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Aggregate and Sectoral TFP Growth in Turkey: A Growth Accounting Exercise[*]

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Abstract.
This paper undertakes a growth accounting exercise for the Turkish economy. At the aggregate level, we find that total factor productivity growth (TFP) has been quite respectable in the last decade, both in comparison to earlier decades as well as in international comparison. In fact, it is higher growth in aggregate TFP, rather than higher growth in factor inputs, that accounts for higher GDP growth in the 2000s. The paper also derives TFP at the sectoral (agriculture, industry and services) level. We find that in the last decade TFP growth has been relatively high in all three sectors, with the greatest contrast appearing in agriculture. The 2000s was unique in the sense that this was the only decade since the 1970s where TFP growth in agriculture was not only positive but also higher than industry and services. This high TFP growth in agriculture seems to have ended in recent years.
Keywords: *Growth Accounting; Total Factor Productivity.*
JEL Classification: *O40, O47.*

Özet. Türkiye'de Toplam ve Sektörel Toplam Faktör Verimliliği Büyüme Hızları: Bir Büyüme Muhasebesi Çalışması
Bu çalışmanın amacı Türkiye ekonomisinde büyümenin kaynaklarını büyüme muhasebesi yaklaşımı ile incelemektir. Bu amaçla hem tüm ekonomi hem sektörel düzeyde veriler kullanılmıştır. Tüm ekonomi gözönüne alındığında son on yıllık süreçte toplam faktör verimliliğinin (TFV) hem daha önceki dönemlere hem de uluslararası karşılaştırmalara kıyasla önemli artış gösterdiği görülmektedir. Hatta 2000li yıllarda gözlemlenen yüksek milli gelir artışının ardında esas olarak üretim faktörlerindeki artışın değil, TFV'ndeki artışın yattığı ortaya çıkmaktadır. Tarım, sanayi ve hizmetler olmak üzere üç ana sektörde TFV hesaplanmış ve özellikle tarım sektörünün zaman içinde büyük değişim gösterdiği tespit edilmiştir. Tarımdaki TFV artışı 1970'lerden beri ilk defa 2000'li yıllarda pozitif olmakla kalmayıp sanayi ve hizmetlerdeki TFV artışından daha yüksek gerçekleşmiştir. Öte yandan tarım sektöründeki bu hızlı TFV artışının dönemin son yıllarında sona erdiği de görülmektedir.
Anahtar Kelimeler: *Büyüme Muhasebesi; Toplam Faktör Verimliliği.*
JEL Sınıflaması: *O40, O47.*

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1) Introduction

The policy regime governing economic activities in Turkey has changed radically since the early 1980s. Starting in 1980, Turkey left an import substitution industrialization strategy and embarked on a more market-oriented economic policy regime. The 1990s have been characterized by significant macroeconomic instability and highly volatile (and overall rather poor) growth performance. By contrast economic growth has been higher and more persistent in the last decade. The purpose of this study is to undertake a simple growth accounting exercise to deepen our understanding of this contrasting growth performance in the last three decades. We attempt to make two contributions: First, we would like to adopt an internationally comparative perspective to be able to better appreciate the comparative performance of the Turkish economy. Second, we would like to carry out the growth accounting exercise at the sectoral level to document the contribution of productivity growth in agriculture, industry and services.

A growth accounting exercise allows us to decompose aggregate economic growth into growth of factor inputs, namely capital and labor, and growth in a residual term, which is often called total factor productivity (TFP). TFP growth (TFPG) represents that portion of growth not explained by the growth of factor inputs. It is expected to capture various forms of externalities and overall improvements in the organization of production keeping inputs constant.[1] As emphasized by Caselli (2005), economies may be suffering from misallocation of resources such that marginal products of inputs are not equalized. Improvements in the allocation of resources may also be captured by increases in TFP.

Several studies have undertaken growth accounting exercises for Turkey before. Altug et. al. (2008) examines sources of growth for the period 1880-2005. For the entire 1950-2005 period, Altug et. al find that TFPG in Turkey is relatively low, slightly above 1 percent. Saygili and Cihan (2008) study the period 1987-2007. They find that while the contribution of TFP growth to aggregate growth is relatively low until 2000-2001, it is relatively higher for the period 2002-2007. Ismihan and Ozcan (2009) also find that the contribution of TFPG to overall growth is higher in 2000-2004 relative to earlier periods. These studies do not carry out any international comparisons, which is one of the contributions of the present study. It turns out that TFP growth in Turkey in the last decade is quite respectable in international comparison.

Another interesting result of the paper is that TFPG in the 2000s is consistently higher than TFPG in the 1990s. In order to further understand the nature of TFPG in the 2000s, the paper then investigates TFP growth at the sectoral level (agriculture, industry and services). Our findings indicate

1 See Bakis et al. (2011) for evidence on human capital spillovers in Turkey.

that the TFPG in agriculture and services was either very low or negative (in the case of services) until 2000s. The last decade is very special in that for the first time since 1970s, we observe an average TFPG above 1.4 % in all 3 sectors for the first time (considering the Solow definition of TFP). Also, in the 2000s, for the first time since the 1970s the average TFPG in agriculture is higher than the TFPG in industry and services. We suspect that high TFPG in agriculture is associated with reallocation of underemployed labor away from agriculture into services and manufacturing. Hence according to this interpretation, high TFPG recorded in the 2000s is driven primarily by improvements in the allocation of labor rather than technological change per-se or increased externalities associated with, for example, growth in R&D expenditures. Since the share of agriculture in total GDP was relatively low in the 2000s (about 10 percent on average) the contribution of the relatively high growth rates of agricultural TFP to total TFP growth has still been limited. Among the papers cited above, Altug et al. looks at TFPG at the sectoral level (agriculture and non-agriculture). For the period 1980-2005, they find that it is TFPG in the non-agricultural sector that makes the largest contribution to overall growth. Saygili et al. (2005) study both aggregate and sectoral TFP in Turkey for 1972-2003 period. Our main contribution to this paper is adding 2003-2011 period, characterized by structural changes, and better economic performance, to the TFP analysis. Our findings are in parallel with their sectoral TFP trends for 1972-2003 period. Those paper do not consider how sectoral contributions differ across 1990s and 2000s (and also within 2000s with a special attention to the agriculture sector), which is one of the main concerns in our paper.

It should be noted that calculating TFPG is typically plagued with measurement problems. As indicated by Solow, TFPG calculated as the residual of a growth accounting exercise is also “a measure of our ignorance” since it may reflect not only technology but also other factors affecting growth that the accounting exercise does not control for. In this paper we carry out a number of robustness checks to account for some of these problems. The main conclusion that TFPG in the 2000s is higher than earlier periods survives these checks. Nevertheless, given possible data problems that have not been addressed, the results should still be evaluated with care.

The paper is organized as follows. The next section outlines the basic approach for growth accounting and calculating aggregate and sectoral TFPG rates. Section 3 discusses some methodological issues that arise in the calculation of capital, labor and investment. Section 4 discusses the data used in the analysis and presents the results. Section 5 concludes.

2) Estimating TFP

There are two main approaches to estimating the contribution of TFP to economic growth. The primal approach uses data on factor shares, factor inputs and outputs to calculate productivity growth. The dual approach, by contrast, uses data on output, factor shares and factor prices. When social marginal products are equal to factor prices, the two approaches yield identical results. We have tried both approaches but the dual approach did not yield sensible results, basically because we have not been able to construct a reliable measure of real return to capital. Hence in what follows we report the analysis based on the primal approach.

