	-0.06
$\text{cor}(\pi_t, y_{t-1})$	0.69	0.60	0.22	-0.01
$\text{cor}(\pi_t, y_t)$	0.50	0.51	0.11	0.02
$\text{cor}(\pi_t, y_{t+1})$	0.12	0.25	-0.28	-0.26
$\text{cor}(\pi_t, y_{t+2})$	-0.14	0.07	0.02	-0.01

Graph 1: Output gap estimates with the multivariate filter

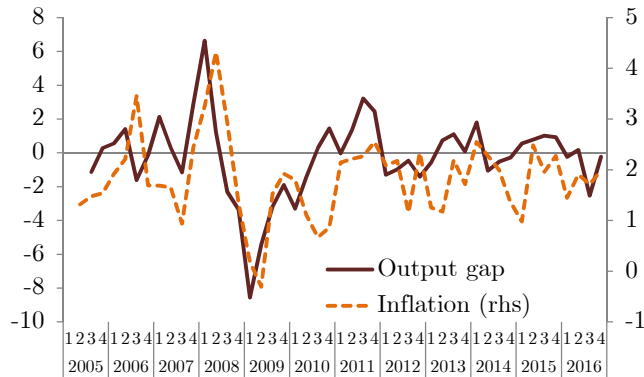


Notes: *Shows the results when y_t , in eq(4), is assumed to be only an autoregressive process.

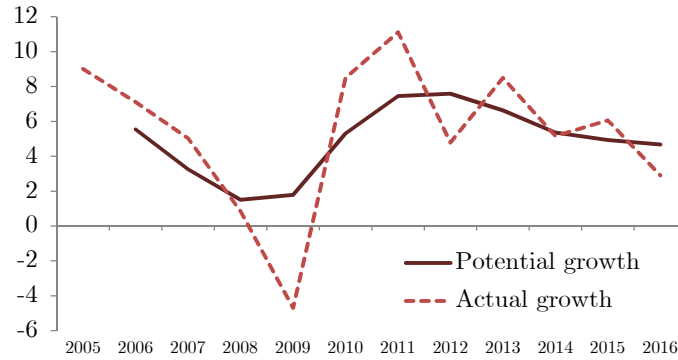
Graph 2: Unemployment gap estimates with the multivariate filter



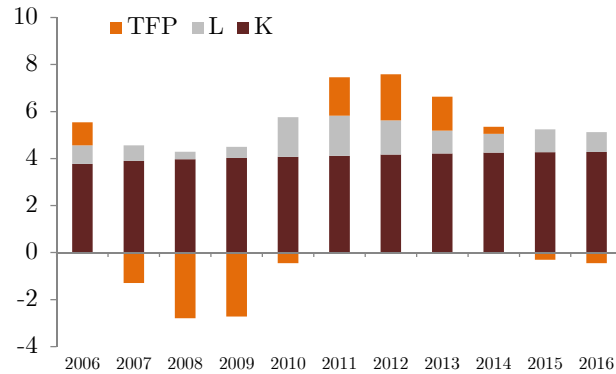
Graph 3: Output gap estimates vs. quarterly inflation



Graph 4: Potential growth in Turkey

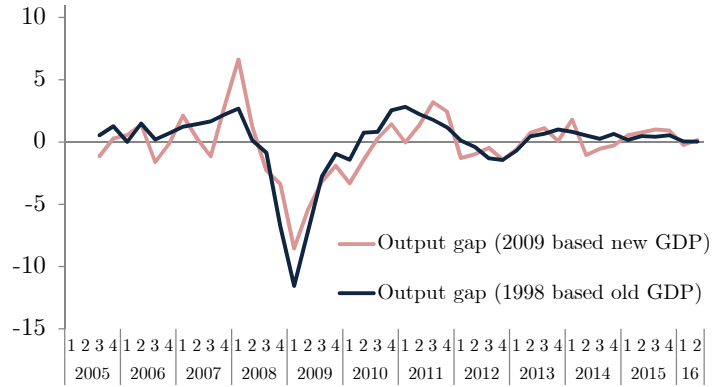


Graph 5: Contributions of labor, capital and TFP to potential growth, new GDP series

