Potential Growth in Turkey: Sources and Trends

Orhun Sevinç
Ufuk Demiroğlu
Emre Çakır
E. Meltem Baştan

March 2021
Working Paper No: 21/07

TÜRKİYE CUMHURİYET MERKEZ BANKASI

Address:

Central Bank of the Republic of Turkey

Head Office

Structural Economic Research Department

Hacı Bayram Mah. İstiklal Caddesi No: 10

Ulus, 06050 Ankara, Turkey

Phone:

+90 312 507 80 04

Facsimile:

+90 312 507 78 96

Potential Growth in Turkey: Sources and Trends

Orhun Sevinç*[,1,2], Ufuk Demiroğlu[1], Emre Çakır[1], E. Meltem Baştan[1]

Abstract

This paper estimates potential growth in Turkey using a production function estimation approach. Our approach aims to measure the inputs of production in the most detailed fashion that is possible and empirically addresses concepts of sustainable potential growth for Turkey. While developing measures of the sources of potential growth, we provide a thorough discussion of the estimated trends in labor force participation, capital growth by asset type, and total factor productivity since the mid-2000s. Our results suggest that the key driver of potential growth has increasingly been capital accumulation. The declining trend in the positive TFP growth stands out as the key area of improvement for potential growth.

*Corresponding author. E-mail: Orhun.Sevinc@tcmb.gov.tr. We thank numerous seminar participants for useful discussions. All errors are ours. The views expressed here are of our own and do not necessarily reflect those of the Central Bank of the Republic of Turkey and its other staff.
[1] Central Bank of the Republic of Turkey, İstiklal Cad. No:10, 06100 Ulus, Ankara, Turkey
[2] Centre for Macroeconomics, London School of Economics and Political Science, Houghton Street London WC2A 2AE

Non-Technical Summary

This paper estimates potential growth in Turkey using a production function estimation approach. Our approach aims to measure the inputs of production in the most detailed fashion that is possible and empirically addresses concepts of sustainable potential growth for Turkey. While developing measures of the sources of potential growth, we provide a thorough discussion on the estimated trends in labor force participation, capital growth by asset type, and total factor productivity since the mid-2000s.

Potential labor input calculation rests on micro data from the labor force survey. The main building block is the estimation of potential labor force participation which takes into account the participation differences of demographic groups, structural variables, and cohorts in addition to cyclical variables. Our approach underlines the key role of cohort and structural factors in understanding the rising labor force participation in Turkey.

Capital estimation takes into account the differences in the depreciation rates and productivities between different asset types, producing capital services that reflects the contributions to production of machinery and equipment, and the construction capital. While estimating capital, we also empirically address the discussion on adjusting capital growth by credit growth by means of sustainable measures of potential growth. Our results suggest no practical use of capital-accumulation-based sustainability measures for the productive potential of the Turkish economy.

Our results are summarized as follows. (1) The key driver of potential growth has increasingly been capital accumulation. (2) The declining trend in the positive TFP growth stands out as the key area of improvement for potential growth. (3) In the next decade, trends in college attainment and marriage rates will be decisive in preserving the rising potential labor force participation rates, which will be more important on the potential output as labor’s share in the value-added increases in Turkey.

1. INTRODUCTION

Potential growth is clearly one of the most self-motivated subjects to study for central bankers. Accuracy in its measurement is essential to understand and efficiently communicate the state of the economy along the business cycle, which is one of the key statistics of short-run macro policies. The measurement, on the other hand, can be performed in a variety of ways depending on the choice. One could be skeptical of the theoretical growth framework and measurement of specific input and more concerned with the underlying long-run trend of growth (e.g. Antolin-Diaz et al., 2017), or rely on the equations of a given economic theory for estimation (e.g. Andıç, 2016). Furthermore, there is an astounding number of different methods one could follow within each approach, aside from adopting some combination of different approaches. The first contribution of this paper is to provide a rich review of the literature of potential growth estimation with a specific interest to those studying the Turkish economy in addition to a more general overview.

The choice of method depends crucially on the aim as well as the preferences of the practitioner. We aim to provide transparent and easy-to-communicate estimates of potential growth. We are not only interested in the headline potential growth figure but also would like to comment on the qualitative aspects of growth. Estimating the Cobb-Douglas production function for Turkey appears as the immediate choice given the set of constraints described. Notwithstanding the simplicity of our approach, we concentrate our efforts on building a meticulously-constructed set of input trends, which requires a set of modules to independently estimate the sources of potential growth in Turkey—making it the second contribution of this paper to the literature concerning Turkey.

Our potential labor input calculation rests on microdata from the labor force survey. The main building block is the estimation of potential labor force participation which takes into account the participation differences of demographic groups, structural variables, and cohorts in addition to cyclical variables. Our approach underlines the key role of cohort and structural factors in understanding the rising labor force participation in Turkey. We combine the population for each demographic group with the estimated participation rate and trend unemployment to calculate potential labor input. One of the main advantages of this approach is the flexibility it provides for making projections for trends in population and participation using a rich set of demographic groups.

Our capital estimation takes into account the differences in the depreciation rates and productivities between different asset types, producing capital services that reflect the contributions to the production of machinery and equipment, and construction capital. Our resulting capital series is an updated version of Demiroğlu (2012), which closely follows the practice of the US Congressional Budget Office (Shackleton, 2018).

When capital services are used as the true capital measure of potential output, factors changing the intensity of capital use such as utilization rate should be reflected in the total factor productivity (TFP), which is the residual output net of the direct input contributions. The capital services should be taken as the true input measure according to the standard economic theory. However, an ongoing discussion suggests that in the developing country context, realized capital accumulation could be excessive as a result of policy in longer periods relative to the business cycle. The potential concern in this discussion is that excessive credit growth could drive vulnerabilities and capital accumulation, which brings the issue of sustainability of capital accumulation (Alberola et al., 2013; Albert et al., 2015).

However, the concept of sustainable potential growth is problematic when it comes to quantification. Besides measurement problems, the arguably excessive part of credit growth might reflect changes in the efficiency of the financial intermediation such as a decline in credit frictions. Nevertheless, to address these discussions in the Turkish economy we—remaining contextually agnostic—develop two measures that adjust the capital growth. The first rests on the idea that a long-run relationship between capital, credit, and exchange rate growth exists through the lens of a time-varying vector autoregression model, which allows for variation in the simultaneous dynamic association between these three key variables. The second estimates the trend capital growth defined by removing cycles of capital growth from the realized growth rate where credit growth identifies the cycles. Both approaches yield a growth rate of capital that is between 5 and 6 percent per annum in Turkey for the last few years, which is in line with the average tendency of capital evolution.

Just as important, our analysis based on quarterly data reveals intriguing patterns. Nearly all of the gaps between actual and adjusted measures of capital at the quarterly frequency are driven by the high volatility of the former series and disappear in the medium term. Our results suggest little practical value of capital-accumulation-based sustainability measures for the productive potential of the Turkish economy.

We combine capital and labor in the production function through the labor share, which has been historically broadly stable in the post-war era but showed a declining trend in recent decades in advanced economies. Our approach is standard in inferring the wage income of self-employed and combines sectoral labor share to calculate labor share, which increases from 35 percent in 2008 to 40 percent in 2017. The immediate interpretation is that the inequality between men vs. machines in Turkey did not increase in the recent period. If anything, the change has been in favor of labor.

Our production function views total factor productivity growth as the residual term as the unexplained part of the observed growth rate after accounting for the contributions of direct employment (in persons) and capital. We calculate the time trend of this measure as TFP and observe that its growth has been gone through significant transformation: declining from about 2 percent annual growth in 2004 to 0.5 percent in the last few years. We face our macro residual measure with firm-level TFP estimates from Entrepreneurial Information System hosting administrative data of the Turkish economy between 2006 and 2016. Strikingly, we observe the remarkable similarity between the most micro and the naively macro estimates of TFP growth for this period.

Finally, we estimate the potential growth of Turkey, combining all the elements described above. Our potential growth estimates point to 5.5 percent between 2005 and 2018, which declines to 4.8 percent during 2017-2018. We leave numerous novel observations to the main text for the sake of compactness. Instead, we outline the main messages from our findings here.

First, the weakness of growth is not the accumulation of capital per se. Most importantly, it seems more related to the capacity of the economy to generate TFP growth, which in our simple setting spans a wide range of elements from the intensive margin of work to human capital accumulation, from utilization rates to pure technological innovation and efficiency of resource allocation. Our results support the policies that focus on bringing down the barriers of access to finance together with supporting TFP growth. On the other hand, both macro and microdata do not support the negative TFP growth result in Turkey as some widely used data sources suggest (See Penn World Table, Feenstra et al., 2015). Second, given the relatively low level of labor share in Turkey, its convergence to the advanced economy averages is promising both for inequality and stabilization of potential growth as capital growth is more volatile than labor's growth given limited growth in TFP. Third, a substantial driver of labor input growth is increasing labor force participation rate, which offers a large room to support potential growth. Our projections suggest that the essential driver of future advances in labor force participation is surprisingly not the trends in demographic composition or cohort behavior but the trends in increasing share of college education, hence suggesting an indirect but sizable benefit of education policies.

The next section reviews the literature and can be skipped by the reader, who wants to focus on the empirical results. Section 3 estimates labor force participation, potential labor, and the labor's share in income. Section 4 introduces the construction of capital series. Section 5 provides TFP growth estimates. Section 6 presents the potential growth and output gap results. Section 7 concludes.

2. RELATED LITERATURE

2.1. Studies with Economic Approaches

2.1.1. Country-wide Studies and Approaches

Our approach in this paper is broadly related to the practice of the Congressional Budget Office (CBO, 2001; Shackleton, 2018). Using the production function methodology, CBO produces and estimates the potential output for the United States for the period between 1948 and 2017, adopting a supply-side approach. The Solow growth model and Okun's law are the main pillars of CBO's method, which involves decomposing output series into a series of labor, capital, and total productivity. The estimates of potential output are derived by using potential levels of inputs that are obtained for six different sectors of the economy. Ultimate potential output series are obtained by summing the output series of six sectors and using chained Fisher indexes. Apart from the household sector, labor component is measured by labor hours across the sectors. The measure of capital, on the other hand, differs across sectors such that capital services are used for nonfarm business and household sectors, whereas aggregate depreciation is used for the government. Productivity refers to labor productivity except for the nonfarm business sector, for which productivity is measured by total productivity. The production function approach uses the potential values of inputs that are equal to cyclically adjusted trends obtained by eliminating the variation stemming from business cycle fluctuations. The elimination is made by first regressing the series of input into variables, which are expected to represent the cycles, among which the most commonly used one is the employment rate. Then, the coefficients of those variables are set to zero. The main indicator of the business cycle is the employment rate. In addition to the cyclical approach, piecewise linear regressions are used to extract the trend values of the inputs.

Potential labor supply is calculated in three stages: First, CBO uses data of the civilian non-institutional population to multiply with the labor force participation rate (LFPR). LFPR is estimated for demographic groups differing by age, gender, education, marital status, and status of having kids. The second stage involves the estimation of NAIRU. At the third stage, potential weekly hours are incorporated.

For capital series, CBO uses the historical values of investment, depreciation, and the existing stock of the distinct types of capital to obtain the total contribution of capital services to the production. The contribution of capital is ignored for farm and non-profit sectors. Unlike labor series, there is no cyclical adjustment made for capital series, restraining the impact of all cyclical developments in the total factor productivity.

Our paper applies a simpler setup compared to CBO. First, we focus on one sector in this paper, while it is straightforward to extend this analysis to many sectors. Second, we do not have a sophisticated module for NAIRU, since we work with annual data due to the limitation of the labor force survey and observed that at an annual frequency the potential unemployment calculated as the time trend performs similarly to more intricate methods. Also, the available asset types to produce capital services are limited to two in our case.

Guisinger et al. (2018) estimate the potential output and output gap for the US using linear and quadratic time trends, production function method applied by the CBO, Hodrick- Prescott (1997) filter, univariate and multivariate unobserved components models[1] for the period 1950:Q1-2015:Q2. The comparison of the potential output series obtained with the CBO method and the HP filter shows that the series mostly move together with the gaps widening

[1]See Harvey (1990), Clark (1987), Watson (1986), and Basistha and Startz (2008) for further details of the methods.

at the beginning, turning points, and through the end of the series. That the divergence among the series is concentrated on corner points ensures that the series are vastly comparable, with due caution exercised on evaluating such points. This finding also shows that there is no particular drawback of using the CBO method for estimating the US potential output.

There are also critiques of the method of the CBO. Gordon (2014) touches upon the slow recovery in the potential GDP calculated by the CBO for the US. Gordon combines the output identity with Kalman filter to derive potential growth rates for the US and to compare those series with the projections of the CBO. He constructs series for both actual and potential output under different scenarios, which differ in the growth rates of unemployment, LFPR, and labor productivity. Collecting evidence through the actual growth rates observed from mid-2009 to mid-2014 and resting on theoretical relationships described by Okun's law and the output identity, he states that the official projections made by the CBO are not feasible even under the most optimistic scenario. With particular reference to the official projections of the CBO for the period between 2014:Q2 and 2020:Q4, he claims there must be radical changes in the growth rates of either LPFR or labor productivity since there is not much scope for the unemployment rate to decline further. An increase in the LFPR is designated as the strongest factor that could increase both the actual and the potential output. Gordon states that the projections of the CBO mainly rely on the improvements on the demand side that might outbalance the increases in the supply. Since the historical causality from the output gap to labor productivity is no longer valid, he states it would be hard for the increased demand to increase labor productivity. It is important to note that even though the analyses mainly rest on the output identity; the Kalman filter, which is also a method frequently criticized, is used in the calculation of the trend series.

Kawamoto et al. (2017) present two approaches used by different agencies in Japan to calculate the potential output and output gap. Both methods rely on the use of production function, but they differ in whether they initially calculate the potential output or output gap. The first approach, used by the Japanese Cabinet Office, the IMF, and the OECD, initially calculates potential output and derives the output gap accordingly. The second approach, only used by the Research and Statistics Department of the Bank of Japan, calculates the output gap initially and then derives potential output using theoretical equivalences. Using the second approach, the main contribution of the paper is in the revision of LFPR and utilization gaps, referring to labor and capital gaps, respectively. The labor gap is divided into three gaps in the labor force, employment rate, and hours worked. The labor force gap, i.e. the gap in labor force participation, is revised using a linear piecewise function that uses trend dummies for the peak periods of the business cycles since 1980. Authors claim that the relation between the course of the business cycles and the kinks in the LFPR would justify the use of trend dummies in uncovering the structural changes. The revised LFPR is assumed to be the fitted value obtained using the piecewise regression. The revision in the utilization gap focuses on the ignored impact of depreciation in calculating the production capacity. If depreciation is taken into account, the production capacity of the country decreases significantly. This translates into a higher utilization rate keeping the production level intact. The fitted values obtained from the regression of the production capacity index over the tangible fixed capital of manufacturing are used as the new series for production capacity. The utilization gap found in this way is found to be higher than the former one particularly in the aftermath of the global financial crisis. This finding supports the already known fact of declining capital stock in advanced economies during the crisis period. Authors test the performance of output gap series using an augmented Philips curve and no striking difference from the results obtained with former series is found. For the potential output series, the revised series indicate a serious decline to almost 0 percent in the aftermath of the crisis with a recovery to 0.5-1 percent through 2017. It is noted that while the harsh decrease in the aftermath of the crisis is not observed with former series, those series cannot capture the recovery through 2017 strongly, either. Authors consider that the recovery stems from the increase in capital stock and LFPR. It is also underlined that the revisions in GDP series in Japan brought about increases in the TFP that is also captured by the revised series.

OECD (2001) presents a detailed documentation on measuring capital stocks, consumption of fixed capital and capital services. Three main ways of measuring capital are listed. The first of them is the perpetual inventory method that involves summing up over past capital formation while deducting the value of assets that have reached the end of their services. The value of assets both in the stock and depleted can be revalued to either the prices of the current year or the price of a single year. Secondly, survey methods are also suggested that would rely on the responses collected from enterprises. A third method, balance of fixed assets, is recommended strongly but its impracticality is also acknowledged.

Burns et al. (2014) estimate the series of potential output and output gaps for 159 developing countries, using the methodology of the World Bank that is frequently used in the Global Economic Prospects Report. The Cobb-Douglas production function is used to decompose output into its components. Potential output is calculated by assuming that all labor and capital are fully employed while TFP takes its trend value. Burns et al. (2014) recognize that in most of the developing countries, data on capital stock do not exist and the quality of labor market data is very poor. The trend value of TFP is calculated by the HP filter. They also assume constant LFPR and the natural rate of unemployment stating that any time variation in these variables could be captured by changes in total factor productivity that would not significantly affect the ultimate calculation of potential output. The cross-country analyses indicate that the performance of the output gap series in estimating those variables worsens as the income level of the countries diminishes.

Dovern and Zuber (2019) investigate the impact of recessions on potential output estimates across 95 recessions between 1990 and 2017 using the real-time vintage of the potential output estimates made by the OECD. The reasons and the characteristics behind the downward revisions of potential output are investigated, reminding that potential output is indeed a long-run concept. The recessions are diagnosed by using the algorithm of Bry and Boschan (1971) on the real GDP series published in the OECD Main Economic Indicator database. Authors state that most of the post-recession revisions of potential output are made due to pre-recession estimation errors. It is also noted that revisions could be made in a period extending to five years while insufficient evidence of revisions is found before recessions. What triggers revisions, on the other hand, is mostly found to be supply-related with insignificant contribution from cycles in demand. These results show that revisions to potential output are permanent and also related to pre-recession values of the current account balance and credit volumes.

Ollivaud and Turner (2015) use production function methodology in estimating the impact of the global financial crisis on the potential output of the OECD countries. Using the production function methodology of the OECD, they decompose output into capital, labor, and productivity. They focus on potential output losses from the global financial crisis by constructing counter-factual scenarios with assumptions on productivity and employment trends and comparing the post-crisis projections of the OECD projections with the series obtained under those scenarios. The results indicate that the negative impact of the crisis on potential output is above 10 percent for the most severely affected countries, particularly due to lower productivity. The contribution of lower potential employment is around 4 percent whereas the contribution of lower capital per capita was around 3 percent.

Cahn and Saint-Guilhem (2010) insert the production function definition of potential output into the large-scale DSGE model. They state that the production function method exaggerates the role attributed to the structural differences across countries. They also claim that differences across shocks play a larger role in explaining differences in potential output levels.

Barnett et al. (2009) estimate the potential output for Canada by using both vintage real-time data and published real output and projections by the Bank of Canada for the period 1994-2005. The potential output is based on the Cobb-Douglas production function and trend values of the related variables are used. Trend values of the components such as NAIRU are estimated. Authors focus on the extent to which projections of future output and output gap change in the face of revisions.