Let *tttt* be the production function where *t* denotes the total factor productivity (TFP), *t* capital and *t* labor in time *t*. Under perfect competition the production factors are paid their social marginal products: $F'_K = r + \delta$ and *L*. Defining capital and labor shares by *K* and *L*, we have *KL* thanks to constant returns to scale assumption. In applied work, a discrete-time formulation is used for TFPG. Assuming constant returns to scale, we can write the TFPG as the log-difference of the TFP level

$$TFPG = \ln(A_{t+1} / A_t) = \ln(Y_{t+1} / Y_t) - s_K \ln(K_{t+1} / K_t) - (1 - s_K)\ln(L_{t+1} / L_t) \qquad (2)$$

We need data on K, s_K, Y and L series to derive TFPG. The big challenge is to find reliable data. As we will see in the following subsection, there are some major problems concerning data. In this section we discuss methodological issues regarding the construction of the variables. The specific data used in the analysis is presented, along with the empirical results, in the next section.

2a)Capital

National accounts do not report data on capital stocks, so one needs to construct it from other sources. A widely used method is perpetual-inventory method (PIM). In this approach one uses investment series, I_t to construct capital stock.

$$K_{t+1} = (1 - \delta)K_t + I_t \qquad (3)$$

As investment, the literature uses gross fixed capital formation (GFCF) item reported in GDP measured by the expenditure approach. To construct capital, one needs to know the depreciation rate (δ), and the initial level of capital (0). Unfortunately, there is no consensus on how to determine these variables. This is for a good reason since there are inherent problems in calculating the depreciation rate because of aggregation: It is not possible to speak of a constant and unique depreciation rate when capital stock estimates contain information and communication technology (ICT) equipment, machinery as well as buildings and office equipment. However, especially for developed countries, there are estimates of depreciation relying on the age-price profile of an asset or of a cohort of assets. In most empirical work on TFP, 0 is guessed. In order to minimize the error associated with the guess, one needs to have a long series of investment. The common practice for guessing 0 is to assume that the economy is on its balanced growth path before the beginning of the period considered for TFP growth. As we need investment series to compute *K*, we assume that the economy is close to the steady state so that *K* grows at a constant rate. Then we can write

$$K_0 = \frac{I_0}{\bar{g} + \delta}$$

where $\bar{g}$ is theoretically the growth rate of capital and output in the steady state. In practice we use the average growth rate of GDP over some given number of years (say 10) following *t*=0.

Conesa, Kehoe and Ruhl (2007, CKR hereafter) use an alternative approach where δ and 0 are determined consistently by calibration. The CKR approach relies on PIM as well. The difference is that here initial capital level (0) and depreciation rate (δ) are chosen so that[2]

- the "ratio of depreciation to GDP" (i.e., consumption of fixed capital) in the observed data ($\overline{D/Y}$) matches the one in the constructed data

$$\frac{1}{T}\sum_{t=1}^{T}\frac{\delta K_t}{Y_t} = \overline{\frac{D}{Y}} \tag{4}$$

- the capital-output ratio in the initial period matches the average capital-output ratio over first ten years

$$\frac{K_0}{Y_0} = \frac{1}{10}\sum_{t=1}^{10}\frac{\delta K_t}{Y_t} \tag{5}$$

The idea is determining the depreciation rate and initial capital by calibration. Using the above set of equations we get a system of equations with *T*+1 unknowns ($K_1, K_2, ..., K_T$ and *T*+1 equations ($T-1$ equations of (3) equations (4) and (5)). In what follows, we use the standard approach in international comparisons and we use both the standard and CKR approaches when we use exclusively data from the Turkish Statistical Office.

2b)Labor

Early works such as Solow (1957) and Denison (1962) assumed that inputs were of constant / homogeneous quality. Beginning with Jorgenson and

2 For further details on method and computer programs see http://www.greatdepressionsbook.com, accessed on 18.12.2012.

Griliches (1967), researchers have taken into account changes in the quality of inputs and shown that this can be important. Since different skill levels imply different productivity (efficiency) levels, one should correct for heterogeneity in skills while computing the aggregate labor supply from heterogeneous labor. The basic idea is that increasing average years of schooling and better health conditions should enhance worker productivity. A typical method is weighting each labor category (based on schooling, experience, gender, etc.) by its respective efficiency/productivity measure.

A recent approach proposed by Bils and Klenow (2000) uses average years of schooling in a country to derive the human capital stock of the country. So, they assume

$$H = Le^{\phi(S,X)}$$

where S denotes average years of schooling, X average years of experience and L worked hours (or equivalently number of workers). Hall and Jones (1999) assume a piecewise linear function of the form $H = Le^{\rho S}$ where ρ is the Mincerian return to schooling which depends on the average level of schooling in the country. We use this approach below to account for changes in the schooling levels of employees.[3]

2c)GDP

We use real GDP as a measure of output. In the calculations below, we use data from Penn World Tables (PWT) and from the Turkish Statistical Institute (TurkStat). In both cases data are based on constant price GDP obtained from national accounts.[4] There are 3 methods for measuring GDP: the expenditure approach, the production approach and the income approach. The GDP calculated by the expenditure approach can be used to get investment series while income approach is useful for computing capital and labor shares of inputs. The GDP calculated by the production approach allows to do sectoral analysis.

The income approach to measuring GDP is to add up all the income earned by households and firms in a single year. The rationale behind the income approach is that total expenditures on final goods and services are eventually received by households and firms in the form of wage, profit, rent, and interest income.

$$Y = W + \Pi + T + \delta K$$

where W denotes “Compensation of Employees, Π denotes “Gross Operating

3 See Saygılı and Cihan (2006) for a study on the relation between productivity and human capital in Turkey.

4 Turkey uses, as of 2012, following EUROSTAT, the European system of national and regional accounts (ESA 1995) for constructing national accounts. ESA 1995 is compatible with SNA 1993 that is used by IMF, World Bank and OECD.

Surplus", T denotes "Net Indirect Taxes on Production and Imports" and δK is "Consumption of Fixed Capital".

An important issue that arises in the income approach is the treatment of income of unpaid family workers and self-employed individuals (owners of unincorporated enterprises) and how that income is distributed between W and Π. In the case of unincorporated enterprises, the owner or other members of the household work without receiving any wages or salaries. This is why the UN System of National Accounts (SNA) distinguishes between "operating surplus", which is associated with incorporated enterprises, and "mixed income", which is treated as the income of unincorporated enterprises. In practice, it is very difficult to distinguish this "unpaid" labor compensation from the rest of the income (that is, the surplus accruing from production). Some authors use the term "operating surplus of private unincorporated enterprises" (OSPUE) as a synonym of gross mixed income (e.g. Bernanke and Gurkaynak, 2001). In practice, UN SNA (1993) recommend to calculate gross mixed income as a residual: "*After deducting compensation of employees and taxes, less subsidies, on production from value added, the balancing item of the generation of income account is obtained, described either as the operating surplus or mixed income depending upon the nature of the enterprise.*" (UN SNA, 1993, p. 199).

ILO makes a distinction between "paid employment" and "self-employment" jobs. Self-employment jobs are defined as "*...those jobs where the remuneration is directly dependent upon the profits (or the potential for profits) derived from the goods and services produced (where own consumption is considered to be part of profits).*" [5] As a result, employers, own-account workers, members of producers' cooperatives and contributing family members are considered as self-employed. These distinctions will become important when we calculate labor share from the TurkStat data, as discussed below.

2d)Investment

In national accounts we do not have an "investment" item. Instead we have *gross capital formation (GCF)* also known as "gross domestic investment". GCF is the sum of three terms: the *gross fixed capital formation (GFCF)*, changes in inventories, and acquisitions less disposals of valuables. *GFCF* (equivalently, "gross domestic fixed investment") comprises all additions to the stocks of fixed assets (purchases and own-account capital formation), less any sales of second-hand and scrapped fixed assets, all measured at constant prices.[6] As mentioned above, capital stock for a country is rarely reported. The

5 http://laborsta.ilo.org/applv8/data/icsee.html, accessed on 14.01.2013.
6 See SNA 1993 (p.283).

usual practice is to compute it from investment (i.e. GFCF) series using PIM, as indicated above. The PIM relies on the past values of GFCF in volume and the amount of depreciated capital used in the previous periods.[7]

2e)Labor share

There are two ways to calculate labor (and capital) shares. The first one uses national accounts, while the second is based on regression analysis.