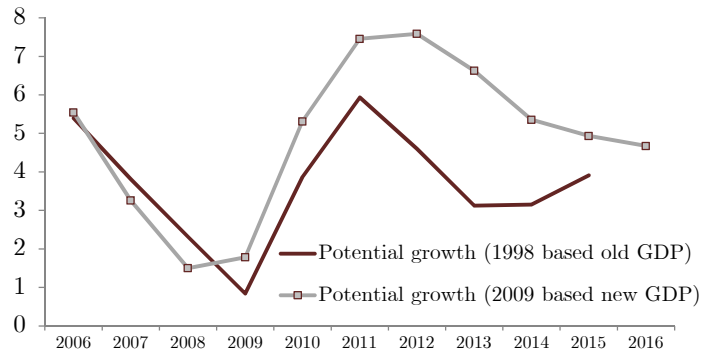


Notes: Cobb-Douglas production function with constant returns to scale is used. Labor share is taken as 0.35. Potential GDP growth comes from the MV filter. Potential of capital is obtained by the HP filter with $\lambda=100$. Potential of labor (\bar{L}_t) is calculated as $\bar{L}_t=(1-\bar{U}_t)W_t\bar{LFR}\bar{T}_t$, where \bar{U}_t is the NAIRU from the MV filter, W_t is the working age population and $\bar{LFR}\bar{T}_t$ is HP filtered trend labor force participation rate. Potential TFP is the residual of Cobb-Douglas as in IMF (2016).

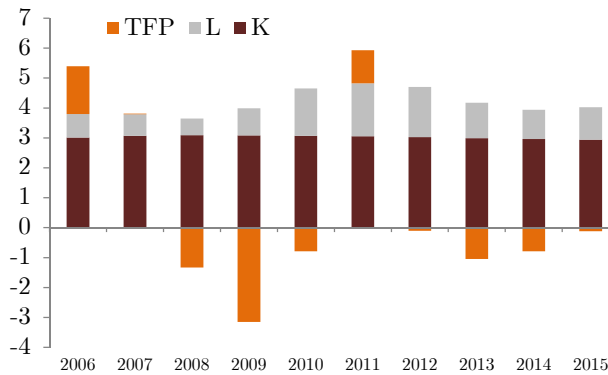
Graph 6: Output gap estimates with new and old GDP series



Graph 7: Potential growth in Turkey with new and old GDP series

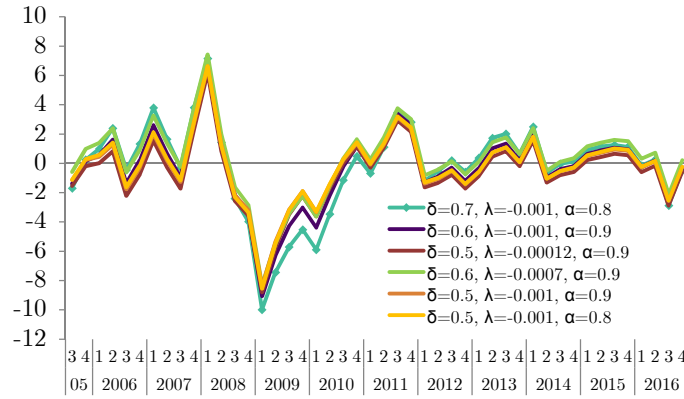


Graph 8: Contributions of labor, capital and TFP to potential growth, old GDP series

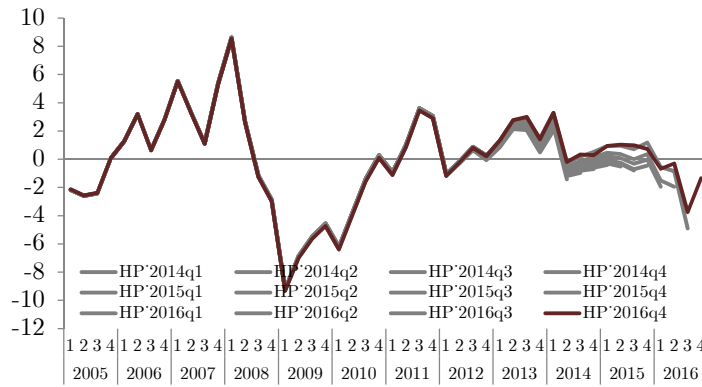


Notes: See notes under Graph 5.

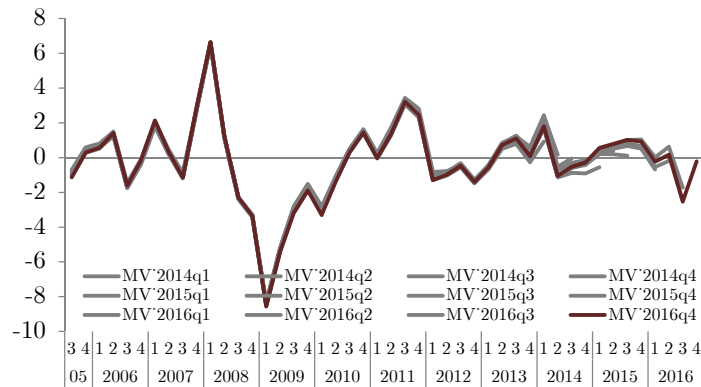
Graph 9: Output gap estimates at different calibration values