Matheny (2009) challenges the widespread anticipation among economists about the labor force participation rate in the US after the global financial crisis. As the predicted decline in the labor force participation rate is attributed to the changes in demographics (aging of the baby-boom generation), fertility, and life expectancy, Matheny claims that the labor force participation rate might have even increased after 2011 due to reasons such as household net worth, unemployment rate and (surprisingly) life expectancy. Matheny links all these factors to the increasing rate of labor force participation among elder people. He postulates that potential output could be higher than anticipated due to all of these factors

The ECB slightly diverges from other institutions with its inclusion of methods other than the production function method into its toolset. Anderton et al. (2014) evaluate the potential output from a euro area perspective introducing the New Multi-Country Model (NMCM) developed by the ECB along with the results obtained with the production function approach. NMCM has been developed by the ECB to be used in the Eurosystem and the ECB’s macroeconomic projections. It consists of six country groups such that the first five belong to Germany, France, Italy, Spain, and the Netherlands whereas the last one refers to the rest of the euro area countries. Following Klump et al. (2007), NMCM also relies on a normalized CES production function with time-varying factor-augmenting technical progress and non-unitary elasticity of substitution. Along with these properties, another difference of the NMCM from the classical production function approach is its inclusion of cross-equation restrictions. Assumptions of non-unitary elasticity of substitution, "non-constant augmenting technical progress and the consideration of heterogeneous sectors with the differentiated price and income elasticities of demand across sectors" are crucial points that make the NMCM model more flexible.

The impact of the global financial crisis on components of potential output across the Euro Area is mostly seen on the capital and labor series with a mere impact on total factor productivity. Anderton et al. (2014) warn that the temporary nature of these effects could turn into a permanent one unless required structural reforms are implemented.

European Commission publishes studies on the estimation of potential output and the output gap every four years, along with the changes in the methodology. In 2002, the major transition from the production function method to the use of the HP filter was agreed upon. Denis et al. (2002) introduce the basic components of the production function method with special reference to the methods of calculating TFP, NAIRU, the population of working age, participation rate changes, and investment to potential GDP ratios. TFP is calculated as the HP filtered Solow residual with forecasts for future periods relying on simple autoregressive processes. NAIRU is calculated by the Kalman filter while population working age and participation rate rest on Eurostat's calculations and projections. In 2005, average hours worked is added to the model as explained later on by Denis et al. (2006). The inclusion of average hours worked corrects the TFP trend upward. It is mentioned in the same paper that NAIRU was replaced by a non-accelerating wage inflation rate of unemployment. The change mainly affects the extent of the contribution made by inputs. In 2010, there is a shift from the calculation of TFP with HP filter to Kalman filter as noted by D'auria et al. (2010). D'Auria et al. (2010) also highlight the critiques made by the member states on the upward bias in potential output that ultimately affects structural balance estimations. Havik et al. (2014) describe the changes made to the NAWRU methodology. Before the changes, the non-cyclical part of NAWRU was estimated by including adaptive expectations into the Phillips curve setting. With the change, rational expectations are also included in the estimation. The other significant change has been on the horizon of projections, increasing from 5 to 10 years.

Mc Morrow et al. (2015) evaluate the performance of the production function method in estimating potential output and output gap by using the production function methodology introduced in 2002 as a part of the EU's policy surveillance procedures. In 2002, ECOFIN decided to replace the HP filter used until then with the production function method in a slightly modified version of the OECD and the IMF methods. The evaluation of the methods is made on four grounds including short-term stability of the estimates, long-term, real-time, reliability /accuracy of the methods, the performance of the obtained series during the financial crisis, and economic plausibility of the output gap estimates. It is seen that the modest versions render HP filter and the EU's method relatively stable in the short run while the EU's production method brings about fewer revisions in longer periods. However, the authors note that in the post-crisis period, both methods lead to significant revisions. In the aftermath of the financial crisis, the HP filter indicates zero output gap while the EU's method indicates an output gap around -3 percent, indicating that the EU's method is more in line with economic conditions. Economic plausibility is evaluated in three steps such that the first two of them include estimation of the EU's method by calculating TFP with Kalman and HP filters, respectively. The third step solely includes the application of HP filter on real GDP. It is observed that series including TFP estimated with Kalman filter are more in accord with other cyclical indicators. The authors emphasize that the inclusion of "hours worked" into the production function in Autumn 2005 and the new estimation method of TFP relying on Kalman filter improved the performance of the EU's method considerably. The comparison with the series of the OECD and the IMF indicates fewer revisions noted for the EU method and less number of years in which the sign of the output gap changes. According to these results, the authors conclude that the EU's method outperforms the methods of international organizations and the HP filter.

The criteria used in the study of Mc Morrow et al. (2015) are taken from the study of the Bundesbank (2014) that evaluates the reliability of OECD's and IMF's estimates of the output gap and compares their findings with the series obtained with the HP filter. The report compares the series for G7 countries and reaches two conclusions: First, the estimates with the HP filter are found more reliable with less frequent revisions in smaller magnitudes. Second, the estimates of potential output with the OECD and the IMF are found over-optimistic, causing an over-pessimistic view of the output gap. The over-pessimism is highlighted for pre-crisis years.

2.1.2. Studies for the Turkish economy

Turning to studies on the Turkish economy, Metin-Özcan et al. (2006) decompose output series in Turkey and compare them with the series in MENA countries, all to be obtained from the findings in Sekkat (2007). By presenting an evaluation of the Turkish economy since 1960, the study is a prominent one in the literature on Turkish growth performance. Contributions of capital, labor, and total factor productivity calculated in Sekkat (2007) are based on the capital shares in output that were estimated in Senhadji (2000). Relaxing the assumption of identical technologies, Senhadji (2000) estimates different production functions for 88 countries using the Cobb-Douglas production function. Sekkat (2007) and Metin-Özcan et al. (2006) use the contributions derived from the findings with production functions.

Akçay and Ocakverdi (2011) calculate an output gap indicator for Turkey using an unobserved components model and Kalman filter for the period between 1989Q1 and 2010Q3. Following the critiques made to the CBRT after interest rate cuts, authors investigate whether the comments that attribute the increase in inflation to the cuts are fair, or not. The authors construct a state-space model that was inspired by the production function. Equations related to output (in Cobb-Douglas functional form), labor force participation, and employment rate are defined, and similar to other studies, unobserved components refer to potential levels of these variables. This study differs from others with the deliberate exclusion of inflation dynamics from the system. Authors state that the inclusion of the inflation dynamics (in the form of Phillips curve specification, for instance) leads to a self-fulfilling inference that should be isolated while testing the validity of the critiques. It is postulated that the dynamics of long-term components have stochastic trends with AR (1) structure whereas the terms related to gaps follow AR (2) structure. They find that the Turkish economy stays below its potential level since the third quarter of 2008 and as of 2010Q3; the economy still operates at a negative gap of 4.1 percent of potential output. They also foresee that the output gap would not close before 2012Q3, defying the critiques against the CBRT's decision at the time. They also comment on their finding of the NAIRU level of 13 percent by 2010Q3; stating that the increase in structural unemployment after the 2001 crisis was also a factor behind that rate.

Üngör (2012) combines the production function method with the HP-filter and makes a comparison with the study of Alp et al. (2012) concerning the findings for the output gap. Üngör uses the Cobb-Douglas production function while obtaining the contributions of capital, labor, and TFP to output. The study focuses on the period between 2002Q1:2011Q2, but Üngör extends the series until 2014:Q4 to eliminate the end-point bias of the HP-filter. Üngör (2012) and Alp et al. (2012) find qualitatively similar results, albeit with different magnitudes and timings of the peak and trough points.

2.2. Studies with Statistical and Hybrid Methods

Filtering methods are widely used in the estimation of potential output and output gaps. Filtering methods could be divided into three as one-sided (Kalman filter), two-sided (like the HP filter, the HPMV or the Baxter-King filters) and multivariate filters. With the filtering methods comes the well-known end-point problem in the estimation of the potential output and the output gap. The problem emerges since less information is used through the end of the sample, diminishing the reliability of the trend-cycle.

There is a dichotomy on the filtering approach between univariate and multivariate filters. Anderton et al. (2014) state that univariate filters are easy to use, but the assumption of the existence of a trend component increases the tendency to over detect trends even though there is none or locate the trend and cycles at the wrong point. Reliance of the detection mechanisms on parameters is presented as another point of concern in addition to the chronic end-point problem. Multivariate approaches are considered superior, but they are also criticized for their reliance on a large set of parameters, making the estimation difficult.

On the reliance of the HP filter on the smoothing parameter, Alp et al. (2011) estimate the optimal HP filter smoothing parameter for Turkey for the period 1987-2007 using two alternative methods suggested by Pedersen (2001) and Dermoune et al. (2008). Authors claim that the implicitly agreed value of 1600 for the smoothing parameter fits well for capturing longer business cycles than are observed in emerging markets. Also in line with the proposition of Aguiar and Gopinath (2007), authors state that the requirement of a more volatile trend component in emerging markets requires a lower smoothing paremeter. Among the two methods applied, the approach of Pedersen (2001) initially requires that the length of the business cycles be determined. The optimal parameter is estimated depending on that length.

The parameter is found to be 98 with this method. The other method by Dermoune et al. (2008) postulates that the smoothing parameter is equal to the ratio of the variance of the cyclical component to the variance of the trend component. The parameter is found to be 19 with this method, indicating a shorter cycle with a more volatile trend component compared to the advanced economies. Finally, the absolute volatilities obtained with the parameters of 98 and 19 provide less volatile cyclical variations in GDP compared to those obtained with the parameter of 1600. The relative volatilities of sub-components of GDP, on the other hand are similar to those obtained with the parameter of 1600.

An interesting objection by Hamilton (2017) states that the HP filter should "never be used" due to three reasons that are in line with the points mentioned in Anderton et al. (2014). As a trivial alternative, he suggests that regressing the variable at date t+h on its four most recent values as of date t would suffice to get the required information about cyclicality without knowing the true nature of the non-stationarity.

Alp et al. (2012) measure the output gap in Turkey with a perspective focusing not only on its level but also its composition. A model economy is built using 5 equations on gaps of output, domestic and foreign demand, real exchange and interest rates. With this kind of approach, external and domestic demand are represented separately. The equations are estimated using Bayesian estimation techniques for the period 2002Q1-2011Q3. The discrepancy among external, domestic and aggregate output gap is illuminated by early 2011. In early 2011, while the positive aggregate output gap calls for an increase in interest rate, authors warn that such an increase would deteriorate the current account balance further by increasing the odds of the realization of financial risks, which stresses the state-dependent nature of the relationship between monetary policy and financial stability.

Pichette et al. (2015) uses the integrated framework (IF) and extended multivariate filter (EMVF) approaches in measuring potential output for Canada while presenting the pros and cons of each method. For the EMVF, it is stated that the method does not clearly identify the inflationary and disinflationary periods in the economy. To tackle with this problem, the EMVF is altered in such a way that the results get less prone to the changes in labor share. Authors also add that even though IF method is used to estimate and project trend hours worked by cohorts or age groups, there might be higher errors in the models using the IF method.

Aytaç (2015) uses both the HP filter and DSGE methods to estimate potential output and output gap in Turkey for the period 2005:Q1-2014:Q2. The DSGE model is estimated by nine endogenous variables including inflation, wages, capital stock, price of capital, investment level, consumption, interest rate and employment. The model used for DSGE estimation is that of Smets and Wouters (2007) that was used to study the business cycles in the Eurozone. The unobservable variables in the model are real interest rate, potential output, technology shocks and change variables. Difficulty in selecting the prior parameters that would reflect the country-specific properties of data correctly is tackled by selecting them among 100000 draws of Metropolis Hastings Algorithm with Monte Carlo simulation. To solve the equations simultaneously, Bayesian VAR methodology is used along with Monte Carlo simulation and Csminwel method for optimization. In general, the results of two methods are consistent. The only inconsistency is noted for the third quarter of 2011.

Unobserved components analysis is one of the most frequently encountered models in explaining potential output and output gap. Sharing the logic of using "observed" variables in explaining the series of potential output and output gap, which are "unobserved", some studies use univariate models whereas some others employ multivariate models. It is seen that most of the discussion revolves around the set of variables or methods to be used in multivariate settings, indicating the dominance of multivariate models.

Öğünç and Ece (2004) use both univariate and bivariate unobserved components models to estimate series of potential output and output gap in Turkey for the period between 1987:Q1 and 2003:Q4. In the univariate estimation, output is modeled as sum of output gap and potential output whereas potential output is modeled as a random walk with drift where drift is time-varying. The drift, which is equal to trend growth rate, shows the potential growth rate. Potential growth rate is also modelled as a random walk with drift and this representation allows the shocks in one period to be transmitted to another. Authors state that univariate representation disguises information about whether the crises are supply or demand triggered. Therefore, they include an inflation equation to the system, explaining inflation (headline inflation) by using its own lags, the public manufacturing price inflation, lagged output gap and the import price inflation. It is seen that parameter uncertainties decline significantly as bivariate model is used, although there is not a clear distinction between the pictures of series obtained with univariate and bivariate series, apart from the end-points of the sample. This finding is attributed to the weak relation between inflation and output gap in 1990s. Authors state that in 1990s, exchange rate dynamics and inertia in inflation were the dominant factors affecting inflation. Relatively stronger relation detected through the end of the sample is attributed to the first glimpses of inflation targeting regime.

Özbek and Özlale (2005) use the univariate model in decomposing output for the period between 1988:01 and 2003:02 into cyclical and trend components. In the decomposition, cycle is assumed to follow an AR(2) process with white noise error term whereas trend component is modelled as a random walk with drift. They also assume that all the parameters in the models are time-varying in an autoregressive fashion. The drift term in the trend component is also assumed to follow a random walk. The autoregressive structure of the drift term indicates that shocks to trend term are permanent, following the statement of Aguiar and Gopinath (2007). They use the extended Kalman filter (EKF) due to the non-linearity observed while estimating state and time-varying parameters simultaneously. The potential output and output gap series in this way are compared with their counterparts estimated with HP filtering and standard Kalman filter (SKF). The less smooth series found with the EKF are viewed more realistic compared to alternatives. In addition, output gap series found with the SKF and EKF give different signals about the stance of the economy. For instance, for the 2001 crisis, series obtained with SKF designate positive output gap for the first quarter of 2001 despite the outbreak of the crisis in February 2001. Özbek and Özlale (2005) evaluate the performance of the output gap series with EKF in explaining inflation. It is seen that output gap series are negatively correlated with inflation and the coefficient of the output gap is insignificant in explaining inflation. Despite this poor performance, the findings of the study are crucial by explicitly indicating the decrease in the smoothness of the series with the use of time-varying parameters.

Kara et al. (2007) measure the output gap for Turkey for the period between 1988Q2 and 2005Q2 using multivariate unobserved components model across 5 equations and allowing for time-varying parameters. Similar to Özbek and Özlale (2005), they use the EKF due to the non-linearity observed when time-varying parameters are allowed. The 5 equations include inflation-output gap dynamics including real effective exchange rate, actual output decomposition including the level of the output gap, potential output defined in a random walk process with a time-varying drift and output gap dynamics defined with real interest rate, a demand index and reel effective exchange rate . They also compare the series found with the EKF with those found by the HP filter and the standard Kalman filter. The findings reveal that the magnitude between the series found with EKF and SKF differ particularly during crises. That is, it is seen that while one of them indicates a positive output gap, the other might indicate a zero output gap. Authors attribute this result to the permanent impact of crises on parameters, which cannot be sufficiently captured by SKF series. In addition, it is seen that the series with EKF are more robust to revisions compared to the series found with the HP filter and the SKF. Higher standard errors of output gap series and some coefficients in unexpected signs are noted as the drawbacks of the EKF method.

Blagrave et al. (2015) estimate the potential output for 16 countries with 11 equations using the MV filter and Bayesian estimation techniques following Benes et al. (2010). Estimation is done for the period between 1993 and 2013. The set of equations include equations for the level and growth of potential output, output gap, CPI inflation (in the form of Phillips curve), level and growth of potential unemployment rate (NAIRU), and unemployment gap. Growth and inflation expectations are added as the last set of blocks in order to improve the accuracy at the end of the samples. Blagrave et al. (2015) also draw attention to the fact that shocks to output in advanced economies over the cycles are associated with fluctuations around the trend whereas in emerging market economies, shocks to trends themselves explain a more significant part of the business cycle.

Andıç (2018) estimates potential output and output gap series for Turkey for the period 2005Q1-2016Q4 using the multivariate filter (MV), following Benes et al. (2010) and Blagrave et al. (2015) . According to the results, potential output vacillates between slightly below 2 percent and slightly below 8 percent for the period of analysis. While the trough of potential growth rate is observed in 2008, it increases between 2011 and 2013 and declines afterwards. Andıç decomposes the potential output series obtained by the MV filter into its components using the Cobb-Douglas production function, reaching a more hybrid model. The decomposition shows that the highest contribution comes from capital, followed by labor and total productivity, respectively. Similar to Öğünç and Sarıkaya (2011), Andıç (2018) also shows that Turkish economy was operating above its potential before the financial crisis. Output gap vacillates between -/+ 8 percent of potential GDP while the highest gap (and positive) is seen just before the global financial crisis. Andıç also evaluates the impact of revision in national accounts on potential output and the output gap. She notes that there is not a systematic upward or downward change in the output gap series following the revision. However, volatility in the output gap is higher in the revised series. The growth rate of potential output, on the other hand, increases unambiguously. The increase in potential growth rate stems from the increase in capital accumulation supported by the increase in construction investments and the increase in TFP. The robustness of the estimates coming from the HP filter and the MV filter against revisions are also compared. In line with most of the findings in the literature, MV filter is found to be more resilient against revisions.

Öğünç and Sarıkaya (2011) calculate the output gap for Turkey for the 2002Q1-2010Q3 period combining state space model with Bayesian estimation techniques in a semi-structural model. Authors model the economy with a New Keynesian approach built upon the output and inflation dynamics. In the model, output gap is explained by ex-ante and ex-post output expectations, ex-ante real interest rate gap, real effective exchange rate gap and external demand gap. The Phillips curve equation, on the other hand involves inflation expectations and effective terms of trade gap. Authors prefer the Bayesian approach since its performance surpasses other methods in short samples and provides more practicality than others provide in general equilibrium settings. Bayesian approach also allows for analyzing confidence bands around parameters. In estimation, to deal with the end-point problem authors extend the data set until 2011Q4 with forecasts. In addition, they use the H-CPI index in order to minimize the impact of short-term price fluctuations on potential output. The potential growth rate is found to be around 5 percent for the related period and a 1-point increase in output gap leads to 0.18-point increase in inflation. Authors compare their findings with those in Kara et al. (2007) and Saygılı and Cihan (2008). While Saygılı and Cihan (2008) claim that output is below potential from the 2005-2007 period, findings of two other studies show that it is above potential. Öğünç and Sarıkaya (2011) also show that the findings are robust against revisions.

Following Andıç (2016), which calculates the parameters of the production function for Turkey, Andıç (2017) measures the impact of the revision of the GDP series in Turkey in December 2016. Re-estimation of the model in Andıç (2016) with new series indicates that not only the actual but also the potential GDP series have risen after the revision. While it was slightly above 4 percent in the former series, it has risen to slightly below 6 percent, corresponding to almost 1 percent increase. As the contribution of factors is examined, it is seen that the contribution of capital and productivity have increased with the revision.