Labor share using national accounts: The standard formula for calculating labor share is $LS = W/(Y-T)$. The reason why we use $Y-T$ instead of Y in denominator is that we cannot attribute net indirect taxes on production and imports to capital income or labor income in an appropriate way without further information. So, we assume that the share of these indirect taxes attributable to capital (labor) income is equal to the share of capital (labor) income in the rest of the economy.

Adjusted labor share: The main disadvantage of *LS* is that it ignores the labor income of proprietors and unpaid family workers. Self-employed workers typically earn a mix of capital and labor income which is difficult to decompose. This is what we see as *mixed income* or *operating surplus* in national accounts. The idea of adjustment is that self-employed workers should be considered as if they are remunerated at the average compensation of wage earners when calculating labor share. This is the so-called "adjusted labour share" (ALS):

There are two popular ways to get a measure of ALS. One approach uses mixed income in national accounts (e.g. Gollin (2002) and Conesa et al. (2007)):

$$ALS_1 = \frac{W}{Y - T - OSPUE}$$

where *OSPUE* stands for operating surplus of private unincorporated enterprises. This specification assumes that the share of labor income in OSPUE is the same as its share in the rest of the economy (i. e. in the corporate sector). Unfortunately, not all countries distinguish between corporate and unincorporated enterprises in national accounts. They typically report the total operating surplus which does not help in determining the share of unincorporated sector which forms *OSPUE*.

A second method uses self-employment statistics as suggested by Gollin (2002) and Bernanke and Gurkaynak (2001):

$$ALS_2 = \frac{W}{Y - T}\frac{L}{E} \tag{6}$$

7 See OECD (2001, Measuring Capital, Ch. 6), and Lequiller and Blades (2006, p.23).

where E is the number of employees and L is total employment, so that $E/L = 1 - z$ is the share of employees in the total workforce (z being the share of self employment). This adjustment assumes that the self-employed workers earn the same wages as people who work as employees. The advantage of this approach is that we do not have to think about how operating surplus is distributed between capital and labor. Actually this is equivalent to assuming that $OSPUE = z(Y - T)$.

Bernanke and Gurkaynak (2001) use z to derive their *imputed OSPUE* measure. This allows to take into account countries only reporting operating surplus without distinguishing between incorporated and unincorporated businesses.

Labor shares using regression analysis: One can compute factor shares using regression as well. However, because of endogeneity problems, this approach is not used widely in the TFP literature. In this method we regress $\ln(Y)$ on $\ln(K)$ and $\ln(L)$. The intercept in this regression would be an estimate of TFPG and the coefficients of $\ln(K)$ and $\ln(L)$ give estimates for K and L. Alternatively one can get TFPG as a residual as well. Once we know factor shares we deduce TFP growth using the production function as in the Solow residual.

In the empirical work reported below, we use two different approaches in calculating labor share. In international comparisons using data from the Penn World Tables, we simply assume that labor share is 2/3 for all countries in all periods. This is the approach taken, for eexample, by Hall and Jones (1999) and Caselli (2005). In the more detailed analysis using TurkStat data, we use adjusted labor share ALS_2.

3) Results

In this section we present estimates of aggregate and sectoral TFPG for the Turkish economy. At the aggregate level estimates are derived both on the basis of PWT and TurkStat data sets. Sectoral estimates are based on TurkStat data only. In each subsection we also present information on the details of the data used.

3a) Aggregate TFPG

3ai) International comparisons using Penn World Tables

We use Penn World Table (PWT) version 7.1 by Heston et al. (2011) and Barro-Lee Educational Attainment Dataset version 1.2 (Barro and Lee (2010)) for international comparisons. We use a subsample of PWT covering the 1960-2010 period. We keep countries with full set of variables over this period. There are 98 countries in our subsample. Since there is no constant price GDP, employment and investment measures in PWT 7.1, we follow

Caselli (2005) to compute them. First, to obtain real GDP we multiply real GDP per capita by total population: **rdpch*POP**. Here rdpch denotes PPP converted GDP per capita, computed by chain rule, at 2005 constant prices (international dollars) and POP is total population. Second, to compute a "labor" measure we divide our constructed real GDP measure by real GDP per worker: **rdpch*POP/rgdpwok** with **rgdpwok** denoting PPP Converted GDP Laspeyres per worker at 2005 constant prices.

The production function is assumed to be a Cobb-Douglass, $Y = AK^{\alpha} X^{1-\alpha}$, with $\alpha = 1/3$ as in Hall and Jones (1999) and Caselli (2005). We will compute TFPG rates both for raw labor $X = L$ and schooling adjusted labor (human capital) $X = H$. As in Hall and Jones (1999), human capital as a function of raw labor and Mincerian returns to education in the country. We assume $H = Le^{\rho S}$ with S being average years of schooling and ρ Mincerian return to schooling. Average years of schooling (15+ population) comes from Barro and Lee (2010). Original observations have 5-year intervals. A linear approximation is used to generate annual data on human capital. Following Hall and Jones (1999) the Mincerian return is assumed as $\rho = 0.135$ if $S \leq 4$; $\rho = 0.101$ if $4 < S \leq 8$; and $\rho = 0.068$ if $S > 8$. We call this the Hall-Jones method of calculating TFPG. Below we also report results for the case of raw labor (L) with no correction.

The initial capital stock is derived using PIM as $K_{1960} = I_{1960} / (\bar{g} + \delta)$ where for each country $\bar{g}$ is the average growth rate of GDP from 1961 to 1970. Ideally, we would like to use GFCF as the measure of investment (I) here. However, the PWT 7.1 reports the ratio GCF/GDP as investment share. Thus, TFP papers relying on PWT for computing capital stock via PIM use GCF instead of GFCF[8] (e.g. Hall and Jones, 1999; Caselli, 2005). Conesa et al. (2007) also prefer GCF to compute capital stock by the PIM method. So, in this paper the investment measure we use is GFC computed as **rdpch*POP*ki/100** where **ki** is the reported investment share (in %) of PPP Converted GDP Per Capita at 2005 constant prices. We assume $\delta = 0.06$ following most of the literature. But using $\delta = 0.03$ does not change our qualitative results.

In Table (1) we report two sets of results for Turkey and a sample of 22 countries chosen as comparators. The variable *gS* stands for TFPG estimated simply as solow residuals, where labor is treated as a homogeneous input and is captured by the variable *L*, i.e. changes in labor composition are not accounted for. The variable *gHJ* is TFPG calculated with the human capital variable *H* contructed as described above. Results are listed separately for 1990s and 2000s ; in each case countries are ranked according to values of *gHJ* which is

8 Our results on Turkish economy show that the choice of GCF vs. GFCF has a very minor, negligible effect on results.

our preferred measure of TFPG. We report results for four different periods based on considerations of economic policy regime in Turkey: the period 1980-1989 corresponds to the period of liberalization of domestic markets and international trade, but not capital account liberalization. 1990-2001 captures the period of liberalized capital account but under the old political regime, before the Justice and Development Party (AKP) takes over. Finally the period 2002-2010 (or 2011, when we use the TurkStat data) corresponds to the period when AKP was in power. The results show that TFPG in Turkey in the 1990s was very low and in fact barely positive. By contrast, TFPG vastly improved in the 2000s, increasing to over 3 percent per annum. If we include the crisis years of 2000-2001 in the definition of the last decade, TFPG averages 2.3 percent per year. Turkey's rank is quite high among the comparator countries during that period. In fact, in the period 2002-2010, among the 98 countries for which complete data is available, Turkey ranks 7th in terms of TFPG calculated through the Solow residual (*gS*); see the full table in the Appendix. We conclude that in international comparison, TFPG in Turkey in the 2000s can be considered quite respectable.