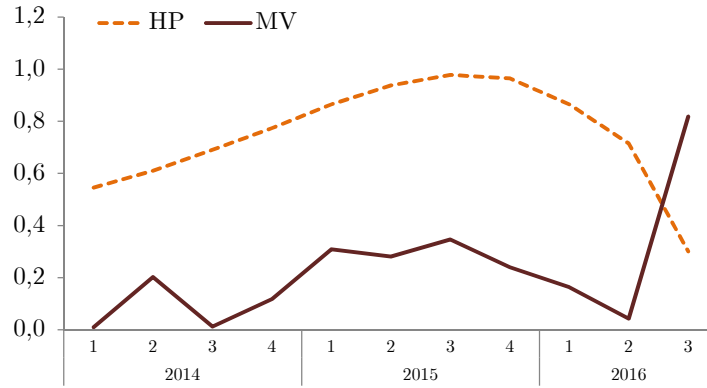
Graph 10: Revision in output gap estimates of the HP filter



Graph 11: Revision in output gap estimates of the MV filter

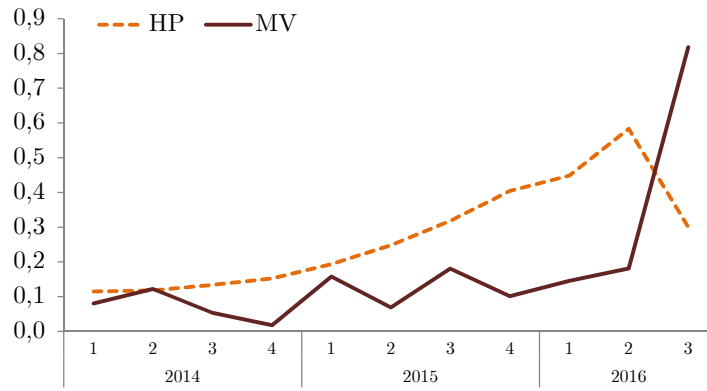


Graph 12: Amount of revision in the output gap estimates, criterion 1



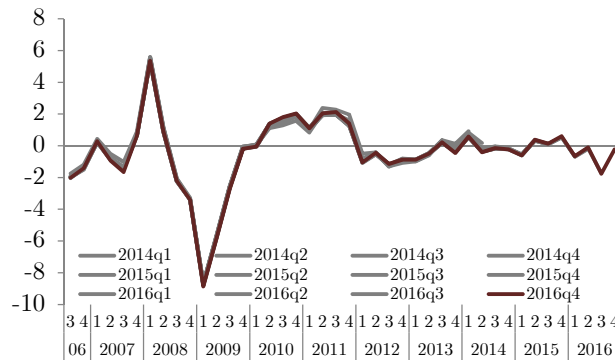
Notes: For criterion 1, see equation (10).

Graph 13: Amount of revision in the output gap estimates, criterion 2



Notes: For criterion 2, see equation (11).

Graph 14: Revision in output gap estimates of the MV filter with non-smoothed trend



Appendix 1

Table A1: Calibration values of residual standart errors

	Calibrated value
ε_t^Y	0.7
$\varepsilon_t^{G^Y}$	0.3
ε_t^y	1.4
ε_t^U	2.1
$\varepsilon_t^{G^U}$	1.9
ε_t^u	2.8
ε_t^π	0.4

Notes: The table indicates that $\sigma_{\bar{Y}}=2\sigma_{G\bar{Y}}$ and $\sigma_U=1.1\sigma_{G\bar{U}}$