Benes et al. (2010) calculate the potential GDP and output gap for 11 countries and the euro area by using the multivariate filter for the period 1970Q2 to 2010Q2. The filter includes blocks defined for gaps, identifying relationships and laws of motion for equilibrium. The gaps are defined for output, unemployment and capacity utilization. The identifying relationships are described with an augmented Phillips curve, dynamic Okun's law and an equation similar to the Okun's Law describing the dynamics of capacity utilization. The third block consists of the potential values of output, unemployment, capacity utilization and perceived value of long-run inflation. Following the estimation made with Bayesian techniques, the robustness of the method as the new data arrives is checked for against the HP filter using mean absolute error. The results indicate that the MV filter outperforms the HP filter. For all countries, the trough of the output gap is seen in 2009 and as the recovery starts in output gap, it is succeeded by the recovery in capacity utilization and unemployment gap.

Billmeier (2009) compares the performance of the four types of output gap measures using the data of a small set of European countries. The output series obtained by the HP-filter, the Blanchard- Quah decomposition, the production function approach and a frequency domain filter are compared among themselves. It is seen at first glance that the output gap series obtained by the BQ decomposition depict a different picture than other measures both with respect to the course of the series and its correlations with other series. Billmeier draws attention to the fact that the performance of output gap series is susceptible to the uncertainty around output gap measures. He stresses that the parameter uncertainty is at its highest for the output series derived by the BQ decomposition and the production function method. The comparison of methods across countries is made by assessing the ability of each of the methods in estimating inflation vis-à-vis the univariate model.

Coşar et al. (2013) construct small and large scale dynamic factor models to construct output gap series for Turkey for the 2005Q1-2013Q1 period. Emphasizing the end-point problem observed with filtering techniques, they claim that the end-point uncertainty could be removed by factor models. By combining indicators such as capacity utilization rate, working hours per worker, number of job applications and survey responses and extracting a common component out of these variables, an indicator showing the cyclical state of the economy is obtained. Authors highlight the fact that any revision in their findings would stem from the backward revisions in the series, with no additional uncertainty coming from the estimation technique. Timeliness of the method is also underlined since the method allows them to gauge the stance of the economy two-quarters ahead of the release of the official data. Considering that filtering methods oblige the use of the official GDP series, timeliness of the estimation technique becomes more significant. It is also seen that selected variables perform in an economically meaningful way in the Phillips curve equation.

Coşar (2018) extends the approach in Coşar et al. (2013) with changes in the selected indicators and the method used. Still refraining from filtering techniques, Coşar constructs separate gap indicators to understand inflation and output dynamics. Coşar (2018) extends the dataset considerably and adds financial indicators to the estimation following the recent studies. Leaving aside the factor models in Coşar et al. (2013), Coşar (2018) weighs indicators according to their univariate and bivariate correlation (with inflation and output), principal components and data envelopment analysis. Among the gap measures constructed with different weights for indicators, those performing the best in Phillips curve equation and having the highest coefficient in explaining the HP-filtered output gap are selected as output gap indicators. Among the indicators, the ones that perform better in the former equation are predominantly used to capture inflation dynamics whereas the ones explaining the latter are found more in line with output dynamics. Coşar (2018) states that although the two types of output gaps are mostly correlated, the ones obtained according to the Phillips curve equation is more informative when inflation starts to increase.

Any attempt to evaluate the performance of the series relying on different methods would be worthwhile. Performance of the output series in Phillips curve and Okun's law equations and the extent of similarity with other series in capturing the cycles are used to test the performance of the series. Almost every study in this field presents correlations of the obtained series with series calculated with other methods. Cotis et al. (2004) state that correlations among the different measures is around between 0.7 and 0.9. Cotis et al. (2004) also state that trend and univariate filters have more drawbacks than methods relying more on an economic approach such as multivariate filters and production function approaches. In particular, criteria of consistency with economic assumptions and consistency across time are not sufficiently provided by former methods. They state that though Kalman filter appears to pass most of the criteria as a multivariate filter, it lacks transparency and when modelled as a two-sided filter, is prone to the end-point problem. However, they still underline that creative hybrids could let data speak more freely compared to purely economic approaches such as production function approach. The production function approach is more transparent with no apparent end-point problem, but it does not provide sufficient information on uncertainties. Moreover, how the trend values of the variables are calculated constitutes another point of contention.

Akkoç (2018) uses the HP-filter, quadratic Beveridge Nelson filter and Kalman filter, structural VAR to estimate the output gap and potential output for Turkey for the period of 1998-2017. Recessionary periods in 2001 and 2008 are detected explicitly by the output gap series apart from the one estimated by the structural VAR method. In estimation with the structural VAR, Akkoç follows the method of Blanchard and Quah (1989), which decomposes the fluctuations in output gap to supply and demand shocks. This approach assumes that supply shocks lead to permanent effects on GDP while demand shocks have no impact in the long run. Unemployment is also assumed resilient to both demand and supply shocks. With this restriction, the dynamics in the economy are only explained by unemployment and GDP itself. While the HP filter finds the biggest absolute values of output gap, the series obtained by the Kalman filter provide almost the same results, providing evidence for the support of filters with economic information. The output gap series obtained by the HP filter vacillate between -10/+10 percent of potential GDP with similar values obtained for different values of lambda. For the Beveridge Nelson decomposition, while the series constructed with AR(2) and ARMA(2,2) decompositions vacillate between -2/+3 percent of potential GDP, the one obtained by the AR(12) vacillate between -3/+6 percent of potential GDP, proving the vulnerability of the decomposition to the model specification. The output gap series with univariate Kalman filter provides estimates of output gap vacillating between -2.5/+2.5 percent of potential GDP, while the bivariate filter provides estimates between -10/+10 percent of potential GDP, similar to HP filter. Lastly, the series obtained by the structural VAR including inflation provide a smoother picture than the one constructed by including only unemployment. In this respect, while the former changes between 0/0.10 percent of potential GDP, the latter changes between -0.05/0.20 percent of potential GDP.

Saraçoğlu et al. (2014) estimate output gap in Turkey with modified HP filter and structural VAR methods for the period 1988:01-2013:03. The modified HP filter is an extension of the standard HP filter with time-varying parameters. Also, while the standard HP filter is a non-parametric method, sub-components of the modified HP filter could be modelled individually with ARIMA models. The SVAR approach is similar to that of Blanchard and Quah (1989), extended with the inclusion of oil prices to the model. The output gap series obtained by the modified HP filter vacillates between -15/+3 percent of potential GDP while the series obtained by the SVAR vacillates in a much narrower band between -5/+3 percent. Similar to Akkoç (2018), the series obtained by the structural VAR move in a closer band compared to other methods. Performances of the series are compared by using the Phillips curve equation, with the SVAR model outperforming other models.

2.3. Issues to Consider

Studies also differ with respect to their preferences for using time-varying parameters. This discrepancy among studies might lead to wrong detection of trends in the economies that could end up with defected policy actions. It is seen that studies relying on constant parameters can be updated even by same authors in a couple of years due to the requirement of using time-varying parameters. The significance of using time-varying parameters is mainly noted by Aguiar and Gopinath (2007) with their introduction of the phrase “Cycle is the trend” to the literature. Stating that there are shocks coming to the trend term that needs to be differentiated from the transitory shocks, they warn that particular attention should be paid to the analyses of the output series in emerging markets. The frequent regime switches and sudden changes in fiscal and monetary policies are claimed to trigger those shocks that are different in nature from the shocks to the cyclical components. As a result, Aguiar and Gopinath (2007) conclude that there is not a real standard business cycle model that could explain the business cycles both in emerging and in developed small open economies. Their findings clearly demonstrate the importance of using time-varying parameters in estimates of output gap and potential output series.

The attributes to the time-varying structure of potential output are indeed encountered frequently. Adding time-varying parameters to estimation is mostly seen in studies using unobserved components analysis, multivariate filtering or dynamic factor models, which all rely on estimating a number of equations simultaneously. It is also seen that the time-varying structure is followed not only through potential output itself, but also through variables needed to estimate it. Allowing for time-varying parameters in estimation of NAIRU as in Alichi (2015), in Okun's law as in Lancaster and Tulip (2015) or TFP as in Felipe and McCombie (2019) are examples of inserting time-varying parameters to the estimation process. On the other hand, some studies put emphasis on existence of structural breaks in potential GDP, which is criticized for insufficient performance due to the vulnerability of structural break tests (Antolin- Diaz et al.,2017).

A sketch of studies using time-varying parameters shows that such parameters are needed not only in studies of emerging markets, but also in advanced economies. Particularly following the arguments such as "Great Moderation" put forward by Kim and Nelson (1999), studies also focus on slowdown in advanced economies such the EU or the US. Antolin-Diaz et al (2017) investigate the time-varying structure of the potential GDP using dynamic factor model and Bayesian estimation techniques in a setting including 28 indicators, which are considered to be related to both cyclical and trend components of output. While the paper ultimately aims at making nowcasting of US GDP, starting with a time-varying potential output assumption validates not only the use of such parameters, but also improves the robustness of nowcasting estimates. The change in the trend output is considered equivalent to the changes in consumption level, depending on the permanent income hypothesis. Antolin-Diaz et al. (2017) also assume stochastic volatility of factor variables, which prevents the long cyclical movements from being perceived as changes in the trend component. They also decompose the long-run growth rate into labor productivity and labor input, concluding that labor productivity is the main reason behind the decline, the first glimpses of which go beyond the global financial crisis. The study is a good example of diagnosing the trend and cyclical parts of GDP by using a large dataset that inherently brings about the distinction due to the characteristics of variables. Özbek and Özlale (2008) also investigate the time-varying patterns of potential output growth shocks in the US by using unobserved components models with time-varying parameters and Kalman filter. They document that for the period between 1949Q1: to 2005: Q4, the potential output in the US exhibits significant deviation from its steady state level though this cannot be supported by a pure random walk specification.

In the discussion related to emerging markets, Lanzafame (2016) investigate the course of potential output in 21 Asian countries using an aggregate supply model (built on Okun's Law and Phillips Curve) with time-varying parameters and Kalman filter. He finds that the decline in actual growth rates of these countries in 2000s is highly correlated with the decline in potential growth rates. He also finds that an increase in actual growth volatility has negative impact on potential growth rate. This finding could be considered to be in line with the views of Aguair and Gopinath (2004) since sudden stops in emerging markets also lead to significant fluctuation in actual growth rates.

For the studies on Turkey, Özlale and Özbek (2005) and Öğünç and Sarıkaya (2011) can be listed as good examples of studies allowing for the time-varying structure of potential output in Turkey. Both of these studies validate the use of a time-varying structure in the estimation of potential output in Turkey.

Lastly, some criteria according to which the performance of potential output and output gap are evaluated can be listed. Cotis et al.(2004) evaluate the calculation methods of potential output in various perspectives and present 4 core criteria to measure the performance of potential output and output gap series. These are consistency between economic priors (i.e. the underlying assumptions of the method), transparency in estimation techniques, and consistency over time (no-end point problem) and inclusion of mechanisms that would make goodness of fit analyses possible (ability to do analyses). In addition to these criteria, it is seen that in most of the studies, potential output and output gap series are used in estimating inflation and current account figures to evaluate its performance. This is indeed not surprising since those series are essential parts of the tool set of policy makers. Authors also state that despite the absence of an international consensus on the method to be used in estimating potential output and output gaps, there is an increasing convergence around the production function among the OECD, the World Bank with the slight diversion of the IMF and institutions of the EU depending on the policy areas. Consensus is not only highlighted in the international arena. On the domestic front, central banks possess a leading role in suggesting policies on employment, productivity, capital accumulation, potential growth due to their repercussions on medium term inflation targets.

Though the methods listed differ in the steps taken for estimation, it is possible to attain same results with the modification of the methods. For instance, the outcome of the HP filter can be obtained by using a state-space decomposition estimated by the Kalman filter (Harvey, 1990). By formulating the Beveridge-Nelson decomposition in a state-space form, Morley et al. (2003) indicate the similarity of the trend resulting from the Beveridge-Nelson decomposition and from the Kalman filter under certain conditions. The most remarkable connectedness among methods is observed in the use of univariate filters to obtain the trends of the variables used in the production function approach.

3. POTENTIAL EMPLOYMENT

Our measure labor input is potential employment, which is equal to the potential labor force multiplied by one minus the trend employment rate:

$$E_t^* = LF_t^* \times \left[1 - \left({u_t^*}/{100}\right)\right] \tag{1}$$

To estimate the potential labor force, we obtain potential labor force participation rates for different age-gender groups in the working-age with a cohort-based participation model. The aggregate potential labor force is the sum of the potential labor force of each age-gender group that is determined by the product of potential participation rate and group populations:

$$LF_t^* = \sum_{g,a} \left(LFPR_{g,a,t}^* \times Population_{g,a,t}\right), \tag{2}$$

where g, a, t indexes gender, age group, and time. The next section details the estimation of the potential labor force participation rate.

3.1. Potential Labor Force Participation: A Cohort Based Model

We define the labor force participation rate as the percentage of the civilian non-institutional working-age population (15 years and older) who are either employed or actively seeking work. The data source is the microdata from TURKSTAT’s Household Labor Force Survey, which has over 400,000 participants in each year’s survey. The data covers the period from 2004 to 2018.

We use a cohort-based labor force participation model to determine the potential participation rate, estimate projections, and specify the factors of labor force participation, following the studies of Aaronson et al. (2006), Kudlyak (2013), and Aaronson et al. (2014). At the first stage of the estimation, the working-age population (15 years and older) is divided into 11 age groups for each gender since the labor force participation changes dramatically

Table 1: Labor Force Participation Rates of Demographic Groups

	2004	2006	2009	2012	2015	2018
Male						
15-19	34.2	35.2	37.0	34.6	37.5	39.6
20-24	72.7	71.5	72.3	70.7	74.5	75.6
25-29	92.8	91.8	92.7	90.8	91.4	91.6
30-34	95.3	94.8	94.7	94.7	95.0	95.1
35-39	95.7	94.2	95.0	94.7	95.0	95.0
40-44	93.0	92.8	93.6	94.0	94.0	94.4
45-49	80.4	81.4	82.5	86.8	89.2	90.4
50-54	63.1	64.1	65.1	69.3	73.3	76.9
55-59	51.1	49.2	49.7	54.3	56.7	63.3
60-64	39.3	37.2	38.1	42.2	42.4	46.6
65+	23.3	20.2	19.6	20.2	19.9	20.9
Female						
15-19	17.6	17.3	17.3	15.8	18.4	17.9
20-24	32.1	31.3	34.5	36.7	42.2	45.4
25-29	30.5	31.9	35.8	40.3	44.2	48.8
30-34	28.0	29.7	34.8	39.6	42.7	46.0
35-39	29.1	30.5	34.1	40.0	44.2	48.2
40-44	26.1	28.1	32.1	39.9	42.9	47.4
45-49	22.7	23.0	25.7	33.3	36.0	42.4
50-54	19.2	19.8	21.7	26.4	27.7	31.7
55-59	18.0	16.6	17.8	20.1	21.2	22.8
60-64	15.0	12.9	14.4	16.0	14.9	17.3
65+	7.3	5.7	5.9	6.4	5.8	5.9

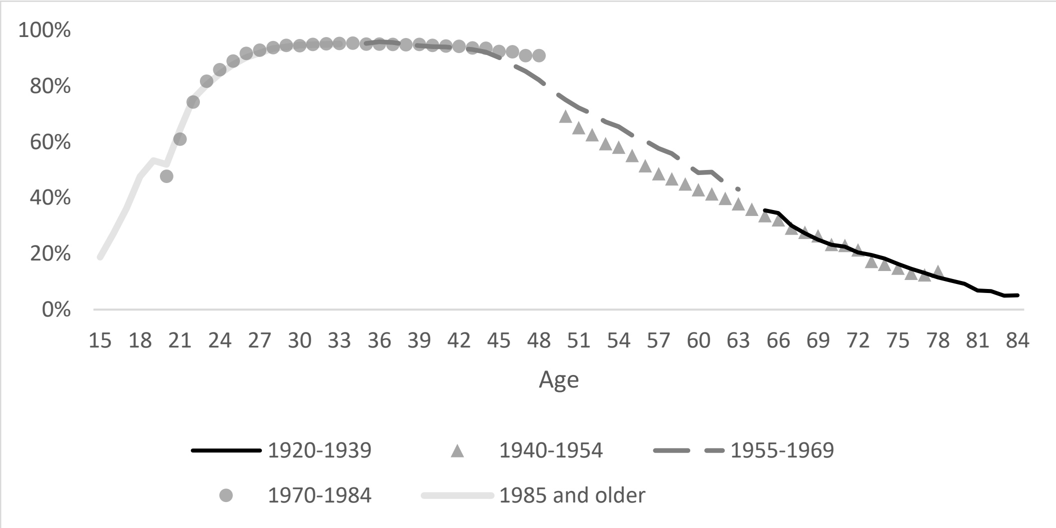
Notes: Table shows the labor force participation of each age-gender group. Data retrieved from TurkStat Household Labor Force Survey.

between the age groups (Table 1). It sums up to 22 age-gender groups in total. The age range of the demographic cells is five years, except for the group for the oldest ones, which includes people from 65 to 84 years old.

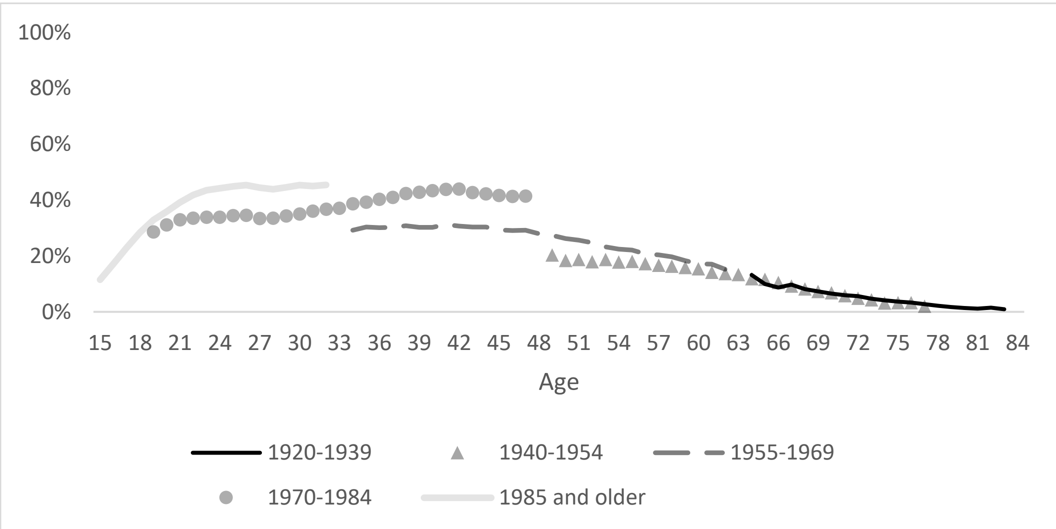
Cohort models stand out in their ability to capture the unobserved changes affecting the labor force participation. Baby boomers in the US, for example, are known for their high labor market attachment. For the Turkish case, there is a secular trend resulting in a steady increase in women's participation rate that is captured better with a cohort model. The cohort model enables us to have forecasts for the future as well.