Table 1: TFPG for selected countries

	1971-1979			1980-1989			1990-2001			2002-2010		
	iso3	gS	gHJ	iso3	gS	gHJ	iso3	gS	gHJ	iso3	gS	gHJ
1	ROU	6.22	7.16	CHN	5.04	4.39	CHN	5.82	4.89	CHN	5.96	7.24
2	MYS	3.82	2.82	EGY	3.56	2.9	IRL	3.62	3.48	ROU	4.55	4.33
3	TWN	3.43	2.42	TWN	2.73	3.83	CHL	2.98	2.62	IND	4.08	3.46
4	CHN	2.77	2.76	THA	2.48	1.81	EGY	2.26	1.25	TUR	3.81	3.17
5	BRA	2.76	2.84	KOR	2.47	1.92	IRN	1.92	0.44	PER	3.44	3.13
6	IDN	2.75	1.77	IND	2.31	1.35	MYS	1.84	2.26	IDN	3.12	2.44
7	KOR	2.29	2.96	PRT	1.41	0.53	TWN	1.7	1.09	ARG	3.09	2.82
8	IRL	2.01	1.44	SWE	1.34	0.97	IND	1.62	1.7	THA	2.94	2.02
9	THA	1.65	2.05	FRA	1.12	0.17	KOR	1.44	0.74	MYS	2.5	2.03
10	FRA	1.41	0.54	TUR	1.06	0.84	ARG	1.43	1.21	TWN	2.47	1.92
11	PRT	1.3	1.06	CHL	0.88	1.77	THA	1.3	0.76	MAR	1.94	2.2
12	MEX	0.85	0.86	USA	0.65	0.52	SWE	1.1	0.71	KOR	1.88	1.52
13	TUR	0.68	-0.32	MYS	0.54	-0.43	USA	1.03	0.82	BRA	1.33	0.6
14	PER	0.65	-0.46	ISR	0.3	0	ISR	0.99	0.75	IRN	1.22	2.38
15	ISR	0.58	-0.15	IRL	0.18	-0.13	PRT	0.76	0.35	SWE	0.8	0.59
16	CHL	0.51	-0.1	MAR	0.05	-0.93	IDN	0.63	0	EGY	0.74	-0.03
17	IND	0.49	-0.21	IDN	0.03	0.64	TUR	0.49	-0.2	ISR	0.62	0.56
18	SWE	0.44	-0.17	MEX	-0.47	-1.5	FRA	0.48	0.96	CHL	0.02	-0.47
19	ARG	0.43	-0.25	BRA	-1.5	-1.95	MAR	0.07	-0.83	FRA	-0.19	-0.65
20	USA	0.4	-0.17	ARG	-1.96	-0.84	PER	-0.26	0.56	USA	-0.27	-0.44
21	EGY	0.32	-0.83	ROU	-2.22	-2.67	MEX	-0.54	-1.39	MEX	-0.72	0.5
22	MAR	-0.69	-1.41	PER	-2.68	-3.37	BRA	-0.63	-1.89	PRT	-1.12	-1.57
23	IRN	-3.13	-4.29	IRN	-5.52	-5.79	ROU	-1.05	-1.33	IRL	-1.53	-1.88

Note: **gS** and **gHJ** both represent country averages of TFPG in the considered periods. **gS** is the standard Solow residual which uses raw labor without distinguishing between high- and low-educated workers while **gHJ** accords a higher weight to labor inputs with higher levels of education. This second one is based on Hall and Jones (1999). **iso3** is three-letter country code defined by the International Organization for Standardization (ISO).

3aii) Aggregate TFPG using TurkStat data

In order to do some robustness checks we compute TFPG for the Turkish economy using an alternative data source (from the Turkish Statistical Institute, TurkStat) and an alternative method (CKR approach, Conesa et al., 2007). Each time, we compute TFP in two ways: using raw labor with no adjustment, and using composition (quality) adjusted labor that takes into account differences in education levels, and improvements in education levels of workers (à la Hall-Jones).

We derive aggregate measures for physical capital, labor and output from TurkStat and State Planning Organization (SPO) data to compute TFPG for

Turkey over the 1970-2011 period. All data are available from these institutions' web sites.[9] As we will see later obtaining aggregate measures for constant price capital, output and total hours worked (or number of employees) is not straightforward because of changes in classifications, changes in base year, and revisions in employment (and population) estimations based on Address Based Population Registration System (ABPRS; "ADNKS" in Turkish).

We use the new 1998 constant price GCFC series published by TurkStat to construct our investment series. This series covers the 1998-2011 period. We use growth rates of 1987 based series to extrapolate our investment series back to the year 1987, and growth rates of investment series in Saygili and Cihan (2008) to extend our series back to 1950.[10]

To derive a measure for labor we use aggregate employment data for the years 1988-2011. Unfortunately, labor series based on Household Labor Surveys contain a break in 2004 because according to recent estimates based on ABPRS the Turkish population is overestimated approximately 3.7 million people in the old series. Thus, we revise the labor series for the years 1988-2003 by extrapolating the new labor series covering 2004-2011 using growth rates for 1988-2003. For years prior to 1988, again, we extrapolated the new series using the growth rate of an older series in Bulutay (1995).

Since we do not have access to education levels of workers in TurkStat data we cannot take into account changes in education levels of labor force for year before 1988. For the period 1988-2011 we compute both raw labor (L) and schooling adjusted labor (human capital, H).

For real GDP we use constant price GDP (1998 TLs) from TurkStat for period 1998-2011. For years prior to 1998 we use constant 1998-TL estimates published by the SPO in Economic and Social Indicators 1950-2010.

In order to get a comparable set of estimates for TFPG based on Turkish data we compute TFPG using the same hypothesis we used for PWT data, i.e. $\alpha = 1/3$, $\delta = 0.06$. . Further, to assure greater comparability between results based on PWT and Turkish data we compute, using PIM, the initial capital level from Turkish data for the year 1950. We have investment data going back to year 1950 and we know that the earlier the initial capital estimate the lower is the effect of any potential error in the initial capital guess. Hence we report results starting with the year 1971.

Our results are reported in Table (2). Qualitative results do not change much across different data sets. However, there are some discrepancies between the quantitative results from the different data sets, even though they are not very large. We note that TFPG estimates using PWT data are lower

9 http://www.turkstat.gov.tr/jsp/duyuru/upload/vt_en/vt.htm, http://www.mod.gov.tr/en/SitePages/mod_easi.aspx
10 Saygili and Cihan (2008) cite Temel and Saygili (1995) for the period before 1963 and "various SPO sources" for the 1963-1986 period as their main sources in constructing their investment series.

than those using TurkStat data for the period 1980-1989 and the reverse is true for the period 2002-2010. As emphasized by Lau (2004), growth rates of GDP measured in constant local currency units and constant international dollars may deviate from each other, if anything because relative prices in constant local units and those in international dollars at the base year are often not equal. We also note that the PWT have been subjected to criticism because of low reliability of GDP data that it provides (see, for example, Johnson et. al. 2012). In any case, the discrepancy between TFPG rates calculated from PWT and TurkStat data underscores the importance of data and measurement problems alluded to in the introduction, and difficulties in attributing the Solow residual to technology.