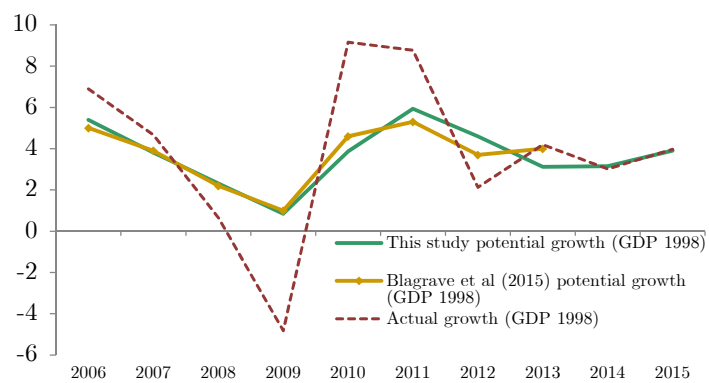
Appendix 2

Table A2: Model estimation, 2005Q1-2016Q2, 1998 based GDP series

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Y_t	1								
y_t	1								
Y_{t-1}		1							
G_t^Y		1							
G_{t-1}^Y			1						
y_{t-1}				0.5				0.83*** (5.05e-06)	11.2** (4.42)
r_{t-1}				-0.001					
$rert_{t-1}$				0.0015** (0.0006)					
$rert_{t-1}D10$				-0.0017** (0.0008)					
y_t^f				0.019*** (0.003)					
D06Q1				-0.022** (0.009)					
D08Q3				0.019* (0.010)					
D08Q4				-0.03** (0.013)					
\bar{U}_t					1				
u_t					-1				
\bar{U}_{t-1}						1			
G_t^U						1			
G_{t-1}^U							1		
u_{t-1}								0.8	
π_{t-1}									0.4*** (0.12)
pm_t^{TL}									0.06*** (0.016)
D09Q3									1.46** (0.61)
constant									1.03*** (0.25)

Notes: The first row shows the equation numbers. Dependent variable of each equation is different. Standard errors in paranthesis. ***/** show the significance at 10, 5 and 1 percent, respectively.

Graph A2: Comparison of potential growth estimates with old GDP series



Central Bank of the Republic of Turkey

Recent Working Papers

The complete list of Working Paper series can be found at Bank's website

<http://www.tcmb.gov.tr>

Quantifying Uncertainty and Identifying its Impacts on the Turkish Economy

(Evren Erdoğan Coşar, Saygın Şahinöz Working Paper No. 18/06, February 2018)

Forecasting Industrial Production and Inflation in Turkey with Factor Models

(Mahmut Günay Working Paper No. 18/05, February 2018)

Türkiye Ekonomisi için Güncellenmiş Doğrudan Çıktı Açığı Göstergesi

(Evren Erdoğan Coşar Çalışma Tebliği No. 18/04, Şubat 2018)

Türkiye İçin İthalat Talep Fonksiyonu

(Olca Yücel Çulha, Okan Eren, Ferya Ögünç Çalışma Tebliği No. 18/03, Şubat 2018)

Export Behavior of Turkish Manufacturing Firms Under Crises

(Aşlıhan Atabek Demirhan, Hakan Ercan Working Paper No. 18/02, January 2018)

Foreign Currency Borrowing, Exports and Firm Performance: Evidence from a Currency Crisis

(Spiros Bougheas, Hosung Lim, Simona Mateut, Paul Mizen, Cihan Yalçın Working Paper No. 18/01, January 2018)

The Empirical Content of Season-of-Birth Effects: An Investigation with Turkish Data

(Huzyefe Torun, Semih Tümen Working Paper No. 17/21, December 2017)

Do Subsidized Export Loans Increase Exports?

(Yusuf Emre Akgündüz, Süleyman Hilmi Kal, Huzyefe Torun Working Paper No. 17/20, December 2017)

A Financial Connectedness Analysis for Turkey

(Ferhat Çamlıca, Didem Güneş, Etkin Özen Working Paper No. 17/19, December 2017)

Production Fragmentation and Factor Price Convergence

(Hülya Saygılı Working Paper No. 17/18, August 2017)

Evidence for the Explosive Behavior of Food and Energy Prices: Implications in Terms of Inflation Expectations

(Aytül Ganioglu Working Paper No. 17/17, July 2017)

Regional Economic Growth in Turkey: The Effects of Physical, Social and Financial Infrastructure Investments

(Hülya Saygılı, K. Azim Özdemir Working Paper No. 17/16, July 2017)

Forecasting the Growth Cycles of the Turkish Economy

(H. Murat Özbilgin Working Paper No. 17/15, June 2017)

Home-ownership, Housing Demand and Household Wealth Distribution in Turkey

(Evren Ceritoğlu Working Paper No. 17/14, June 2017)

Credit Cycles and Capital Flows: Effectiveness of the Macroprudential Policy Framework in Emerging Market Economies

(Salih Fendoğlu Working Paper No. 17/13, May 2017)

Are Macroprudential Policies Effective Tools to Reduce Credit Growth in Emerging Markets?

(F. Pınar Erdem, Etkin Özen, İbrahim Ünalmiş Working Paper No. 17/12, May 2017)

Volatility: As a Driving Factor of Stock Market Co-movement

(Ali Gencay Özbekler Working Paper No. 17/11, May 2017)

The Effect of House Price Changes on Cohort Consumption in Turkey

(Evren Ceritoğlu Working Paper No. 17/10, April 2017)

Beef Price Volatility in Turkey: Can Import Policy Affect the Price and Its Uncertainty?

(Meltem Gülenay Chadwick, Emine Meltem Baştan Working Paper No. 17/09, April 2017)