Figure 1: Labor Force Participation Rates by Age and Birth Cohorts

(a)Male



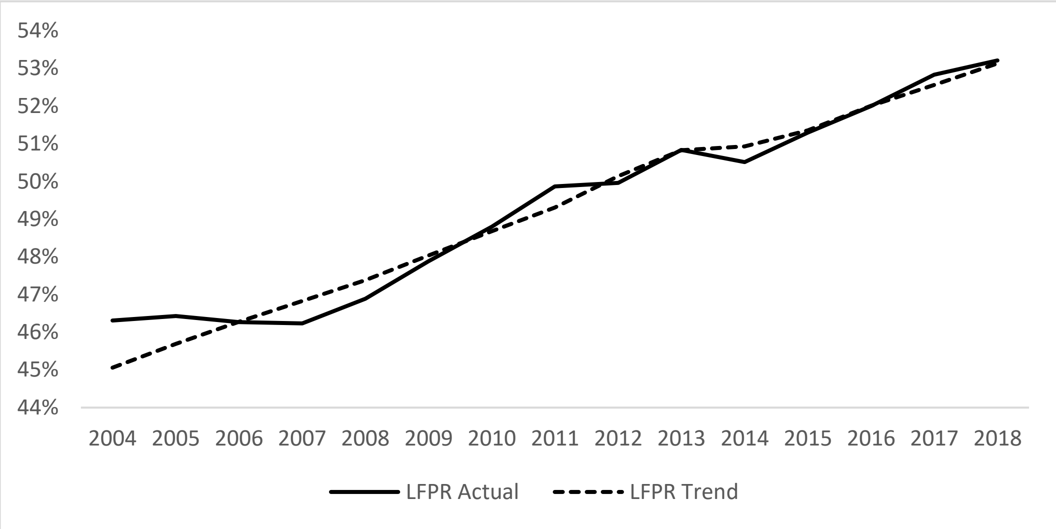
(b) Female



Notes: Authors' calculations using Household Labor Force Survey. Panels (a) and (b) show the labor force participation rates of different birth cohorts in working ages. Panel b demonstrates younger female generations join the labor force with a significantly higher rate.

Figure 1 shows the evolution of participation rates by birth year. After the 1940-1954 cohorts, participation rates of each female generation exhibits major upward shifts for the same ages, implying stronger labor force attachment. Cohorts of males have similar participation rates in prime working ages while the younger generation has higher rates after the age of 50, suggesting a possible delayed retirement.

Figure 2: Actual and Potential LFPR



Notes: The trend labor force participation rate is derived from the model fit by setting the cyclical variable to zero.

Also, the model includes structural variables that are found significant; the percentage rate of being married for women, and the rate of college graduation for both genders. Lastly, to control the effects of the business cycles, the model includes the unemployment gap: the deviation of the unemployment rate from its Hodrick-Prescott trend[2]. Equation (3) shows the specification of the full model.

$$logLFPR_{i,t} = \alpha_0 + \alpha_i + \frac{1}{n_i}\sum_{c=1}^{15} \beta_c C_{c,i,t} + \sum_{j=1}^{22} I(i=j)\left(\gamma_j^0\, ugap_t + \gamma_j^1\, ugap_{t-1}\right)$$
$$+ \sum_{j=1}^{22} I(i=j)\left(\theta_j\, college_{j,t}\right) + \sum_{j=1}^{22} I^f(i=j)\ \left(\phi_j\, marriage_{j,t}\right) + u_{i,t}\ , \qquad (3)$$

where α_i and β_c are time invariant age and cohort fixed effects respectively. $C_{c,i,t}$ takes the value of one if the cohort c appears in the age-gender group i in year t and the value zero otherwise. n_i is the number of ages in age-gender group i. $I(i=j)$ is the indicator function taking value one if the age-gender group i is equal to j and zero otherwise. The cyclicality is controlled with the unemployment gap ($ugap$) and its first lag[3]. $\gamma_j^{0/1}$ are the group-specific coefficients for the unemployment gap and its lag. Structural variables are the percentage of college graduates and married. We also allow for structural factors to have potentially

[2] We use quarterly data and apply HP Filter at the smoothing parameter 1600, and then use the annual average of the gap series. Using Hamilton Filter as an alternative, we find the resulting LFPR trend quite similar.
[3] The unemployment gap does not vary by demographic groups.

different effects by age-gender group. $I^f(i = j)$ is the indicator function taking value one if age-gender group i is equal to j as well as includes females, and zero otherwise. Therefore the college rate is included for all age-gender groups while the marriage rate is included only for the women in the model. After the estimation, the trend or potential rate of participation is obtained by the predicted values while setting the unemployment gap to zero. The estimated potential labor force participation rate and potential employment are shown in Figures 2 and 3.

3.2. Model Performance and Projections

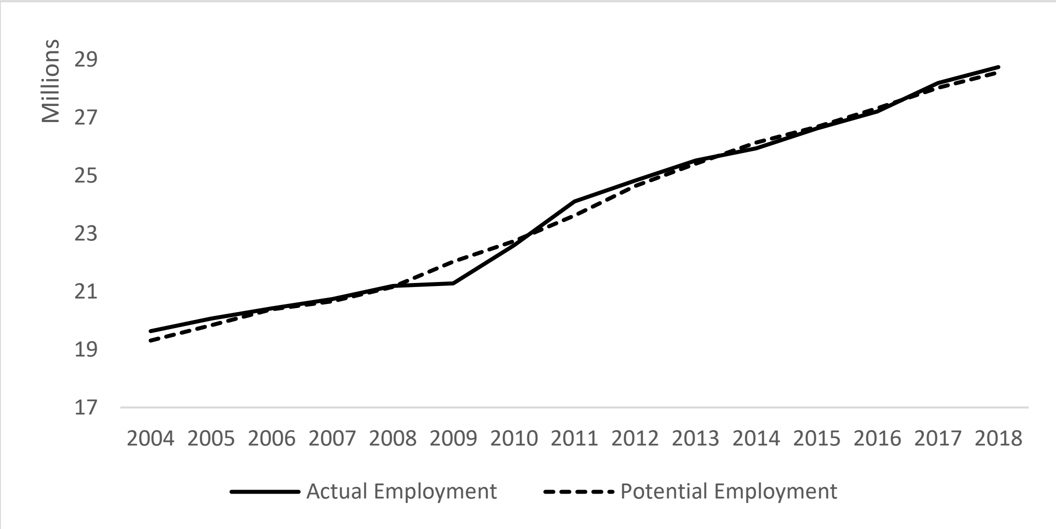
Figure 4 shows the actual labor force participation rate and two model fits. The full model is our benchmark model specified above, which includes age-gender effects, cohort effects, and structural effects. The second fit is from the model only with the age-gender fixed effects. As seen in the figure, the full model tracks the original data closely while the model without cohort and structural factors performs poorly. Capturing the differences in cohorts and the structural factors appear crucial.

We provide the result of a counterfactual exercise showing the potential importance of the elements of equation 3 in lifting the future course of labor force participation. Assuming that the trends of increasing college graduation and decreasing marriage rate continue until 2030 in alignment with their historical progress and linear trends in cohort effects, we project the labor force participation rates using TURKSTAT's population projections.

Figure 5 reports the projected labor force participation rate and some counterfactuals in solid black lines. When we let the structural and cohort effects evolve according to their historical trends, the overall labor force participation rate reaches just over 60 percent of the labor force. Furthermore, each counterfactual shows how the LFPR moves if population shares, marriage and college graduation rates, and cohort profiles are fixed at their 2018 levels.

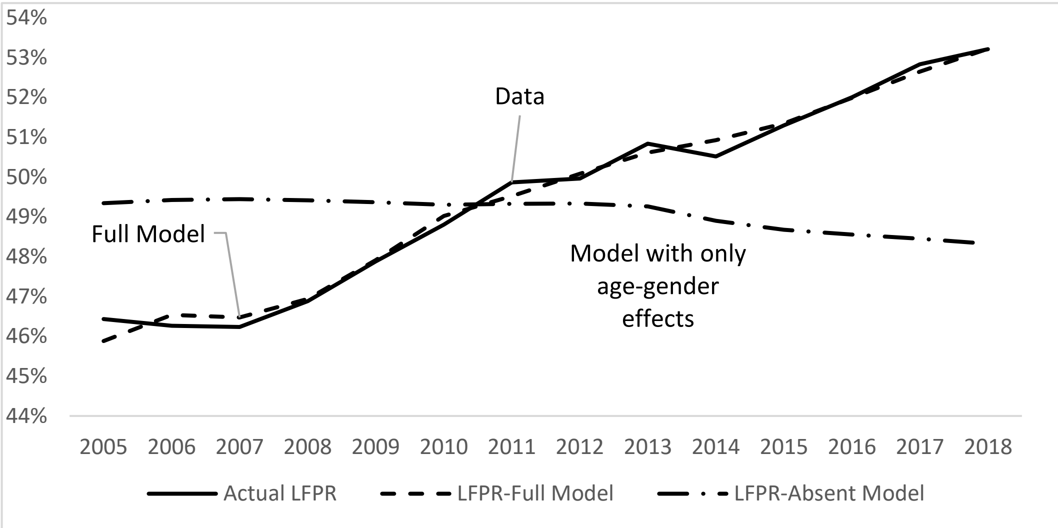
While Figure 4 proves the joint importance of cohort behavior and structural trends in driving the LFPR, Figure 5 allows us to differentiate between the two effects over the projection path. The dotted line shows the counterfactual when we keep the cohort effects at the 2008 level. Being close to the benchmark, it suggests a small contribution to the evolution of LFPR. On the other hand, the short dashed line, showing the counterfactual when marriage and education trends are fixed, increases only 4 points after 2018 compared to 7 of the benchmark. This

Figure 3: Actual and Potential Employment



Notes: The potential employment is calculated using the trend labor force participations, population level and trend unemployment.

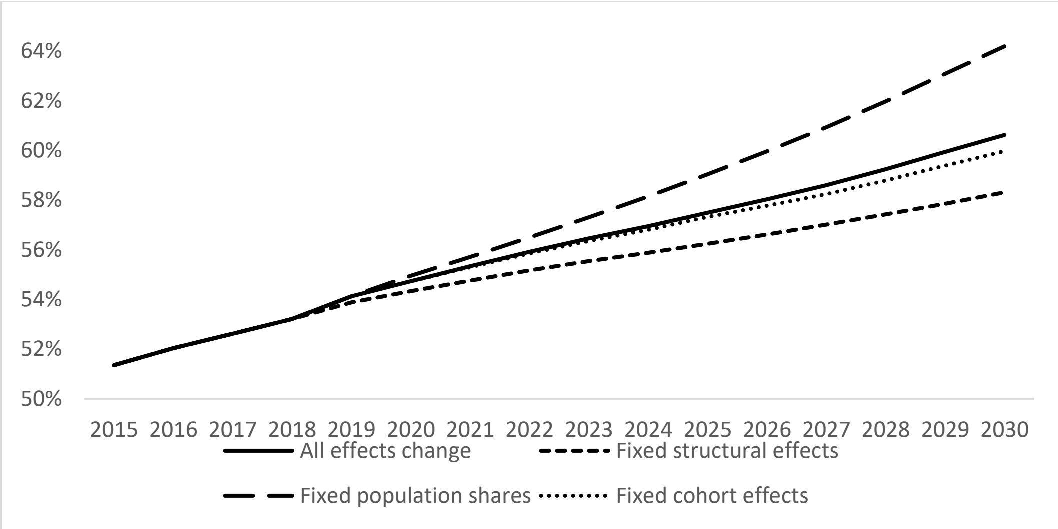
Figure 4: The Data and the Model Fit



Notes: The full model is the benchmarks model described above. The absent model excludes cohort effects and structural explanatory variables.

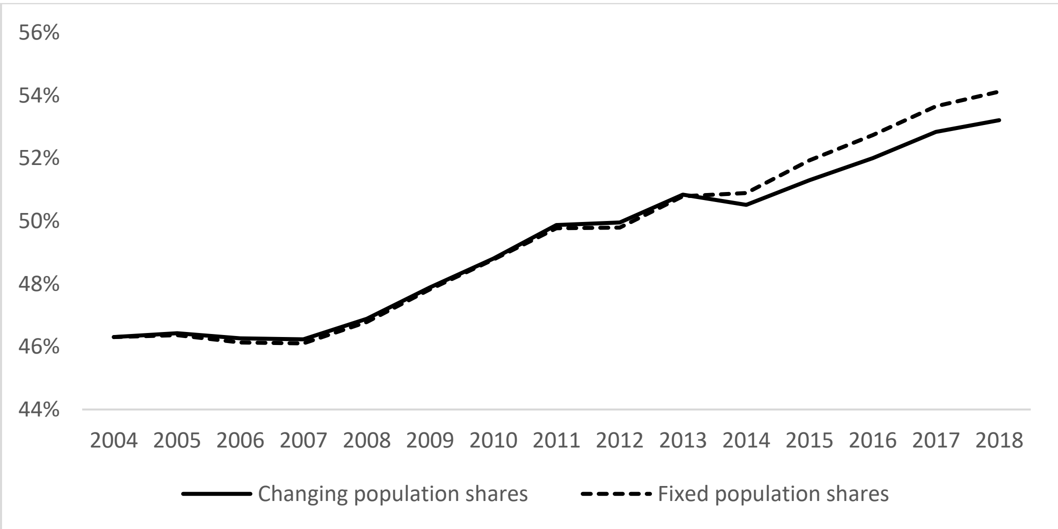
marks the potential of education policies in driving the LFPR in Turkey. We choose not the further break-down among the two key structural elements, given that there is strong association of education trends with the marriage patterns such that the increase in education governs the secular trends in the economy.

Figure 5: Full Model Projection and Counterfactuals:



Notes: The solid line shows our projection for labor force participation rate through 2030 assuming the cohort effects and structural variables would continue evolving according to their linear trends. Each dotted line reflects a counterfactual projection of labor force participation rate in a scenario where the stated effects are fixed to their 2018 levels and other determinants move according to their linear trends.

Figure 6: Labor Force Participation Rate with Fixed and Current Population Shares



Notes: The figure shows the actual and counterfactual labor force participation rates in the scenario where each age-gender group's share in the total population stay at the 2004 level.

Long dashed line shows the counterfactual when all other elements evolve as projected but the population share is fixed at 2018 level, suggesting three points larger increase than the baseline projection. This shows that the change in Turkey's population structure will affect the participation rates negatively, due to aging. Prime working age population shrinks as the older

Table 2: Population Projections (Thousands) and Implied Annual Labor Force Growth

	Population Level	Population Growth				
	2019	2019-2025	2026-2030	2031-2040	2041-2060	2061-2080
Male						
15-24	6590	-0.23	0.36	0.35	-0.31	-0.27
25-54	17826	1.07	0.22	0.22	0.09	-0.21
55+	7232	3.54	3.37	2.70	1.23	0.49
Male Total	31648	1.38	1.10	1.01	0.44	0.07
Female						
15-24	6268	-0.27	0.37	0.36	-0.31	-0.21
25-54	17461	1.08	0.18	0.18	0.07	-0.21
55+	8186	3.33	3.34	2.68	1.28	0.45
Female Total	31915	1.41	1.15	1.06	0.50	0.08
Total Labor Force	63563	1.40	1.12	1.04	0.47	0.07

Notes: TURKSTAT produces population projections for years 2030, 2040,2060 and 2080. The figures for the years in between are extrapolated assuming the population moves linearly. The figures in the table are annual growth rates implied by TURKSTAT projections and our linear extrapolation.

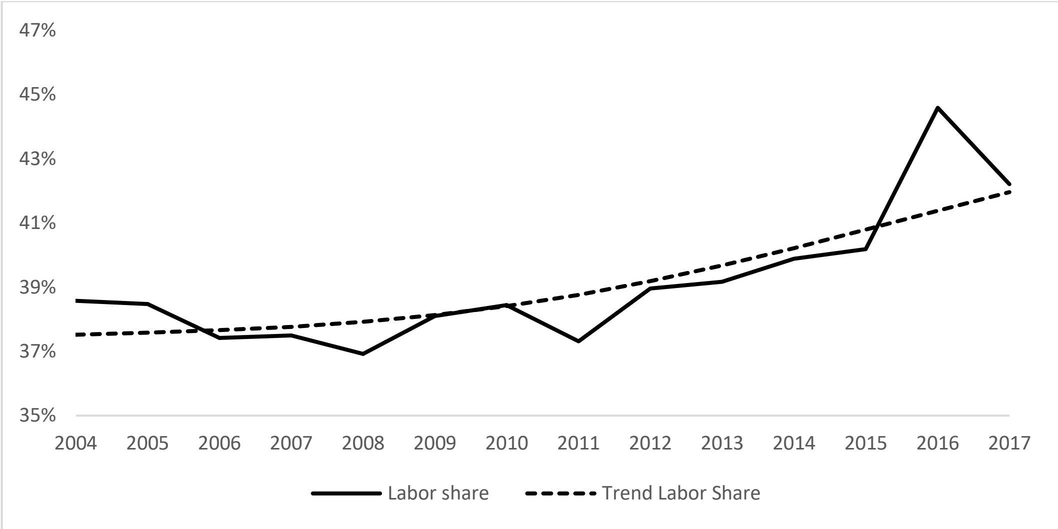
population with low rate of participation expands. Figure 6 shows this proceeding is already in motion. If the population shares of age groups were fixed at 2004, the LFPR would be higher now, implying a negative impact of demographic change on labor participation.

We expect to see both the population growth and the increase in the labor force participation rate to continue contributing economic growth. Our projections estimate Turkey's labor force participation rate will steadily converge to and reach the developed world levels around 2030. TURKSTAT's population forecasts, on the other hand, predicts labor force to grow until 2080, although at a diminishing rate (Table 2).

3.3. Labor Share

The Cobb-Douglas production function that is used for estimating potential growth requires the estimation of labor and capital share parameters, α and 1-α respectively. Given that the production function exhibits constant returns to scale and under cost minimization of the firms, contribution of labor to the production is equal to the share of labor compensation in the output (Shackleton, 2018) and the remaining contribution is due to capital.

Figure 7: Labor Income Share



Notes: Authors' calculations using HLFS and National Accounts.

We calculate the labor share using the national data on labor compensation and value added and adjust for the self-employed (Arpaia et al., 2009).

$$\alpha = \sum_{i=1}^{k} \frac{CE_{i,t}}{VA_{i,t}} \times \frac{TE_{i,t}}{E_{i,t}} \times \frac{VA_{i,t}}{GVA_t} \tag{4}$$

where α is the labor income share adjusted for the self-employed. CE is compensation of employees and VA is the value added for the sector i. GVA is the gross value added for the whole economy. TE and E are the number of total employment and the number of employees respectively. i and t are indexes for the sector and time. We calculate the labor shares on a sectoral basis and aggregate them using the sectoral weights measured as sectoral value added. Labor compensation and value added are from national accounts and the ratio of total employment to number of employees is calculated from TURKSTAT's Household Labor Force Survey micro files.

We see an increase in labor share of 3 percentage points, and therefore a decline in capital's share, in the period of interest, averaging around 0.4 and 0.6. We use the Hodrick-Prescott trend of the shares in the model to smooth out the variations. While the spike in 2016 is possibly the result of the sharp rise in minimum wages, the rising trend is seen in the figure.