Table 2: TFPG in Turkey : PWT vs. TurkStat data

	gS	gHJ	gS	gHJ
1971-1979	0.61		0.51	-0.48
1980-1989	1.59		1.03	0.80
1990-2001	0.62	0.09	0.48	-0.22
2002-2010	2.39	1.79	3.81	3.17

Note: gS and **gHJ** both denote yearly averages of TFPG in the considered periods. The first one relies on raw labor while the second one takes account of changes in levels of education of employees following Hall and Jones (1999). For both TurkStat and PWT data sets we use $\alpha = 1/3$, $\delta = 6\%$ to compute TFPG rates.

Having compared TFPG estimates from the PWT and TurkStat data sets, we now further explore the data from TurkStat. We make two modifications to the above analysis: As a robustness check we use the CKR approach to calculate the depreciation rate and capital stocks. We also relax the assumption that capital share is exogenously given to be equal to 1/3. To derive share of capital we use TurkStat "GDP by income approach 1987-2006" data set.[11] Instead of deriving a naive labor share (the share of "Compensation of employees" in GDP) that does not take into account *OSPUE*, we would like to use adjusted labor share that does. Since Turkish data does not distinguish between incorporated and unincorporated enterprises when reporting operating surplus hence we do not have data on mixed income. This is why we use self-employment rates, published by OECD, to calculate adjusted labor share corrected for self-employment that we developed in Subsection 2e, equation (6). Share of self-employment (z) data are obtained from OECD

$0.51 = 1-(1-0.0235)^{30}$. /www.turkstat.gov.tr/PreIstatistikTablo.do?istab_id=677 at 18.12.2012. Unfortunately, TurkStat does not publish GDP by income approach for years past 2006.

Factbook (2009) for the period 1990-2006.[12] Unfortunately, the information on self-employment rates is not available for years 1987-1989. We assumed that it was equal to its 1990 value for these years. The average (across 1987-2006) self-employment adjusted labor share, 67.86%, is very close to the standard 2/3 value.

We use (3), (4) and (5), to calculate initial capital level K0 and depreciation rate δ. The "ratio of depreciation to GDP" (i.e., consumption of fixed capital) in the observed data, $\overline{D/Y}$, is 6.73%. The average of depreciation rate seems very low compared to OECD average (in 2010 this ratio is 14.3 %). Over 34 OECD countries only Mexico (9.15% over 1997-2010) has a depreciation rate near to the Turkish average.[13]

We have a system of equations with 21 unknowns ($K_{1987},...,K_{2006}$ and δ) and 21 equations (19 equations of (3) where t=1987,…,2005, equations (4) and (5)). We choose years 1987-2006 because these are the only years for which TurkStat reports "GDP by income approach" where we have the "consumption of fixed capital" item. The choice of 1961-1970 years for the capital-output ratio is to minimize the effect of any error or anomaly in the data.[14]

As a final robustness check, we also take into account factor utilization. For this we compute employment on the basis of hours worked as well as number of persons and capacity-adjusted capital stock as well as raw capital stock. Data for average hours worked is obtained from the OECD.[15] For capacity utilization rate we use the "Capacity Utilization Rate of Manufacturing Industry" index published by Central Bank of the Republic of Turkey (CBRT) for years 2007-2011 and the "Capacity Utilization in Manufacturing Industry" index published by State Planning Organization (Economic and Social Indicators 1950-2010) for years 1978-2006. All data are available from these institutions' web sites.[16] Our capacity utilization index is far from being perfect. Firstly, it measures capacity utilization only in manufacturing. So, by using this correction for the entire economy we discard any sectoral heterogeneity regarding capacity utilization. Secondly, the capacity utilization index is based on surveys, so by construction it does not distinguish between capital and labor. We assume that it reflects capital utilization in this paper. This is a strong assumption but given that we already control for average hours worked per worker, the residual link between cyclical movements of output and labor utilization should be weaker.

12 http://dx.doi.org/10.1787/542746080432, accessed on 18.12.2012

13 For details, see http://dx.doi.org/10.1787/888932550385, retrieved on 18.12.2012.

14 Actually, with the calibrated depreciation rate we find that 51% of the initial capital stock depreciates by 1990:

15 See http://dx.doi.org/10.1787/lfs-data-en, accessed on 18.12.2012.

16 http://www.tcmb.gov.tr/imalat/CUR.html and http://www.dpt.gov.tr/

Table (3) presents the results of these extensions. Results show that depending on the methodology, TFPG accounts for between 34 to 45 percent of aggregate growth in the 2000s in contrast to the 1990s, where this share is around 3-20 percent. The share of TFPG in overall growth is also relatively high in the 1980s. Using hours worked instead of number of employees does not seem to change the results in any substantial manner. Interestingly, employment growth in terms of hours worked is lower than that calculated on the basis of number of employees both in the 1980s and 2000s. But using capacity adjusted capital makes an important difference, especially when we consider the sub-periodization 2002-2006 and 2007-2011. In the first sub-period, the capacity is increasing (from 75.4% in 2002 to 81.0% in 2006) while in the second sub-period it is decreasing (from 80.2% in 2007 to 75.4% in 2011). As a result, relative to the case where capital is not adjusted for utilization, the contribution of capital to overall growth increases in the period 2002-2006 (with a consequent decrease in the contribution of TFPG) and decreases in the period 2007-2011(with a consequent increase in the contribution of TFPG). As a result, adjusting for utilization of capital decreases the contrast between these two sub-periods.

In any case, the data in Table (3) reveals , from a growth accounting point of view, the distinguishing characteristic of the 2000s. Clearly the 2000s display higher growth in GDP than the earlier three or four decades. The table shows that growth in the capital stock does not account for the higher growth rate of GDP. While increase in employment in the 2000s is slightly higher than the earlier periods (especially when defined as number of employees and when adjusted for changes in quality), the main driver of high growth in GDP in the 2000s relative to earlier decades has been higher TFPG.

Table 3: Growth accounting for Turkey.

	Y	K	Ku	L	Lh	H	AS	Ash	Asuh	AHJ
Growth rate (%)										
1971-1979	4.7	7.9		1.9	1.3		0.9	1.3		
1980-1989	3.9	4.6	7.1	1.6	1.1		1.4	1.7		
1990-2001	3.2	5.2	5.0	1.4	1.7	2.2	0.6	0.4	0.5	0.1
2002-2011	5.2	4.5	5.1	2.1	1.8	2.9	2.3	2.6	2.4	1.8
2002-2006	*7.0*	*3.9*	*6.5*	*0.9*	*0.9*	*2.1*	*5.1*	*5.1*	*4.3*	*4.3*
2007-2011	*3.4*	*5.1*	*3.6*	*3.3*	*2.6*	*3.8*	*-0.4*	*0.0*	*0.5*	*-0.8*
Contribution (%)										
1971-1979		53.9		27.8	18.2		18.3	27.9		
1980-1989		37.8	57.9	26.9	18.2		35.3	44.0		
1990-2001		51.3	49.1	29.0	35.8	45.6	19.7	12.8	15.0	3.1
2002-2011		27.7	31.5	27.3	22.9	38.4	45.0	49.4	45.6	33.9
2002-2006		*17.9*	*30.2*	*8.5*	*8.7*	*20.3*	*73.7*	*73.5*	*61.1*	*61.9*
2007-2011		*47.5*	*34.1*	*65.5*	*51.7*	*75.2*	*-13.0*	*0.9*	*14.3*	*-22.6*

N**ote:** We use CKR approach for growth accounting. This approach yields α=32.14%, δ= 2.32% for considered period. **Y** is used for GDP, **K** for capital, **L** for number of employees, **H** for schooling adjusted labor. **Ku** denotes capacity-adjusted capital, **Lh** denotes total hours worked in the economy. Similarly, **AS** is TFPG using number of employees, **ASh** is TFPG using total hours worked, **ASuh** is TFPG using total hours worked and capacity-adjusted capital, **AHJ** is TFPG using schooling adjusted labor.