Shift-share analysis—not reported here but can be provided upon request—shows that the increase in labor share equally stems from both structural transformation towards the sector with high labor share and the *within* industries, suggesting that there is also an economy-wide element in it. Rising labor share can be regarded as a positive development for two reasons.[4] First, by reducing the weight of capital growth, it contributes to a more stable potential growth given that capital growth can be highly volatile depending on the investment outlook. Second, it can be regarded as an indication that inequality between workers and machines is not worsening in Turkey, despite the declining labor share as a prominent post-2000 trend in advanced economies (Elsby et al., 2013; Karabarbounis and Neiman, 2014).[5]

4. CAPITAL

4.1. Capital Services

This study follows the methodology adopted by the CBO and the Bureau of Labor Statistics in the calculation of the capital series to be used in the production function approach. According to the methodology, capital series are calculated as series of capital services instead of capital stock[6]. It should be underlined that in per unit terms; the contribution of computers to production is higher than land's contribution, causing the user cost of computers to be higher than land. That distinction between the contributions of these assets (capital goods) necessitates the use of different weights in the aggregation process. In addition to these observations, the reason that prompts the use of capital services is the higher level of cyclicality exhibited by machinery and equipment compared to the series of structures in Turkey (Demiroğlu, 2012). Equal weighting of structures and machinery and equipment would lead to a downward bias in the cyclicality of the potential output series.

In this study, the distinction is made between machinery and equipment and structures in line with the BLS- CBO approach and Demiroğlu (2012). Starting with the equivalence of the marginal cost and the marginal return of capital at the optimal production level, the two types of capital are weighted by their individual contribution to the production. As a result of the stated equivalence, weights include the real user cost, stock and the relative price of each type of capital. The list of related equations can be listed as follows:

[4] See Çakır and Sevinc (2020) for a detailed analysis of rising labor share in Turkey.

[5] There are also papers claiming that the decline in the labor share is a byproduct of measurement (Gutiérrez and Piton, 2020; Koh et al., 2020).

[6] As stated by Shackleton (2018), if a car is valued at 20.000$, it implies that the total worth of services that would be provided to the purchaser would be 20.000$ until the end of use date of the car. This approach is in line with the standard economic theory.

$$P^y F_{k,i} = P_i^K \left(r_i + \delta_i - \frac{\dot{p}_i^K}{p_i^K} \right) \tag{5}$$

$$R_i \equiv \left(r_i + \delta_i - \frac{\dot{p}_i^K}{p_i^K} \right) \tag{6}$$

$$F_{K,i} \equiv R_i p_i^K \tag{7}$$

for $i = 1,2$and the weights of each type of capital are calculated as

$$w_i^s = \frac{F_{Ki} K_i}{F_{K1} \hat{K}_1 + F_{K2} \hat{K}_2} \tag{8}$$

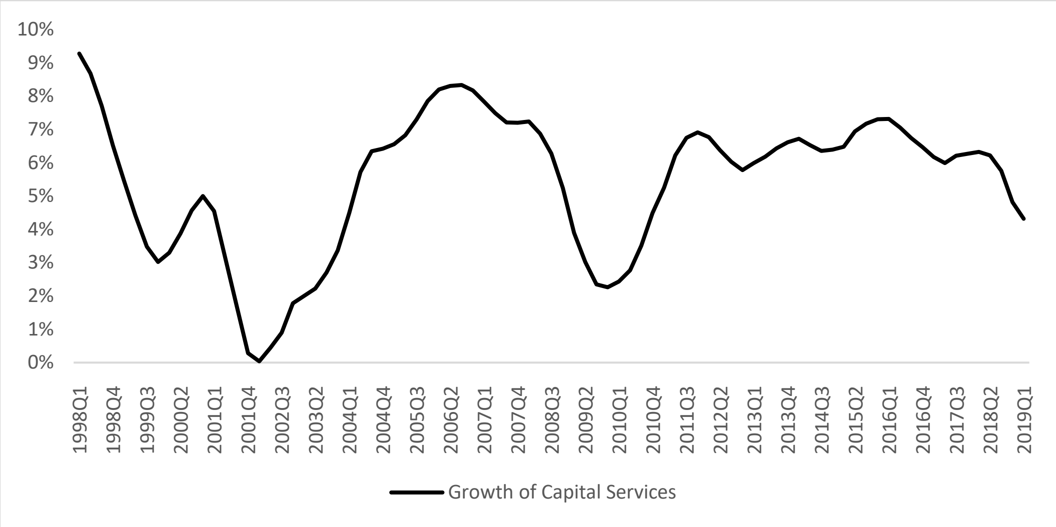
Using the weights and the series of capital stock, the series of capital services is calculated as:

$$K^s = w_1^s K_1 + w_2^s K_2 \tag{9}$$

where $F_{K,i}$ indicates the marginal product of the related type of capital, r_i stands for the real interest rate on the capital good, δ_i stands for the depreciation rate and p_i is the ratio of the investment deflator of the relevant capital good to the GDP deflator.

Starting with the last equation, the capital services index consists of capital stock series. The stock series is calculated by the perpetual inventory method that subtracts the depreciation from the previous year's capital stock and adds the current investment level in obtaining the current year's level of capital stock. However, every capital stock series requires a starting point. In this study, the starting value of the capital stock series is selected in such a way that the ratio of this value over GDP is in conformity with the ratios of capital stock in the following years. Selection of appropriate depreciation rates is the second requirement of the perpetual inventory method. Hulten and Wykoff (1981) present depreciation rates for residential and non-residential capital to be 1.3 percent and 2 percent, respectively. Following Hulten and Wykoff (1981), the depreciation rate for structures in Turkey is calculated by weighing their rates with sectoral shares of both types of capital. The depreciation rate for the machinery and equipment is found by combining the depreciation rates stated by Hulten Wykoff (1981) and the Macroeconomic Advisors (2000) with the share of the informatics sector in investment in machinery and equipment in Turkey. Ultimately, the depreciation rates for structures and machinery and equipment are assumed to be 2 percent and 16 percent, respectively.

Figure 8: Growth Rate of the Capital Services

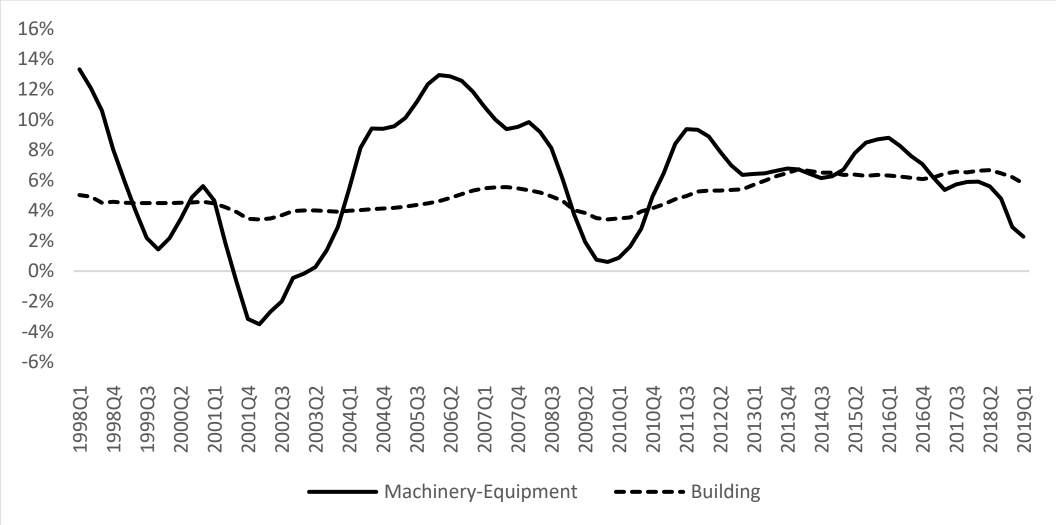


Notes: Authors' calculation using national accounts.

As seen from equations (5) to (7), the real user cost of each type of capital (R_i)comprises of three parts: Real financing costs of the funds used in the purchase of the related type of capital (r_i), physical depreciation (δ_i), and changes in the market prices of the capital good or structure $(\frac{\dot{p}_i^K}{p_i^K})$. Changes in the prices of the capital goods indicate the relative inflation rate of the capital goods vis a vis other goods' since the price of the capital good is equal to the ratio of investment deflator to the GDP deflator[7]. While any increase in the real interest rate and the depreciation increases the cost of the capital, increases in the price of the capital good decreases its cost, and vice versa. For the real interest rate, the average of ex-ante real interest rates on commercial loans for the period 2002-2008 is taken as the reference for the real rate on machinery and equipment. For the rates on structures, a distinction is made between the investment made by the public and the non-public sector. Since households highly invest in structures, for the 2/3 of the investment on structures, the rates on deposits (after tax) is taken into consideration. This ends up with a real interest rate of 8.3 percent for financing the investment in structures. The depreciation rates are selected as in the previous paragraph. The third part, which is related to the market prices, is calculated by taking the long-run

[7] Though might seem unfamiliar, this last part of the equation is indeed not counter-intuitive. With the enhancement in technology, prices of certain capital goods such as computers exhibit sharp declines in short periods. This causes the investor to be able to sell the good at a much lower price than the purchase price, causing an increase in sunk costs.

Figure 9. Growth Rates of the Sub-Components of Capital Services



Notes: Authors' calculation using national accounts.

averages of the ratios of investment deflators to GDP deflator, which are equal to 2.2 percent and 1 percent for the machinery and equipment and structures, respectively[8].

Under the assumptions above, the real user cost is found to be 30.2 percent for machinery and equipment and 10.5 percent for structures on an annual basis. These figures indicate that per unit of stock, the real user cost of machinery and equipment is almost three times the cost of the structures. The critical determinant of that difference is the large difference in the depreciation rates. It is found that the final series are not very sensitive to plausible changes in the underlying assumptions (Demiroglu 2015).

The path of the capital series are depicted in Figure 8 and 9. It is seen that after the crisis in 2001, capital growth increases till the end of 2006 and starts to decline again in 2007. It is seen that the growth rate of capital started to fall before the global financial crisis. Though it hits a local minimum in 2009, it is seen that the trough of the growth rate is seen in the aftermath of the crisis in 2002. Ultimately, the growth rate is 4.8 percent by the end of 2018, 0.3 percent higher than its value at the beginning of 2004. Looking at these figures, it could be suggested that the capital growth rate has not exhibited a significant change in the sample period of the analysis. As the growth rates of the composition of capital series are analyzed in Figure 9, it is seen that between 2004 and 2018, the growth rate of the machinery and equipment mostly

[8] Though the long-run average of the rate for the structures is 0.9 percent, this needs to be adjusted by the price increases in the real estate market. Ultimately, 1 percent is used as the relevant change in market price. The long-run averages are calculated for the period 1987-2010.

dominates the rate of structures. In addition, it is seen that the growth rate of the latter overpasses the rate of the former in periods of crises, which can be explained mostly by a decline in the contraction of investment in machinery and equipment. The same pattern is observed after 2017, too, with the growth rate of machinery and equipment declining at an accelerating rate.

4.2. Adjustments to Capital Growth

The capital services measure the real value of capital stock and is often used as it is in the calculation of potential output. In recent years though, there is a developing literature emphasizing certain imbalances triggered by financial cycles in both in emerging and advanced economies[9]. As the reasons and the repercussions of the global financial crisis are analyzed, it is seen that the existence of external or domestic imbalances could hamper the evolution of potential growth paths as they are corrected mostly with sudden stops. Imbalances such as rapid credit growth or current account deficits could lead to bubbles in property prices (as in advanced economies) or investment levels that are fueled by excessive and mostly external credit growth (as is mostly seen in emerging countries) (IMF.,2015; Alberola et al.,2013). In the context of potential output calculation, the latter impact of the rapid credit growth is mainly seen on investment levels that are considered unsustainable due to the high possibility of future corrections (Albert et al., 2015).

Due to high capital flows and the accompanying credit growth (albeit slowed during the global financial crisis) observed in recent decades in Turkey, the extent of the impact of such corrections on potential output needs to be investigated. We postulate that excessive credit growth leads to accelerated capital accumulation, hence it would be reflected in the current account balance as a high deficit rate, which in turn increases the pressures on the domestic currency and inflation and the probability of a correction.

By remaining neutral to a possible need of re-estimating the existing capital input as a result of such imbalances described above, we address the concept of sustainable capital growth in two alternative approaches. In the first one, we focus on the dynamic and interconnected

[9] An example is the growth of China during the 1990s and early 2000s that is supported by high rates of credit growth, manifested itself through increasing trade surplus and became the subject of sustainability debates (Albert et al., 2015).

relationship between capital, credit, and exchange rate and extract a constant growth rate implied by the multi-dimensional relationship. The second one is a direct attempt to estimate the trend capital growth following Albert et al. (2015). In its simplest form, we eliminate the impact of the cyclical behavior of investment, which is assumed to be affected by credit growth.

4.2.1. A Time Varying Vector Autoregression

To study the interconnected evolution of capital growth, credit growth, and the exchange rate growth, we estimate a time-varying vector autoregression (TVP-VAR) model presented in Primiceri (2005) and Cogley and Sargent (2005). TVP-VAR models depart from the standard VAR specification with their ability to allow variations in the VAR coefficients. The time-varying variance-covariance matrix of the additive innovations enables to detect heteroscedasticity among the variables of the model. Also, the time-varying variance-covariance matrix prevents that an innovation to the i-th variable has a time invariant effect on the j-th variable. Since the adjusted capital growth is postulated on the impact of other macroeconomic indicators (mostly financial) on investment, understanding the changing pattern of the relationship between investment and those variables is relevant for an accurate analysis. Following the studies above, a system of linear equations with time-varying parameters is constructed. The steady-state solution of this system of equations is interpreted as a stable growth path for the endogenous variables and used to construct an adjusted version of the variable of interest, capital. Our model takes the following form:

$$Y_t = c_t + \sum_{j=1}^{2} \beta_{j,t} \, Y_{t-j} + u_t \tag{10}$$

$$u_t \sim N(0, R)$$

where Y_t is a vector of endogenous variables g_t^K, g_t^C, g_t^E; quarterly growths of credit, capital services, and exchange rate, respectively[10]. We aim to capture the story of imbalances in a simple structure. Here the main variable of interest is capital growth. Credit growth is used to address the concern of excessiveness in the policy. The exchange rate is included as the reflector of the reactions to imbalances in a small open economy.

[10]The credit series is the domestic credit volume, and the exchange rate is the USD/TL parity. All series are used as quarterly growth rates. Results are robust to using a currency basket which equally weighs USD and EURO.

The time-varying coefficients $\beta_{j,t}$ evolve according to the first-order random walk process:

$$\beta_t = \beta_{t-1} + e_t$$

$$e_t \sim N(0, Q)$$

and the condition $cov(u_t, e_t) = 0$ is assumed. First, the priors are set by a standard OLS VAR estimation for the training period of the first 10 years. Then, the posterior distributions of the parameters are sampled via the Gibbs algorithm. Gibbs algorithm is a method widely used in Bayesian estimation procedures. Following Cogley and Sargent (2005), Mumtaz and Theodoridis (2019) also use the Gibbs sampling algorithm in the VAR setting with time-varying parameters[11].

After the estimation of parameters, the growth paths of our endogenous variables, which are the implied growth rates from the steady-state form of the equation (10) are obtained as we solve for $g_t^i = g_{t-j}^i$. We interpret this rate as the upper bound for sustainable capital growth. Therefore, the "adjusted capital growth" is defined to be equal to the TVP-VAR steady state growth rate whenever the actual growth exceeds this rate, and it is equal to the actual growth when the latter is below the former:

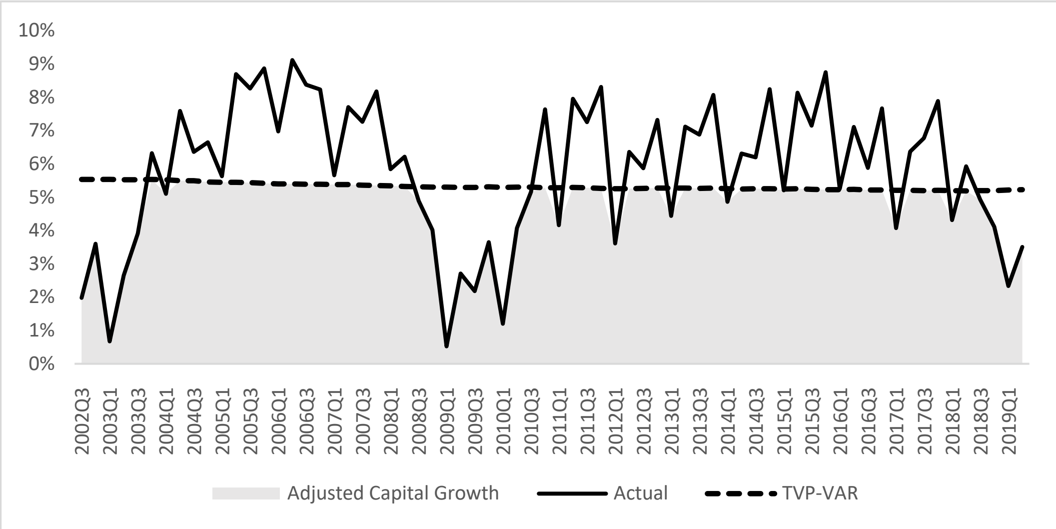
$$\hat{g}_t^K = \begin{cases} \tilde{g}_t^K, & if\ \tilde{g}_t^K \leq g_t^K \\ g_t^K, & otherwise \end{cases}$$

where $\hat{g}_t^K$ is the adjusted growth rate, g_t^K is the actual growth rate, and $\tilde{g}_t^K$ is the TVP-VAR steady-state growth for the capital. This definition reflects the concerns of sustainability in the starkest sense. We use this definition to quantitatively address the issue. Any capital growth below the adjusted rate is assumed to be sustainable. If the growth is above the adjusted rate, it is categorically ruled out as unsustainable.

As the growth rates of the actual and adjusted capital series calculated with the TVP-VAR method are analyzed, it is seen that the path of the latter is almost flat and quite distinctive from the pattern of the former. Between 2004 and 2018, the adjusted rate declines from 5.5 percent to 5.2 percent with the actual rate vacillating between 9 percent and 0 percent. From the lens of the aforementioned interpretation of the sustainability of capital growth, the impact of the credit expansion in the aftermath of the crisis in 2001 is reversed during the

[11]The codes are provided on the website of Haroon Mumtaz about time-varying parameter VAR are used in this study. Further details on estimation can be found on https://sites.google.com/site/hmumtaz77/home.

Figure 10: Annualized Growth Rates of Actual and Adjusted Capital Services via TVP-VAR Method



Notes: The solid line is capital services growth and the dotted line isthe steady state growth rate of capital services implied by TVP-VAR estimation. The shaded area demonstrates how we define the adjusted capital growth.

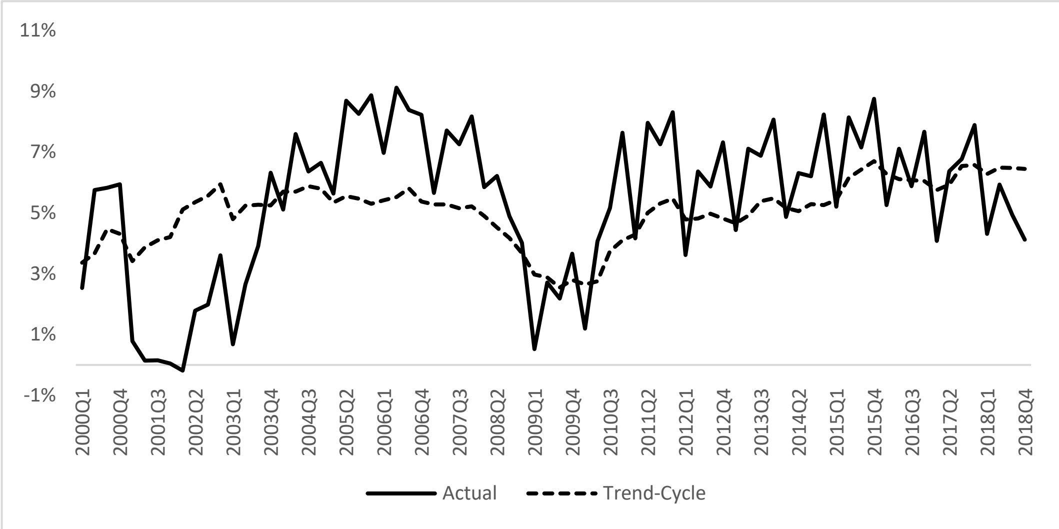
global financial crisis, rendering the sustainable growth path higher than the actual growth path of capital for a limited period. A second time period where a less pronounced rise in the actual accumulation rate is late 2012 to early 2017.

4.2.2. Estimating a Trend Capital Growth

As mentioned above, excessive credit dynamics are regarded as the primary source of over-investment in capital. The expansion in GDP due to over-investment is curbed by incorporating the cyclicality in financial conditions to capital growth. Since the impact of a credit boom is not immediately observable, it needs to be estimated using an unobserved components model that is postulated on the assumption that credit and capital growth have individual structural components but common cyclical components. The cyclical parts of capital growth and credit boom match in such a way that credit could be explained as a function of change in the capital. In this vein, we follow the methodology developed by Planas & Rossi (2010) and also used in Albert et al. (2015) to capture the level of capital growth in sync with stable credit growth[12]. The cyclically adjusted trend growth rate of capital is defined as the adjusted capital growth rate. The parameters in the model are estimated by maximum likelihood and the Kalman filter is used to extract the cyclical component of capital growth. The estimation procedure is as follows:

[12] GAP software developed by Planas and Rossi (2010) is used in these estimations.

Figure 11: Annualized Growth Rates of Actual and Trend Capital Stock via Trend-Cycle Method



Notes: The solid line is capital services growth and the dotted line is capital services growth adjusted for credit growth using the trend-cycle method.

First investment is decomposed into the unobservable trend and cycle components.

$$g_t^c = g_t^{trend} + g_t^{cycle} \tag{11}$$

where g_t^c is the log change of the capital services which is defined as the sum of its trend and cycle components. The trend of capital growth is assumed to follow a second-order random walk path, while the cycle follows a second-order autoregressive process.

$$(1-L)g_t^{trend} = \mu_{t-1} + e_t \tag{12}$$

$$(1-L)\mu_t = v_t \tag{13}$$

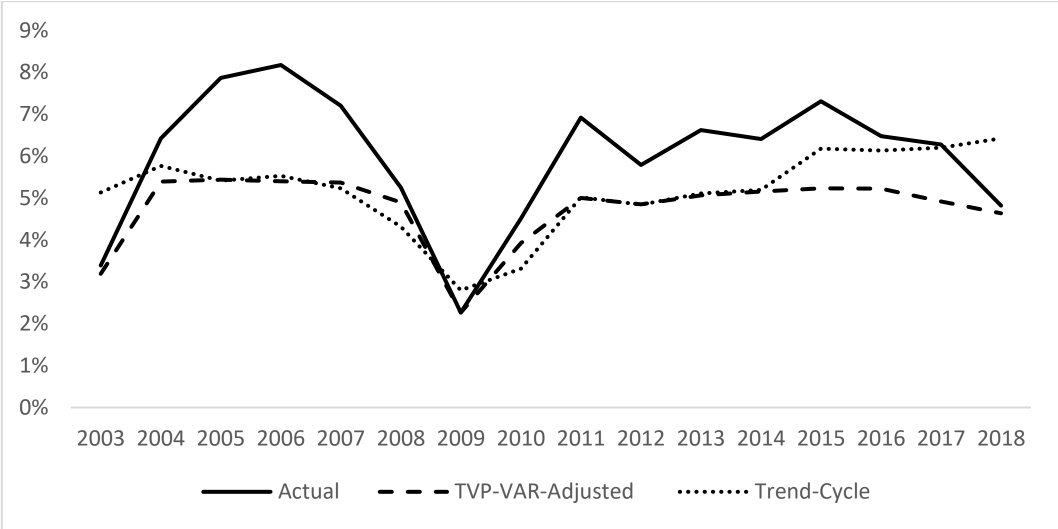
$$(1-\rho_1 L - \rho_2 L^2)g_t^{cycle} = \epsilon_t^{cycle} \tag{14}$$

Where L is the lag operator,v_t,μ_t, v_t, ϵ_t^{cycle} are white noise innovations.

Second, the relationship between the capital growth and the financial cycle, which is proxied by the change in the credit is depicted by the following equation.

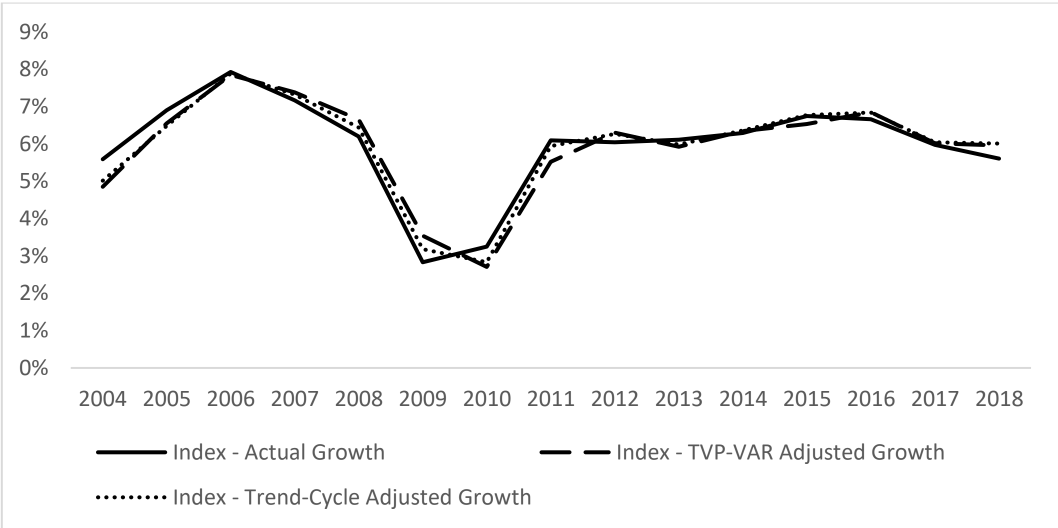
$$\Delta Credit_t = \varphi + \gamma(1-L)^2 I_{t-1} + \sum_{i=0}^{2} \beta_i g_{t-i}^{cycle} + \phi_1 \Delta Credit_{t-1} + \phi_2 \Delta Credit_{t-2} + v_t \tag{15}$$

Figure 12: Yearly Averages of Annualized Capital Growth Rates, Actual and Adjusted



Notes: The figure plots 4 quarter averages of annualized quarterly growths of actual and adjusted capital growths for each year.

Figure 13: Growth Rates of Average Annual Indexes, Actual and Adjusted



Notes: The figure plots the annual growth of capital services indices constructed with quarterly growths of actual and adjusted capital growths.

where φ is a constant, r is the number of lags for which capital growth is assumed to affect the credit. γ, β_i, ϕ_i are parameters to be estimated while v_t is a white noise variable. The estimated trend capital growth is capital growth adjusted for financial cycles.

As the path of the adjusted capital growth calculated with the trend-cycle method and the actual growth path are analyzed, it is seen that the actual capital growth is mostly higher than the adjusted capital growth with the former declining below the latter in periods of crises. It is important to note that the trend capital growth path is also indicating a changing pattern and far from being flat as in the path of adjusted growth calculated by the TVP-VAR method.

It is also important to note that the adjusted growth paths of both capital series are almost constant in recent years with the series calculated with the trend-cycle method standing at a higher rate.

4.2.3. Lessons from Adjusted Capital Growth Measurement

Figure 12 shows the annualized quarterly growth rate of actual and adjusted capital growth rates, averaged over the calendar year. The deviation between the original and adjusted series expands in both periods before and after the great recession. If we naively follow the interpretation based on excessive credit growth argument as described above, the Turkish economy, except the recession, grew faster than what sustainable rates suggested, having its peak in 2006 where the difference hit around 2.6 percentage points in capital growth. The gap corresponds to 1.56 (=2.6 $\times$ 0.6) percentage points in the potential growth rate. In 2014 0.72 (=1.2 $\times$ 0.6) percentage points downward correction in potential growth is implied by the difference.

The fact that the actual-adjusted gap is higher in the period before 2008 somewhat puts doubt on the validity of the sustainability hypothesis in Turkey, simply because the 2003-2006 period has generally been perceived as one of the most successful episodes of the recent macroeconomic history. It would be hard to make the case that capital accumulation over the period was excessive during that period in the sense that it created pressures on the exchange rate and sustainability. Moreover, according to the credit-cycle adjusted adjustment, the gap seems to be closing in 2016, when the recent sustainability discussions intensify.

Lastly, we show that the picture exhibited by the quarterly figures is driven mechanically by the volatility of the series. The seemingly large differences from the averages of the quarterly data could be misleading, given the high-volatility of the actual quarterly capital growth. Large spikes magnify quarterly averages and could be deceptive when understanding the gap in the longer time horizon. When we calculate the annual growth as the growth rate of average yearly indexes, the gap between actual and adjusted rates almost disappears, suggesting an ignorable amount of correction of the potential output, shown in Figure 13.

To sum, in the recent experience of the Turkish economy, drawing a straight line from potential imbalances stemming from credit growth to potential output seems inconsistent in explaining episodes of Turkish growth path, if not quantitatively a worthless effort. Our results suggest that potential vulnerabilities more generally can be addressed better from the perspective of financial stability, not the investment behavior triggered by credit growth per se. The building up of vulnerabilities is perhaps more complicated than the relationship between the headline credit growth and investment. On the other hand, it is not uncommon or theoretically implausible for a developing economy going through fast capital accumulation in the process of convergence. Therefore we prefer to follow the standard economic framework in viewing the growth of capital services as the correct measure of capital input and follow the unadjusted capital measure.

5. TOTAL FACTOR PRODUCTIVITY

The output growth in the Cobb-Douglas framework is the function of observed employment $\widehat{L_t}$, capital services K_t, and total factor productivity A_t. The production function can be rewritten as:

$$lnGDP_t = ln\, A_t + \alpha \times ln\widehat{L_t} + (1-\alpha) \times lnK_t \tag{16}$$

Then the total factor productivity growth is:

$$dlnA_t = dlnGDP - \alpha \times dln\widehat{L_t} - (1-\alpha) \times dlnK_t \tag{17}$$

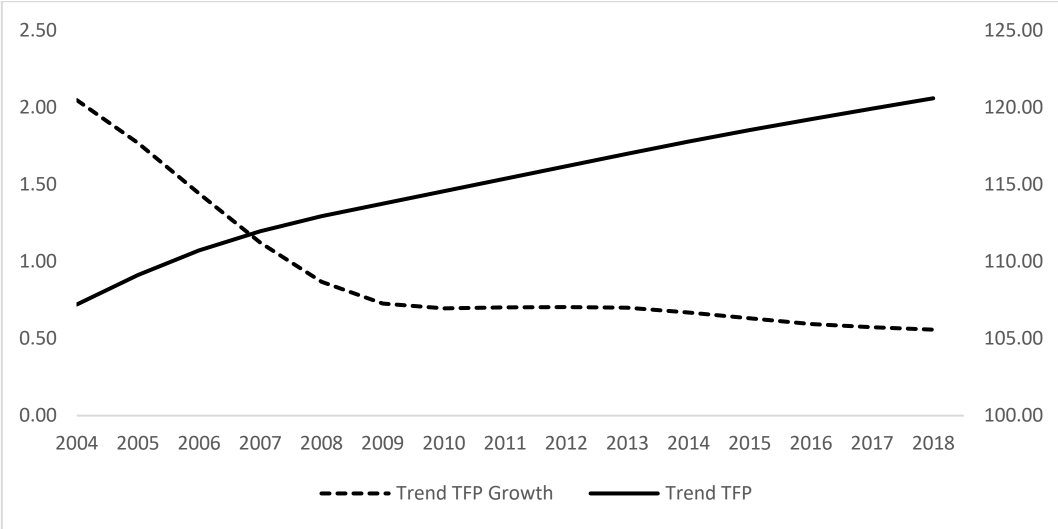
TFP in this framework reflects any unexplained growth that is not accounted for by factors of production. Therefore, rather than being a purely technological or productivity index, it includes elements like capacity utilization, human capital, and accounting errors as well. [13]

We calculate the total factor productivity by substituting the historical values of output, employment, and capital services in equation (17) and convert the growth rates into an index. The potential TFP is estimated as the Hodrick-Prescott trend of the historical values of TFP.

In Figure 14, the trend TFP growth is on the left axis and the index is on the right. TFP's contribution to the potential growth has declined through the mid-2000s and is approximately flat just over 0.5 percent after the global financial crisis.

[13] Since our employment measure includes only the number of workers due to lack of availability of total hours worked our TFP measure also absorbs changes in hours. We do not take a stance in assuming a structure on human capital and let it manifest itself in the TFP. Given the skill premium and rising relative supply of high-skill workers, it is very likely that the contribution of increasing human capital contributes to the TFP growth of our TFP measure. See Hall and Jones (1999) and Caselli (2005) for the estimation of human capital, which we leave for future research.

Figure 14: Total Factor Productivity



Notes: Trend level of total factor productivity is shown in the right axis and the growth rate is on the left axis.

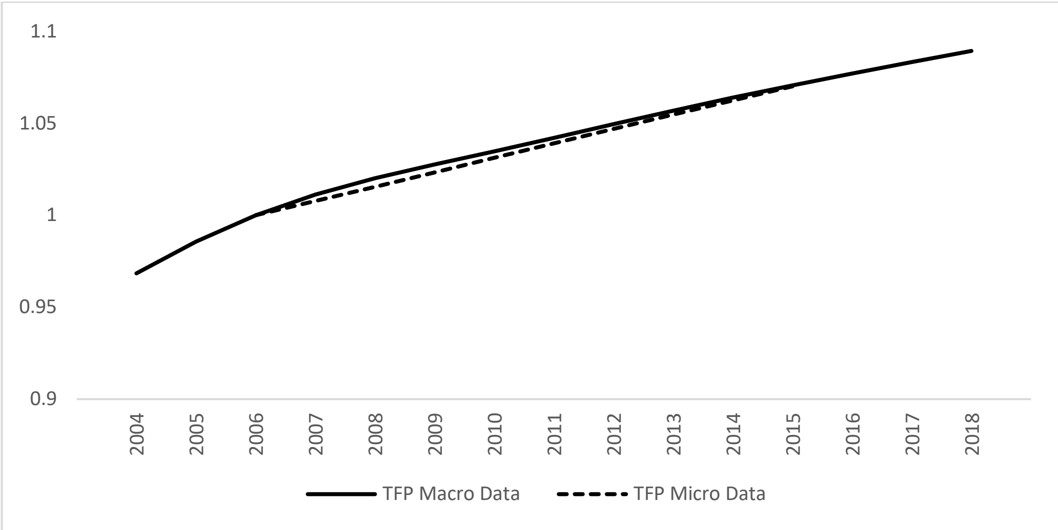
Our residual macro estimate is interesting for two reasons. First, it estimates a positive TFP growth in Turkey in contrast to many other macro estimates (See, e.g, Penn World Table, Feenstra et al., 2015). A rising TFP is more sensible with respect to economic theory and the Turkish experience over the period, given that the country continued to witness developments in trade, technology, and human capital. Second, the estimated TFP growth is steadily declining, which can be alarming considering the future of income convergence of Turkey. Given that our TFP includes a vast range of variables including but not limited to working hours, human capital, efficiency in trade and resource allocation, innovation, and credit constraints, reversing this trend seems to the main policy objective from the lens of potential output.

One concern on the macro TFP estimates could be the difficulty of relating it with firm performances due to aggregation. We directly address this concern in the following. Bağır and Torun (2019) estimate TFP for Turkey using microdata from Entrepreneur Information System in which financial tables for the population of the registered firms and Social Security administrative records provided by the Ministry of Industry and Social Security Institution can be found. They follow The Competitiveness Research Network (CompNet)'s modules[14] where

[14] See Christophori et al (2018) for details.

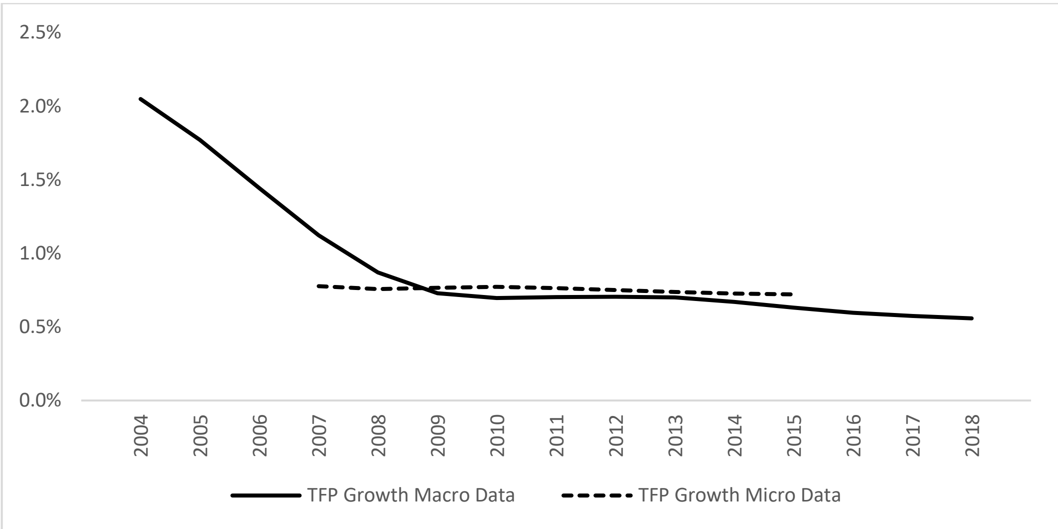
Figure 15: Total Factor Productivity: Micro and Macro Data

(a) TFP Level, Normalized to 1 in 2006



Notes: Macro TFP levels are from our calculations and TFP levels calculated by Bağır and Torun (2019) in firm-level microdata.