We also check whether the definition of investment makes a difference in the results. PWT 7.1 defines investment as GCF. However, we used GFCF for computing capital stock from the Turkish data. A problem in using GFC in Turkish data is that changes in inventories are derived as a balancing item, thus, they *include statistical discrepancy as well*. So we are cautious in using GCF. We verified that the results do not change when we use GCF instead of GFCF.

We have also checked whether changing the periodization has a substantial impact on the results. We have recalculated the data in Table 3 for the following periodization: 1971-80, 1981-90, 1991-2000 and 2001-2011. While exact numbers change, TFPG in the 2000s is still higher than TFPG in the 1990s for both TFP measures. One important change that the new periodization introduces is that raw TFPG in the 1980s become larger than that in 2000s. Also, TFPG in the 1970s turn negative.

3b) Sectoral TFPG

The high level of TFPG in the 2000s raises the question of which sectors played a leading role in this improvement. Hence we now calculate TFPG at the sectoral level. Our (sectoral) labor data come from Turkstat (Household Labor Surveys 1988-2008), (sectoral) GDP and (sectoral) investment data come from TurkStat and State Planning Organization (Economic and Social Indicators 1950-2010). All data are available from these institutions' web sites.[17]

We assume that each sector is characterized by a Cobb-Douglas production function where we allow capital share to be sector dependent (below *a* is used for agriculture, *i* for industry and *s* for services)

$$Y_j = A_j K_j^{\alpha_j} X_j^{1-\alpha_j}, \; j = a, i, s$$

A major problem is to determining sectoral physical capital when we have multiple sectors. Following Caselli (2005), we use the non-arbitrage condition between sectors (marginal firm should earn the same rate of returns in each sector)

$$\frac{\alpha_a P_a Y_a}{K_a} = \frac{\alpha_i P_i Y_i}{K_i} = \frac{\alpha_s P_s Y_s}{K_s}$$

as a plausible requirement. These equations can be written in terms of sectoral shares of GDP and sectoral capital as well

$$K_a = K_s \frac{\alpha_a v_a}{\alpha_s v_s} \text{ and } K_i = K_s \frac{\alpha_i v_i}{\alpha_s v_s}$$

Instead of sectoral value added share of a single year *jt* we use the average sectoral shares over first 5 years ($\bar{v}_j, j = a, i, s$ over 1961-1965) to minimize the risk of mismeasurement as initial sectoral shares when computing initial sectoral capital in 1963.[18] Combining the above equations with the fact that the sum of the sectoral physical capital is equal to the aggregate level of capital, $K = K_a + K_i + K_s$, we can obtain initial capital levels for year 1963 once we have aggregate physical capital for Turkish economy. There is nothing new in this subsection. We follow closely the standard PIM to derive aggregate capital levels for Turkey. We have already discussed how we obtained an aggregate investment and capital measure for Turkish economy using different sources of data. We applied standard PIM instead of CKR approach for determining initial capital level in 1950, $K_{1950} = I_{1950}/(\bar{g} + \delta)$ where, $\alpha = 1/3$, $\delta = 0.06$ and $\bar{g}$ is the average growth rate of GDP over years 1951-1960. Then using the steps discussed above we obtained initial capital levels for each sector in 1963. Once we have initial capital levels in each sector, then we use sectoral investment

17 http://www.turkstat.gov.tr/jsp/duyuru/upload/vt_en/vt.htm and http://www.dpt.gov.tr/

18 Obtained from Table 1.18 in Economic and Social Indicators 1950-2010 published by SPO.

series and PIM to construct sectoral capital over the period 1963-2011. For sectoral investment data we used aggregate investment GFCF series and sectoral investment shares (1963-2009) published by SPO.[19] For remaining years 2010 and 2011 we used sectoral investment shares in a recent SPO report "General Economic Objectives and Investment" available at SPO website.[20] When using PIM, we would like to calculate sectoral capital/labor shares for each sector. For that we need mixed income (or *OSPUE*) in each sector/industry to get reliable measures. But, unfortunately there is no such detailed data for Turkey. Gollin (2002) argues that there are no systematic differences between factor shares of rich and poor countries. Following Valentinyi and Herrendorf (2008), who measure sectoral income shares for USA, we use capital share, $\alpha = 0.55$ for agriculture, and $\alpha = 1/3$ for industry and services.[21]

Unfortunately our sectoral labor series are shorter than our sectoral GDP and capital series. They go back until 1972. We use TurkStat data based on new ABPRS estimates for the 2004-2011 period. We extrapolate this series back using (i) old TurkStat data based on Household Labor Surveys for the 1988-2003 period and (ii) employment series compiled by Saygili and Cihan (2005) for the 1972-1987 period.

To compute sectoral GDPs we used TurkStat data. TurkStat publishes GDP for 3 main sectors (agriculture, industry and service) for the period 1968-2006. These series, which use ISIC Rev.2 classification, are based on 1987 prices. They are compiled using the recommendations of SNA 1968. Unfortunately, we do not have sectoral GDP series published by TurkStat after 2006 for these 3 main sectors. The new GDP series, based on 1998 prices, uses the NACE Rev.1.1 as classification and they follow the ESA 1995 guidelines which break down GDP into 17 sectors. In principle, one can obtain sectoral GDP of agriculture, industry and service sectors from this new series by using some simplifying assumptions. When constructing GDP series for the 3 main sectors from the 17 NACE Rev.1.1 sectors we have the following difficulty: we do not know how TurkSat proceeded to compute sectoral GDP for these 3 sectors from 15 ISIC Rev.2 sectors in the old series based on 1987 prices. In particular, we do not know how TurkStat distributed imputed bank service charges" and "import duties" between the three main sectors.[22] Likewise, we need to decide how to distribute "financial intermediation services indirectly

19 Obtained from Table 2.9 in Economic and Social Indicators 1950-2010 published by SPO.

20 http://www2.dpt.gov.tr/kamuyat/GEHY-2012.pdf, accessed on 30.11.2012.

21 To address the possibility that agriculture is less capital intensive in Turkey, we have also obtained results under the assumptions α= 30 and α= 20 for agriculture. Qualitative results do not change. The contrast between 2002-2006 and 2007-2011 increases as the capital share in agriculture decreases.

22 The only remark TurkStat makes about the methodology used for the calculation of GDP series for these 3 main sectors is the following: "Imputed bank service charges are deducted from the sectors". Nothing is said about "import duties". Back-of-the-envelope calculations suggest that "import duties" were most likely included in the services sector. We thank an anonymous referee for drawing our attention to this issue.

measured" and "net taxes on products" between sectors in the new series. For the new series covering the 1998-2011 period, we assumed that both "financial intermediation services indirectly measured" and "net taxes on products" can be allocated between sectors according to the GDP shares of these sectors. Similarly, we allocated "imputed bank service charges" and "import duties" between main sectors according to sectoral GDP shares for the period 1968-2006. The sectoral GDP series that we obtain for these 3 main sectors using this approximate method are very close to the official figures published by TurkStat. In order to get consistent GDP series through 1968-2011 period, we use our newly constructed sectoral GDP series for the 1998-2011 period. For the years before 1998, we extrapolate these series using sectoral growth rates of the GDP series obtained by our approximate method instead of those coming from GDP series published by TurkStat in order to keep methodological consistency. However, we verified that our results are robust to using TurkStat series as well. There are only minor differences between two approaches.

Table 4: Sectoral TFPG - Turkey

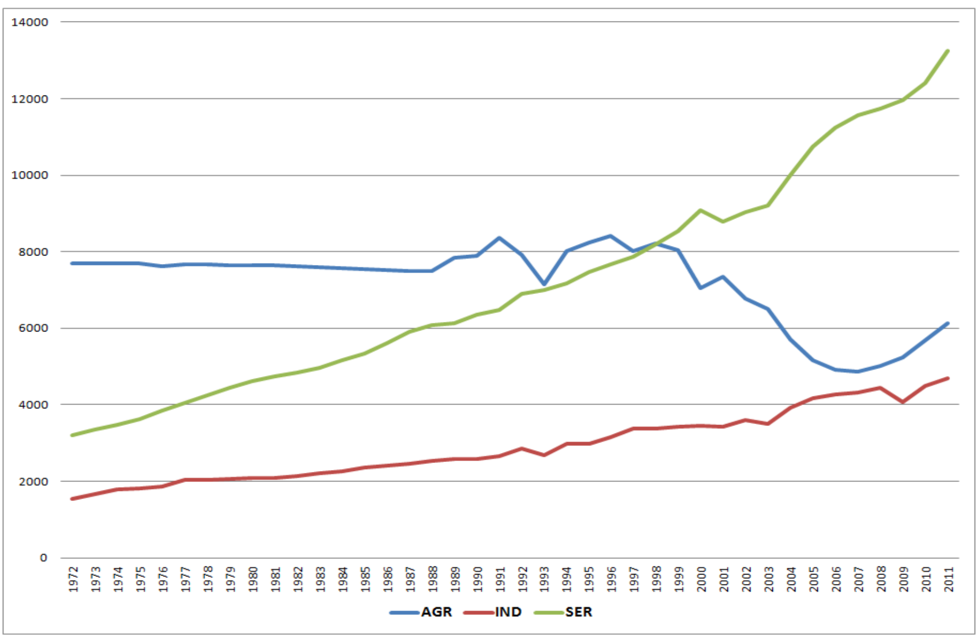
	gSagr	gSind	gSser	gHJagr	gHJind	gHJser
1973-1979	0.23	-0.82	-0.95			
1980-1989	0.23	3.07	0.55			
1990-2001	0.76	0.96	-0.62	0.52	0.55	-1.04
2002-2011	2.49	1.26	1.65	2.22	0.95	1.27
2002-2006	6.91	2.81	3.11	6.59	2.49	2.76
2007-2011	-1.94	-0.28	0.18	-2.16	-0.59	-0.21

N**ote: gSx** denotes the standard TFP growth in sector **x** with **x** =agr, ser, ind (Solow residual) while **gHJx** is the adjusted TFP growth in sector **x** (Hall-Jones approach) where we take into account changes in the education levels of employees.

Sectoral TFPG calculations are presented in Table (4). One sees that TFPG was higher in the 2000s relative to the 1990s in all three sectors. The 1980s are interesting in that (at least according to the Solow definition) TFPG in industry is quite high whereas those in agriculture and services are very close to zero. Perhaps more interestingly, the table suggests a significant change in the role of TFPG in agriculture and services. Whereas until the 2000s TFPG in agriculture and services was either very low or negative, the distinguishing feature of the last decade is a relatively high TFPG in agriculture and services. Further it is the only decade where the TFPG is above 1.25 % in all 3 sectors for the first time (considering the Solow definition of TFP). Also, note that in the 2000s, TFPG in agriculture is higher than TFPG in industry and services. This is also true for the 1970s but the TFPG in agriculture is almost zero in that period.

We suspect that a reduction in hidden unemployment in agriculture in the 2000s probably explains the high agricultural TFPG in the 2000s. As shown in Figure (1), starting with the end of the 1990s, there was a rapid reduction in the absolute level of employment in agriculture until about 2007. The level then stabilizes and shows an upward trend toward end of 2000s.[23] Indeed, if the growth accounting exercise for the 2000s is done for the two subperiods one observes that TFPG is very high in 2002-2006 and then declines in 2007-2011 in all three sectors (see the half bottom of Table (4)). This is probably due to the repercussions of the 2008 global financial crisis which caused a slightly positive growth rate in 2008 and a negative growth rate in 2009. Nevertheless, the contrast in the agriculture is too high to be explained only by the crisis effect. The difference between average TFPG in the two subperiods is approximately 3 % in industry and services while this is almost 9 % in agriculture.

Figure 1: Sectoral Employment



23 Note that official data may overstate the extent of reallocation of labor between sectors, as workers are assigned to sectors where they earn the majority of their income.

Table 5: Average sectoral growth rates

Agriculture	Y	K	L	H
1973-1979	1.15	1.74	-0.08	
1980-1989	0.61	0.50	0.25	
1990-2001	1.13	1.12	-0.55	0.00
2002-2011	2.46	1.42	-1.79	-1.19
2002-2006	3.66	0.69	-8.08	-7.36
2007-2011	1.26	2.15	4.49	4.97

Industry	Y	K	L	H
1973-1979	5.78	11.61	4.09	
1980-1989	5.73	3.48	2.26	
1990-2001	3.65	3.37	2.35	2.96
2002-2011	5.56	6.56	3.17	3.64
2002-2006	7.60	5.59	4.39	4.87
2007-2011	3.53	7.54	1.95	2.40

Services	Y	K	L	H
1973-1979	5.25	9.33	4.64	
1980-1989	4.40	5.12	3.22	
1990-2001	3.59	6.62	3.00	3.62
2002-2011	5.51	3.33	4.13	4.69
2002-2006	7.28	2.59	4.96	5.49
2007-2011	3.74	4.07	3.30	3.89

Note: Y, K, L, H denote sectoral, value-added, capital, labor and composition-adjusted labor.

This big difference between agriculture and the other two sectors comes from the evolution of agricultural employment. The opposite trends in agricultural employment in these subperiods are compatible with a relatively very high TFPG (6.91 %) over 2002-2006 and a relatively very low TFPG (-1.94 %) in the second subperiod.

To verify that evolution of capital or value-added is not the main driver behind this contrast in agriculture we have also calculated the average growth rate of value-added, capital, labor and composition-adjusted labor in each sector over 2002-2006 and 2007-2011 subperiods. The results are presented in the bottom half of the tables for each sector (Table (5)). The growth rate of capital has a similar trend in all 3 sectors. Comparing subperiods 2002-2006 and 2007-2011 we see that the growth rate of capital is about 1.5-2 percentage points higher in the second subperiod. As for value-added, in each sector the average growth rate of value-added in 2002-2006 is twice as high as that in 2007-2011. But the evolution of employment is radically different across sectors. While the difference in average employment growth between 2002-2006 and 2007-2011 subperiods is 2.44 % and 1.66 % for, respectively, industry and services, it is -12.57 % for agriculture. Thus, as suspected, the reduction in hidden unemployment in agriculture is the main driver for high TFPG in agriculture. Also, note that despite this spectacular decrease in agricultural employment we observe a higher-than-average growth rate for the agricultural value-added in 2002-2006 subperiod. One should also note that because the share of agriculture in total GDP is relatively low, the contribution of high TFPG in agriculture to overall TFPG is likely to be quite modest even in the 2000s. The basic trends about employment do not change much when we measure employment in terms of schooling-adjusted labor in the manner of Hall and Jones (1999).

The reader will note that TFPG calculated from aggregate TuskStat data will be different from an aggregated TFPG that can be calculated as a weighted average of the sectoral TFPGs reported in Table 4. This is expected especially during periods of substantial structural change during which resources are reallocated across sectors. When wages in industry are higher than wages in agriculture and there is a labor shift from agriculture to industry, Barro and Sala-i-Martin (2004, p. 449-450) shows that TFP calculated on the basis of aggregate data overestimates true TFP. We believe that these assumptions are valid for the case of Turkey, especially in the last three decades.

4) Conclusion

The main findings of this paper may be summarized as follows: We have shown that TFPG in Turkey has been impressive in the 2000s, more than 3 percent per annum when calculated on the basis of PWT. This is quite high in international comparison as well. Looking at individual sectors, we have also shown that highest TFP growth in the last decade was recorded in agriculture, followed by industry and then by services. We also note that the 2000s was unique in the sense that this was the only decade since the 1970s where TFPG in agriculture was not only positive but also higher than industry and services.