(b) TFP Growth



Notes: Macro TFP growth is from our calculations and TFP growth calculated by Bağır and Torun (2019) in firm-level microdata.

the authors estimate the following model for the NACE Rev. 2 sectors in 2 digits detail with GMM method:

$$rva_{i,t} = \theta^k k_{i,t} + \theta^l l_{i,t} + \beta W_{i,t-1} + \gamma_t + \varepsilon_{i,t} \tag{18}$$

where all the variables are in logs. rva,k and l are real value added, the real book value of net capital and total employment. W is a vector including the third order polynomials of capital and labor and γ denotes time fixed effects. Total factor productivity is obtained by substituting the coefficients in equation (18) into the production function:

$$TFP_{i,t} = rva_{i,t} - \theta^k k_{i,t} - \theta^l l_{i,t} \quad (19)$$

Figure 15 shows that our TFP measure from macro data is remarkably in tune with the TFP calculated with microdata.[15]

6. POTENTIAL OUTPUT

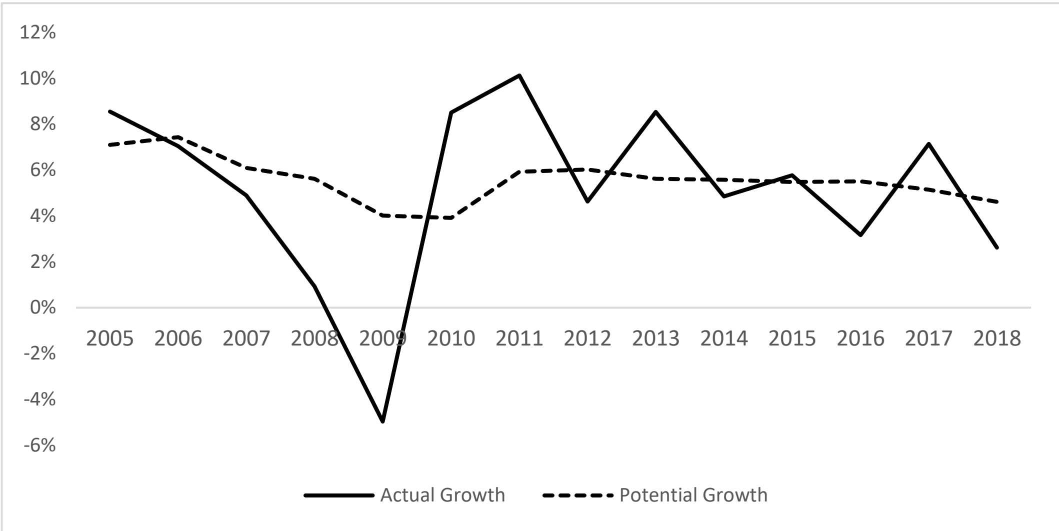
6.1. Potential Output Growth

The path of the potential output growth for the period between 2005 and 2018 exhibits a slightly volatile pattern (Figure 16). It shows that the potential growth rate for Turkey vacillates between 3.9 percent and almost 7.3 percent, suggesting a rate of 5.5 percent on average. The potential growth is at its maximum in 2006 and then declines rapidly to its minimum level in 2010. After 2014, the potential growth diminishes in 5 consecutive years, indicating the variability of potential output in Turkey. These findings are in line with Saygılı and Cihan (2008) and Andıç (2018), stating that the potential growth for Turkey is around 5 percent, for the periods 2002-2007 and 2005-2016, respectively.

A glance at the series indicates the decline in the growth rate during the great recession. The fall in the growth rate starts in 2007 before the severity of the crisis became pervasive on a global scale. Arguably, the eruption of the Global Financial Crisis in 2008 accelerated an already declining tendency in potential growth. In many advanced countries, potential growth hit its minimum during the crisis, and it took a couple of years to recover for them. The rapid recovery of Turkey's potential growth in 2011 suggests that growth dynamics and expansionary policies were strong enough to recover not only the actual but also the potential growth rate. The findings in this paper do not support those of IMF (WEO, April 2018), which states that the potential growth rates in large emerging markets immediately start to decline after 2011[16]. The findings also indicate that the path of the potential output growth in Turkey

[15] The gradually declining TFP growth confirms the findings in World Bank (2019).
[16] The markets in the analysis include Turkey, Brazil, India, Russia, and Mexico.

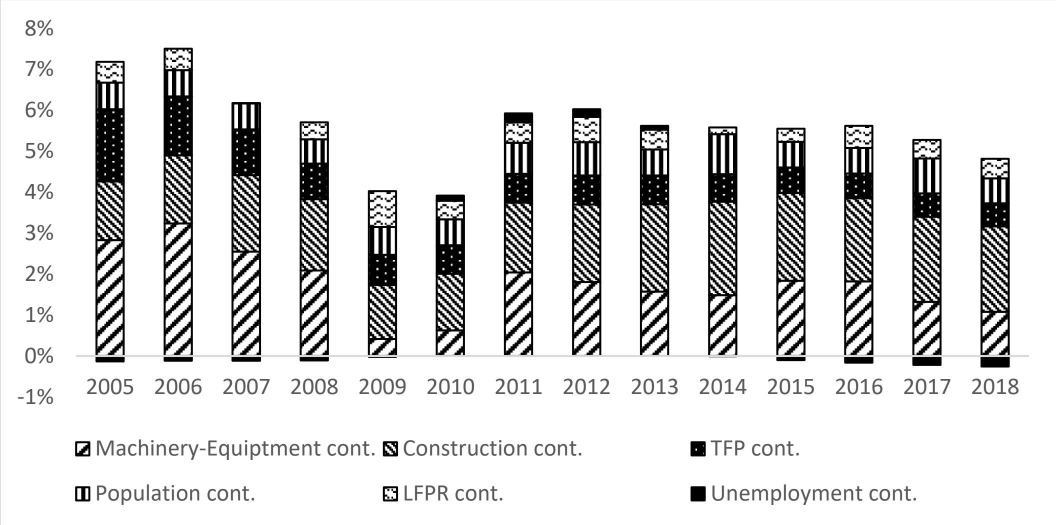
Figure 16: Actual and Potential Growth



recovered earlier than its biggest trade partners since it is documented that it was by 2013 that the potential output growth in the Euro area started to increase again.

The decomposition of the potential growth into its components in Figure 17 indicates that capital accumulation is the main driving force of the potential output. Within the capital's contribution, there has been a significant transformation. Over time, the share of building and construction increased as the machinery and equipment growth slowed down. The contribution coming from total factor productivity diminishes towards a rate of around 0.5 percent in recent years. A decline in the contribution of technological growth could be a sign of weakening performance in automation, innovation, adaptation, and resource allocation, given that export growth, diversification, and human capital continue advancing. The contribution from labor follows a volatile pattern and returns to its 2005 level in 2018. Population growth is the main factor behind the contribution of labor and it is followed by the contribution coming from changes in labor force participation rate. An increase in unemployment above its trend is the last part of labor's contribution and its increase above the trend level makes a negative contribution to potential growth. It is seen that after 2014, unemployment makes a negative contribution to potential growth.

Figure 17: Contributions to Potential Growth



Notes: The figure shows the factor contributions to the potential growth. The main driver is capital accumulation while its composition shifts towards construction in the last decade. TFP contribution is in a decreasing trend while the total labor contribution is somewhat steady during the period.

6.2. Output Gap

Deviations of potential output from the actual are referred to as the output gap, a metric widely used in monetary policy for tracking the economy's position in the business cycle. Therefore each potential growth series implies a trajectory for the output gap. Since the potential output metric is an index, translating the potential output to the output gap requires having a reference point where we know the output gap. We resolve this issue in two stages. Even though potential output is an index by construction, one of the inputs we allow to fluctuate due to business cycles is labor, for which we have a nominal potential figure. Therefore focusing on the time where potential and actual labor meets pins down a reference point where potential output equals actual output, i.e. the output gap is zero. This would be always true if the growth residual were equal to TFP. However, we assume that the residual term is also subject to short-term fluctuations, and our TFP measure is the trend of the residual term. Therefore we need an assumption for when both the employment gap and the output gap are the same. After experimenting with several reference points, we take 2008 as the year where output gap is zero. Our choice is in line with the gap reported in past inflation reports and several studies that compute the output gap with alternative methods.

Figure 18: Output Gap

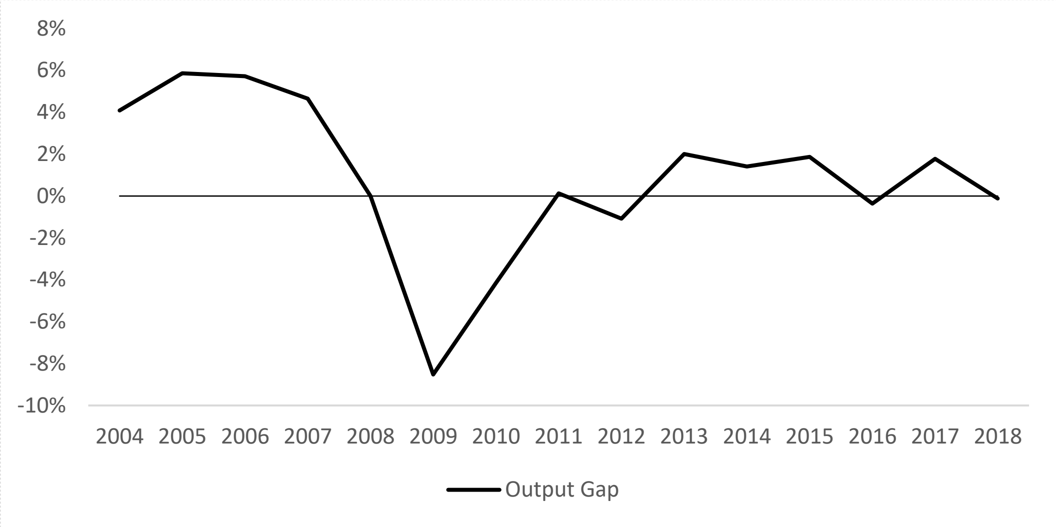
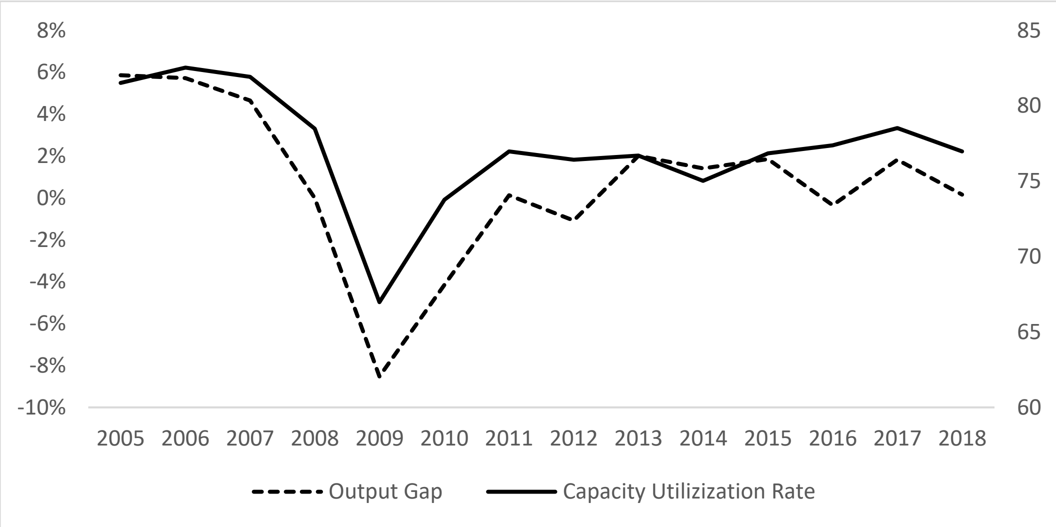


Figure 19: Output Gap and Capacity Utilization Rate



Notes: The output gap is on the left axis and the capacity utilization rate is on the right. The positive output gap before the financial crisis is in line with the high capacity utilization rate during the same period and the two portray similar trends throughout the period.

The resulting gap series in Figure 18 shows the deviation of actual GDP from potential in percentages. We observe a large positive output gap before 2008, a drastic fall during the great recession, and a positive gap around 2 percent between 2012 and 2016. A comparison of our output gap with recent studies estimating it for Turkey suggests that our results are most similar to Coşar (2018) who uses several direct measures for economic activity which are in close association with business cycles and inflation. A notable difference of our series is that it looks more amplified in terms of the size of the gap in both directions.[17]

The second difference, when compared to other available measures, is that our gap series indicate remarkably higher slack for the years before 2007. This could be an artifact of our decision of choosing 2008 as the reference year such that greater potential growth than actual inevitably results in a positive gap before 2008. A first explanation might point to a possible overestimation of TFP growth for the period. A residual measure of productivity invites concerns for measurement error whether calculated with macro or firm-level data. However, counterfactual exercises indicate that significant TFP decline for the period is in fact necessary to achieve an output gap around zero for the years 2005 to 2007 which is suggested by other studies taking inflation into account in their output gap measurement. Such negative TFP growth would be at odds with the existing evidence.

An alternative and more plausible explanation can be based on the overvaluation in the Turkish Lira in that period due to the abundance of international capital flows, enabling inflation rates that are comparable to post great recession times despite the large slack in economic activity. A supportive, simple, and direct evidence is provided by the capacity utilization rates as the series has its peak in the pre-2008 period and remained significantly low afterward, similar to the behavior of the output gap (Figure 19).

7. CONCLUSION

This study provides a detailed account of the sources in potential growth and their trends in Turkey in a simple framework. Based on a realistic estimation of potential growth and its elements, our key finding reveals that the primary policy objective to sustain income convergence in Turkey has to be that of boosting TFP growth. Notwithstanding increasing access to education, continuing expansion and diversification of trade, this striking observation calls for further investigation on the drivers of TFP dynamics in Turkey. While capital accumulation is the essential driver of potential growth, we fail to find strong evidence on unsustainability purely reflected through the capital’s contribution. Our results suggest

[17]The evolution of the gap is also similar to that derived from the HP-filtered annual output series.

that for Turkey, it is difficult to draw a straight line from credit growth to sustainability using adjusted versions of potential growth (hence output gap) as a tool.

On the labor front, we observe that increasing labor force participation, together with population growth, is a substantial contributor to potential output growth. However, the decline in the latter as a result of aging also exerts a negative influence on the former. Despite the strange dynamics of population, secular trends, most notably education, has a clear and sizable impact on the potential labor growth. Our analysis reveals an overlooked effect of education through participation.

This analysis can be used as a basis and extended in many directions. Firstly, by incorporating a multi-sector approach, which can be fruitful in terms of understanding potential growth in Turkey—an economy with a large room for structural transformations. Second, the analysis could benefit from incorporating financial frictions, again highly relevant for an economy characterized by credit constraints at the firm and household level. Third, more sophisticated treatment of trend unemployment through estimation of NAIRU can be more fruitful at the quarterly frequency. Fourth, there is ample room for the measurement of inputs, and hence the refinement of TFP by carefully measuring the quality of labor and capital once the data on hours of work and more asset types, including intangibles, are continuously available. Lastly, a challenge for the current estimates of potential growth seems to be the handling of the extreme sequence of macroeconomic observations such as those recorded during the COVID-19 (Del Negro et al., 2020; Lenza and Primiceri, 2020; Primiceri and Tambalotti, 2020).

APPENDIX

In the estimation of potential TFP, we rely on annual data. We have a short sample, and hence quite limited degrees of freedom on the one hand, and varying options across and within smoothing techniques for estimating the trend component of TFP on the other. While most researchers have followed Hodrick and Prescott (1997) and used 1600 for the smoothing parameter when using quarterly data, there is less agreement in the literature when moving to other frequencies. Backus and Kehoe (1992) use a value of 100 for annual data, while Correia et al. (1992) and Cooley and Ohanian (1991) suggest a value of 400. Baxter and King (1999) have shown that the smoothing parameter value of 10 for annual data is much more reasonable. Ravn and Uhlig (2002) show how the HP-filter should be adjusted when changing

Appendix Table 1:

	Data (1)	Hamilton (2)	HP-6.25 (3)	HP-10 (4)	HP-100 (5)
Time trend	0.74***	0.14	0.73***	0.73***	0.80***
	(0.12)	(0.13)	(0.05)	(0.04)	(0.02)
CUR	0.84***	0.02	0.18***	0.13***	-0.03
	(0.06)	(0.24)	(0.04)	(0.03)	(0.02)
CUR(-1)	0.08	0.36	0.15**	0.12***	-0.01
	(0.1)	(0.18)	(0.05)	(0.04)	(0.01)
R^2	0.87	0.37	0.83	0.97	0.99

Notes: Number of observations is 13 in each specification. Robust standard errors in parantheses. *, **, *** denote significance at 10, 5, and 1 percent.

the frequency observations, complementing the results of Baxter and King (1999) with an analytical analysis. They suggest an adjustment of the filter parameter by multiplying it with the fourth power of the observation frequency ratios, yielding an HP parameter value of 6.25 for annual data given the parameter value of 1600 for quarterly data.

After numerous experiments, we decide to choose the HP filter with smoothing parameter 100 for estimating the potential TFP. The reason is that, while others cannot, it satisfies a simple and intuitive criterion: The trend estimate should positively correlate to the simple time trend without being cyclical. All in all, these are the desired properties of a TFP trend.

To this end, we produce an array of trend series and assess the contemporaneous partial correlation of these series with time trend, a cycle variable, and its lag. We do not want to complicate this test further by using a cycle measure, such as the unemployment gap, which is a product of another smoothing technique. In this respect, the capacity utilization rate (CUR) is an ideal candidate. Columns (1) to (5) of Appendix Table 1 report the OLS results for, respectively, the raw data, Hamilton filter, HP filter with smoothing parameter 6.25, 10, and 100. The raw data in column (1) confirms a positive sloped time trend and strong cyclicality as expected. Only the HP filter with smoothing parameter 100 passes our test. The Hamilton Filter lacks a significant time trend, and small smoothing parameters of the HP Filter are pro-cyclical.

REFERENCES

Aaronson, S., B. Fallick, A. Figura, J. Pingle and W. Wascher (2006). The recent decline in the labor force participation rate ant its implications for potential labor supply. *Brooking Papers on Economic Activity 37*(1), 69-134

Aaronson, D., F. Lange, and B. Mazumder (2014). Labor force participation: recent developments and future prospects. *Brookings Papers on Economic Activity 45*(2), 197-275.

Aguiar, M. and G. Gopinath (2007). Emerging market business cycles: The cycle is the trend. *Journal of Political Economy*, *115(1)*, 69-102.

Akçay, C. and E. Ocakverdi (2011). (Never) Mind the gap: A modest contribution to potential output estimation for Turkey. *Yapi Kredi Occasional Macro Notes*.

Akkoç, U. (2018). Recent measurement methods of the output gap: An application for Turkey. *Current Debates in Economics and Econometrics 2(1)*, 357-376.

Alberola, E., A. Estrada, and D. Santabárbara (2013). Growth beyond imbalances. Sustainable growth rates and output gap reassessment. *Banco de España Working Paper No. 1313*.

Albert, M., J. Cristina, and C. Rebillard (2015). The long landing scenario: Rebalancing from overinvestment and excessive credit growth. Implications for Potential Growth in China. *Banque de France Working Paper No. 572* .

Alichi, A. (2015). A new methodology for estimating the output gap in the United States. *IMF Working Paper No. 15/144.*

Alp, H., F. Öğünç and Ç. Sarikaya (2012). *Monetary policy and output gap : Mind the composition*. *CBRT Research Notes in Economics No. 1207.*

Alp, H., Y.S. Başkaya, M. Kılınç, and C. Yüksel (2011). Estimating optimal Hodrick-Prescott Filter smoothing parameter for Turkey. *Iktisat Isletme ve Finans 26(306)*, 09-23.

Anderton, R., T. Aranki, A. Dieppe, C. Elding, S. Haroutunian, P. Jacquinot, V. Jarvis, V. Labhard ,D. Rusinova, D, and B. Szörfi (2014). Potential output from a Euro Area perspective. *European Central Bank Occasional Paper No. 156.*

Andıç Başer, S. (2018). Multivariate filter for estimating potential output and output gap in Turkey. *CBRT Working Papers No. 1807.*

Andıç, S.(2016). *On estimation of the normalized CES production function for Turkey. CBRT Working Papers No. 1613.*

Antolin-Diaz, J., T. Drechsel, and I. Petrella (2017). Tracking the slowdown in long-run GDP growth. The Review of Economics and Statistics *99(2)*, 343-356.

Arpaia, A., E. Pérez, and K. Pichelmann (2009). Understanding labour income share dynamics in Europe. *European Commission-Economic Papers 2008 - 2015 No. 379*.

Aytaç, A. (2015). Output gap estimatıon for the case of Turkey. *Bilkent University*

Backus, D. and P. J. Kehoe (1992). International real business cycles. *Journal of Political Economy 100*(4), 745-775.

Bağır, Y.K., and Torun, H. (2019). Export competition among Turkish firms. *CBRT Research Notes in Economics 20/03.*

Barnett, R., K. Sharon, and C. Petrinec (2009). Parsing shocks: real-time revisions to gap and growth projections for Canada. *Review, Federal Reserve Bank of St. Louis 91(4),* 247-266.

Basistha, A. and R. Startz (2008). Measuring the NAIRU with reduced uncertainty: A multiple-indicator common-cycle approach. *Review of Economics and Statistics 90(4)*, 805-811.

Baxter, M. and R. King (1999). Measuring business cycles: Approximate band-pass filters for economic time series. *Review of Economics and Statistics 81*(4), 575-93.

Benes, J., K. Clinton, R. Garcia-Saltos, M. Johnson, D. Laxton, P. Manchev, and T. Matheson (2010). Estimating potential output with a multivariate filter. *IMF Working Papers No. 10/285*.

Billmeier, A. (2009). Ghostbusting: which output gap really matters? *International Economics and Economic Policy 6(4)*, 391-419.

Blagrave, P., R. Garcia-Saltos, D. Laxton, and F. Zhang (2015). A simple multivariate filter for estimating potential output. *IMF Working Papers No. 15/79*.

Blanchard, O. J. and D. Quah (1989). The dynamic effects of aggregate demand and supply disturbances. *American Economic Review 79(4)*, 655-673.

Borio, C., F. P. Disyatat, and M. Juselius (2013). Rethinking potential output: Embedding information about the financial cycle. *BIS Working Papers No. 404*.

Bry, G., & Boschan, C. (1971). Cyclical analysis of time series: Selected procedures and computer programs. *National Bureau of Economic Research.*

Bundesbank (2014). *On the reliability of international organizations' estimates of the output gap*. *Deutsche Bundesbank Monthly Report April 2014.*

Burns, A., T. J. Van Rensburg, K. Dybczak, and T. Bui (2014). Estimating potential output in developing countries. *Journal of Policy Modeling 36(4)*, 700-716.

Cahn, C. and A. Saint-Guilhem (2010). Potential output growth in several industrialized countries: A comparison. *Empirical Economics 39(1),* 139-165.

Caselli, F. (2005). Accounting for cross-country income differences. *In Handbook of Economic Growth*, Volume 1A, pp. 679-741. Elsevier.

Clark, Peter K. (1987). The cyclical component of U.S. economic activity. *Quarterly Journal of Economics 102(4)*, 797-814.

Cogley, T. and T. J. Sargent (2005). Drift and volatilities: Monetary policies and outcomes in the post WWII U.S. *Review of Economic Dynamics 8*(2), 262-302.

Congressional Budget Office (2001). CBO's method for estimating potential output: An update. *Congressional Budget Office.*

Cooley, T. F. and L. E. Ohanian (1991). The cyclical behavior of prices. *Journal of Monetary Economics 28*(1), 25-60.

Corrado, C., C. Hulten, and D. Sichel (2006). Intangible capital and economic growth. *Federal Reserve Board Finance and Economics Discussion Series No. 2006–24*.

Correia, I. H., J. J. Neves, and S. Rebelo (1992). Business cycles from 1850 to 1950: New facts about old data. *European Economic Review 36*(2-3), 459-67.

Coşar, E. E. (2018). A revised direct output gap measure for the Turkish economy. CBRT Working Paper No. 1804.

Coşar, E. E., S. Kösem, and Ç. Sarıkaya (2013). Do we really need filters In estimating output gap? : Evidence from Turkey. *CBRT Working Paper No. 1333* .

Cotis, J. P., J. Elmeskov, and A. Mourougane (2004). Estimates of potential output: benefits and pitfalls from a policy perspective. *The euro area business cycle: stylized facts and measurement issues, Centre for Economic Policy Research*, 35-60.

Çakır, E. and O. Sevinc (2020). Rising labor share in Turkey. *Unpublished*.

D'Auria, F., C. Denis, K. Havik, K. McMorrow, C. Planas, R. Raciborski, W. Röger, and A. Rossi (2010). The production function methodology for calculating potential growth rates and output gaps. *European Commission Economic Papers No. 420.*

Del Negro, M, M. Lenza, G. Primiceri, and A. Tambalotti (2020). What's up with the inflation and the business cycles after the COVID-19 shock? *Northwestern University Working Paper.*

Demiroğlu, U. (2012). The capital stock and an index of capital services in Turkey. *CBRT Research Notes in Economics 12/26.*

Demiroğlu, U. (2015). Calculating a country's capital input: A review, and calculations for the Turkish capital stock. *Iktisat Isletme ve Finans 30(347), 69-94.*

Denis, C., D. Grenouilleau, K. Mc Morrow, and W. Röger (2006). Calculating potential growth rates and output gaps - A revised production function approach. *European Commission Economic Papers No. 247.*

Denis, C., K. McMorrow, and W. Röger (2002). Production function approach to calculating potential growth and output gaps – estimates for the EU Member States and the US. *European Commission Economic Papers No. 176.*

Dermoune, A., B. Djehiche, and N. Rahmania (2008). A consistent estimator of the smoothing parameter in the Hodrick-Prescott filter. *Journal of the Japan Statistical Society 38*(2), 225-241

Dovern, J and C. Zuber (2019). Recessions and potential output: Disentangling measurement errors, supply shocks, and hysteresis effects. *The Scandinavian Journal of Economics*

Elsby, M., B. Hobijn, and A. Sahin (2013). The decline of the U.S. labor share. *Brookings Papers on Economic Activity 47*(2), 1–63.

Feenstra, R. C., R. Inklaar, and M. P. Timmer (2015). The next generation of the Penn World Table. *American Economic Review, 105*(10), 3150-3182.

Felipe, J. and J. Mc Combie (2020). The illusions of calculating total factor productivity and testing growth models: From Cobb-Douglas to Solow and to Romer. *Journal of Post Keynesian Economics 43*(3), 470-513.

Gordon, R. J. (2014). A new method of estimating potential real GDP growth: Implications for the labor market and the debt/GDP ratio. National Bureau of Economic Research Working Papers No. 20423.

Guisinger, A. Y., M. T. Owyang, and H. Shell (2018). Comparing measures of potential output. *Review, Federal Reserve Bank of St. Louis 100*(4), 297-316.

Gutiérrez, G. And S. Piton (2020). Revisiting the global decline of the (non-jousing) labor share. *American Economic Review: Insights 2*(3), 321-338.

Hall, R. E. and C. I. Jones (1999). Why do some countries produce so much more output per worker than others? *Quarterly Journal of Economics 114*(1), 83-116.

Hamilton, J. D. (2018). Why you should never use the Hodrick-Prescott filter. *The Review of Economics and Statistics 100*(5), 831-843.

Harvey, A. (1990). Forecasting, structural time series models and the Kalman Filter. *Cambridge University Press.*

Havik, K., K. Mc Morrow, F. Orlandi, C. Planas, R. Raciborski, W. Roeger, A. Rossi, A. Thum-Thysen, and V. Vandermeulen (2014). The production function methodology for calculating potential growth Rates & Output Gaps. *European Commission Economic Papers No. 535.*

Hodrick, R. J. and E .Prescott (1981). Post-War U.S. business cycles: An empirical investigation. *Journal of Money, Credit and Banking 29*(1), 1-16.

Hodrick, R. J., and E.C. Prescott (1997). Post-War U.S. business cycles: An empirical investigation. *Journal of Money, Credit and Banking 29*(1), 1-16.

Hulten, C., and C. F. Wykoff (1981). Depreciation, inflation, and the taxation of income from capital. In The Measurement of Economic Depreciation, 81–125.

International Monetary Fund (2015). World Economic Outlook April 2015. *International Monetary Fund.*

International Monetary Fund. (2018). World Economic Outlook April 2018. *Washington, DC: International Monetary Fund*.

Kaiser, R. and A. Maravall (2004). Combining filter design with model based filtering (with an application to business cycle estimation). *Banco de España Working Paper No. 0417.*

Kaiser, R. and A. Maravall (2005). Combining filter design with model-based filtering (with an application to business-cycle estimation). *International Journal of Forecasting 21*(4), 691-710.

Kara, H., F. Öğünç, Ü. Özlale, and Ç. Sarıkaya (2007). Estimating the output gap in a changing economy. *Southern Economic Journal 74*(1), 269-289 .

Karabarbounis, L. and B. Neiman (2014). The global decline of the labor share. *The Quarterly Journal of Economics 129*(1), 61–103.

Kawamoto, T., O. Tatsuya, N. Kato and K. Maehashi (2017). Methodology for estimating output fap and potential growth eate: An update. *Bank of Japan Research Papers 17-05-31.*

Kim, C-J. and C. R. Nelson (1999). Has the U.S. economy become more stable? A Bayesian approach based on A Markov-Switching model of the business cycle. *The Review of Economics and Statistics 81*(4), 608–616.

Klump, R., P. McAdam, and A. Willman (2007). Factor substitution and factor augmenting technical progress in the US. *Review of Economics and Statistics 89*(1), 183–92.

Koh, D., R. Santaeulàlia-Llopis, and Y. Zheng (2019). Labor share decline and intellectual property products capital. *Econometrica Forthcoming*

Kudlyak, M. (2013). A Cohort Model of labor force participation. *Economic Quarterly, Federal Reserve Bank of Richmond 89*(1), 25-43.

Lancaster, D and P. Tulip (2015). Okun's law and potential output. *Reserve Bank of Australia Research Discussion Papers No. 2015-14* .

Lanzafame, M. (2016). Potential growth in Asia and its determinants: An empirical investigation. *Asian Development Review* 33(2), 1–27.

Lenza, M. and G. Primiceri (2020). How to estimate a VAR after march 2020. *CEPR Discussion Papers No. 15245.*

Macroecononomic Advisers (2000). *Washington University Macro Model (WUMM) 2000 Model Book*, Washington: St Louis.Matheny.

Matheny, K. J. (2009). Trends in the aggregate labor force. *Review, Federal Reserve Bank of St. Louis, 91*(4)*,* 297-310.

McMorrow, K., R. Raciborski, W. Roeger, and V. Vandermeulen (2015). An assessment of the relative quality of the EU output gap estimates. *Quarterly Report on the Euro Area 14*(3), 19-28.

Metin-Özcan, K., Ü Özlale, and Ç. Sarıkaya (2006). Sources of growth and the output gap for the Turkish economy. *In Explaining Growth in the Middle East,* 237-266.

Morley, J., C. Nelson, and E. Zivot (2003), Why are the Beveridge-Nelson and unobserved-components decompositions of GDP so different? *The Review of Economics and Statistics 85*(2), 235-243.

Mumtaz, H., & K. Theodoridis (2020). Dynamic effects of monetary policy shocks on macroeconomic volatility. *Journal of Monetary Economics 114*.

OECD(2001). Measuring capital: OECD manual. Measurement of capital stocks, consumption of fixed capital and capital services.

Öğünç, F. and D. Ece (2004). Estimating the output gap for Turkey: an unobserved components approach. *Applied Economics Letters 11*(3) pages 177-182.

Öğünç, F., Ç. Sarikaya (2011). Gorunmez ama hissedilmez degil: Turkiye'de çikti acigi. *Central Bank Review, 11*(2), 15-28.

Ollivaud, P. and D. Turner (2015). The effect of the global financial crisis on OECD potential output*. OECD Journal: Economic Studies 2014*(1), 41-60.

Ollivaud, P., G. Yvan, and D. Turner (2016). Links between weak investment and the slowdown in productivity and potential output growth across the OECD. *OECD Economics Department Working Papers No. 1304.*

Özbek, L. and Ü. Özlale (2005). Employing the extended Kalman filter in measuring the output gap. *Journal of Economic Dynamics and Control 29*(9), 1611-1622.

Özbek, L. and Ü. Özlale (2008). Analyzing time-varying effects of potential output growth shocks. *Economic Letters 98(3),* 294-300.

Pedersen, T. M. (2001). The Hodrick-Prescott filter, the Slutzky effect, and the distortionary effect of filters. *Journal of Economic Dynamics and Control 25*(8), 1081-1101.

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 No. 2015-1.*

Planas, C. and A. Rossi (2004). Program GAP technical description and user-manual. *Publications Office of the European Union.*

Primiceri, G. (2005). Time varying structural vector autoregressions and monetary policy. *The Review of Economic Studies 72*(3), 821-852.

Primiceri, G. and A. Tambalotti (2020). Macroeconomic forecasting in the Time of COVID-19. *Northwestern University Working Paper.*

Ravn, M. O. and H. Uhlig (2002). On adjusting the Hodrick-Prescott filter for the frequency of observations. *Review of Economics and Statistics 84*(2), 371-376.

Rosnick , D. (2016). Potential for trouble: The IMF's estimates of potential GDP. *Center for Economic and Policy Research Reports and Issue Briefs No. 2016-08*.

Saraçoğlu, B., Ö. Yiğit, and N. A. Koçak (2014). Alternative methods Of estimating output gap for Turkey. *Business and Economics Research Journal 5*(3), 43-65.

Saygılı, Ş., C. Cihan (2008). Türkiye ekonomisin büyüme dinamikleri – 1987-2007 döneminde büyümenin kaynakları, temel sorunlar ve potansiyel büyüme oranı. *TÜSİAD Ekonomik Araştırmalar Bölümü Yayınlar.ı*

Sekkat, K. (2007). Sources of growth in Morocco: An emperical analysis in a regional perspective. *Review of Middle East Economics and Finance 2*(1) 1-17.

Senhadji, A. (2000). Sources of economic growth: An extensive growth accounting exercise. *IMF Staff Papers 47*(1), 129-157.

Shackleton, R. (2018). Estimating and projecting potential output using CBO's forecasting growth model. *Congressional Budget Office Working Paper No. 53558.*

Smets, F. and R. Wouters (2007). Shocks and frictions in US business cycles: A bayesian DSGE approach. *American Economic Review 97*(3), 586-606.

Üngör, M. (2012). A production function method of estimating the output gap. *CBRT Research Notes in Economics No. 1219.*

Watson, M. W. (1986). Univariate detrending methods with stochastic trends. *Journal of Monetary Economics 18*(1), 49-75.

World Bank (2019), Firm productivity and economic growth in Turkey. *World Bank Productivity Report 2019*

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**)

Cost of Credit and House Prices
(Yusuf Emre Akgündüz, H. Özlem Dursun-de Neef, Yavuz Selim Hacıhasanoğlu, Fatih Yılmaz Working Paper No. 21/06, March 2021)

External Vulnerabilities and Exchange Rate Pass-Through: The Case of Emerging Markets
(Abdullah Kazdal, Muhammed Hasan Yılmaz Working Paper No. 21/05, February 2021)

The Impact of Oil Price Shocks on Turkish Sovereign Yield Curve
(Oğuzhan Çepni, Selçuk Gül, Muhammed Hasan Yılmaz, Brian Lucey Working Paper No. 21/04, February 2021)

Decomposition of Bank Loans and Economic Activity in Turkey
(Hande Küçük Yeşil, Pınar Özlü, Çağlar Yüncüler Working Paper No. 21/03, February 2021)

The Role of Expectations in the Inflation Process in Turkey: Have the Dynamics Changed Recently?
(Ümit Koç, Fethi Öğünç, Mustafa Utku Özmen Working Paper No. 21/02, February 2021)

Consequences of a Massive Refugee Influx on Firm Performance and Market Structure
(Yusuf Emre Akgündüz, Yusuf Kenan Bağır, Seyit Mümin Cılasun, Murat Günay Kırdar Working Paper No. 21/01, January 2021)

Do Household Consumption and Saving Preferences Vary Between Birth-Year Cohorts in Turkey?
(Evren Ceritoğlu Working Paper No. 20/15, October 2020)

Credit Decomposition and Economic Activity in Turkey: A Wavelet-Based Approach
(Oğuzhan Çepni, Yavuz Selim Hacıhasanoğlu, Muhammed Hasan Yılmaz Working Paper No. 20/14, October 2020)

Do Investment Incentives Promote Regional Growth and Income Convergence in Turkey?
(Hülya Saygılı Working Paper No. 20/13, October 2020)

An Analysis of International Shock Transmission: A Multi-level Factor Augmented TVP GVAR Approach
(Bahar Sungurtekin Hallam Working Paper No. 20/12, October 2020)

Synchronization, Concordance and Similarity between Business and Credit Cycles: Evidence from Turkish Banking Sector
(Mehmet Selman Çolak, Abdullah Kazdal, Muhammed Hasan Yılmaz Working Paper No. 20/11, October 2020)

Identification of Wealthy Households from the Residential Property Price Index Database for Sample Selection for Household Surveys
(Evren Ceritoğlu, Özlem Sevinç Working Paper No. 20/10, October 2020)

Corporate Debt Maturity, Repayment Structure and Monetary Policy Transmission
(Hatice Gökçe Karasoy Can Working Paper No. 20/09, May 2020)

Detecting the Position of Countries in Global Value Chains Using a Bilateral Approach
(Oğuzhan Erdoğan Working Paper No. 20/08, May 2020)

A Measure of Turkey's Sovereign and Banking Sector Credit Risk: Asset Swap Spreads
(Abdullah Kazdal, Halil İbrahim Korkmaz, Doruk Küçüksaraç, Yiğit Onay Working Paper No. 20/07, May 2020)

Nowcasting Turkish GDP Growth with Targeted Predictors: Fill in the Blanks
(Mahmut Günay Working Paper No. 20/06, May 2020)