These findings raise a number of interesting questions. The most obvious question is: what accounts for high TFPG in the 2000s? Is it simply higher macroeconomic stability? What is the role of macro-management in superior TFPG? Has trade played a significant role? Regarding agriculture, does the relatively high TFPG in this sector reflect a reduction in underemployment as was suggested above, or has there been a genuine increase in the TFP as well?[24] What explains the increase in agricultural employment, and the parallel decrease in agricultural TFPG in the latter part of the decade?[25] Still another question relates to the role of reallocation. The results above suggest that reallocation of labor away from agriculture towards industry and services may have played an important role in overall TFP growth.[26] If that is correct,

24 Imrohoroglu et. al. (2012) argue that low productivity growth in the agricultural sector played a major role in the divergence of income per capita between Turkey and its peer countries between 1968 and 2005.

25 See Gursel and Imamoglu (2013) for an analysis of the dynamics behind the evolution of employment in agriculture.

26 See Rodrik (2010) for the role of structural change and reallocation of labor in productivity growth in Turkey. The role of reallocation (which turns out to be substantial) in the rapid increase in aggregate labour productivity in the last decade in Turkey is discussed in Atiyas and Bakis (2014).

what accounts for this reallocation? Is it likely that the limits of productivity growth that relies on reallocation is likely to have reached its limits?[27] Findings answers to such questions warrants further research.

We reiterate measurement problems and difficulties and attributing the Solow residual to TFP. In addition, we have maintained throughout the calculations the assumptions of perfect competition and constant returns to scale (though we did try to make corrections for capacity utilization). These assumptions may not hold in practice.[28] In part, our approach is dictated by data availability, especially in international comparisons. While we suspect that these extensions would not change the (especially qualitative) results in any fundamental ways, these also are worthwhile extensions for future research.

27 In their cross-country study of productivity growth in industry, Taymaz and Kılıçaslan (2006) find that countries that have been successful in industrial growth have achieved this primarily through productivity growth within industries and the role of structural change has been limited.

28 See, for example, Altug and Filiztekin (2002) and Saygili and Cihan (2008).

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Appendix

Table A.1: TFPG results for countries in the PWT dataset

	1971-1979			1980-1989			1990-2001			2002-2010		
	iso3	gS	gHJ	iso3	gS	gHJ	iso3	gS	gHJ	iso3	gS	gHJ
1	ROU	6.22	7.16	BWA	5.51	3.84	CHN	5.82	4.89	CHN	5.96	7.24
2	MUS	5.27	4.98	CHN	5.04	4.39	IRL	3.62	3.48	TTO	5.91	5.6
3	ECU	4.85	3.72	CYP	3.57	4.34	UGA	3.19	3.23	ROU	4.55	4.33
4	BWA	4.5	3.63	EGY	3.56	2.9	CHL	2.98	2.62	MOZ	4.15	3.48
5	HKG	3.82	2.73	LUX	3	2.71	LKA	2.65	1.98	MWI	4.1	4.24
6	MYS	3.82	2.82	PAK	2.93	2.27	SGP	2.53	3.1	IND	4.08	3.46
7	CMR	3.58	2.49	TWN	2.73	3.83	NOR	2.41	2.02	TUR	3.81	3.17
8	TWN	3.43	2.42	HKG	2.59	3.63	TTO	2.28	3.36	COD	3.73	3.64
9	PRY	3.23	2.52	THA	2.48	1.81	EGY	2.26	1.25	SGP	3.72	3.22
10	COG	3.02	1.18	KOR	2.47	1.92	SYR	2.1	2.04	TZA	3.6	3.05
11	SYR	2.92	1.77	FIN	2.32	2.3	MUS	2.01	1.75	PAN	3.58	3.22
12	ISL	2.82	2.23	IND	2.31	1.35	IRN	1.92	0.44	PER	3.44	3.13
13	SGP	2.8	2.79	COG	2.19	2.17	MYS	1.84	2.26	LKA	3.43	3.17
14	CHN	2.77	2.76	LKA	2.19	3.3	ZMB	1.78	0.98	GHA	3.32	2.92
15	BRA	2.76	2.84	GBR	2.06	3.55	GBR	1.76	1.44	RWA	3.27	2.59
16	IDN	2.75	1.77	SGP	1.81	0.94	BEN	1.73	0.85	IDN	3.12	2.44
17	HND	2.68	1.63	JPN	1.73	1.38	TWN	1.7	1.09	ARG	3.09	2.82
18	URY	2.53	1.84	AUS	1.41	1.33	IND	1.62	1.7	LSO	3.02	2.25
19	FJI	2.39	1.4	PRT	1.41	0.53	SLV	1.55	0.35	URY	3.01	2.77
20	KOR	2.29	2.96	MUS	1.4	0.67	AUS	1.54	1.47	THA	2.94	2.02
21	TTO	2.19	1.47	SWE	1.34	0.97	DOM	1.54	1.06	JOR	2.64	2.12
22	IRL	2.01	1.44	ITA	1.3	0.58	DNK	1.48	1.41	HKG	2.6	2.1
23	GTM	2	1.02	BEL	1.25	0.78	KOR	1.44	0.74	PHL	2.59	2.28
24	AUT	1.99	1.3	TZA	1.16	1.26	ARG	1.43	1.21	DOM	2.53	2.02
25	PHL	1.89	1.06	FRA	1.12	0.17	URY	1.37	2.49	MYS	2.5	2.03
26	GAB	1.76	0.4	ESP	1.11	0.69	MOZ	1.33	1.29	TWN	2.47	1.92
27	ITA	1.72	1.04	TUR	1.06	0.84	THA	1.3	0.76	ZMB	2.41	1.89
28	BOL	1.69	0.73	NOR	1.06	0.44	PNG	1.18	0.75	ECU	2.17	3.58
29	LKA	1.67	1.39	BEN	1.04	0.24	NZL	1.18	1.01	PNG	2.15	2.66
30	COL	1.66	1.99	CHL	0.88	1.77	GRC	1.18	0.93	MUS	2.14	1.34
31	GRC	1.65	1.26	ZWE	0.81	0.49	MLI	1.17	0.87	MAR	1.94	2.2
32	THA	1.65	2.05	PAN	0.77	0.04	CYP	1.16	0.88	KOR	1.88	1.52
33	CYP	1.63	0.61	MLI	0.72	0.45	GHA	1.16	0.74	PRY	1.83	2.41
34	DZA	1.59	0.25	KEN	0.7	0.29	FIN	1.15	1.03	MLI	1.69	0.93
35	HTI	1.53	0.81	USA	0.65	0.52	SWE	1.1	0.71	BGD	1.68	0.8
36	MLI	1.41	1.12	MYS	0.54	-0.43	USA	1.03	0.82	UGA	1.62	0.92
37	FRA	1.41	0.54	GHA	0.5	-0.17	ISR	0.99	0.75	COL	1.55	0.99
38	PRT	1.3	1.06	DNK	0.46	0.31	FJI	0.98	0.63	PAK	1.39	0.26
39	BEL	1.27	2.64	AUT	0.34	-0.22	NLD	0.97	0.72	BOL	1.36	0.65
40	ZWE	1.27	0.64	GMB	0.31	-0.39	LUX	0.95	0.65	BRA	1.33	0.6
41	LUX	1.17	2.7	CAN	0.3	-0.02	ITA	0.9	1.82	IRN	1.22	2.38
42	NLD	1.15	0.58	ISR	0.3	0	BEL	0.88	0.6	SYR	1.18	0.73
43	ESP	1.09	0.17	ISL	0.28	1.61	ESP	0.88	1.02	ZAF	1.14	2.67
44	GBR	1.09	0.77	JAM	0.25	-0.49	BOL	0.83	1.6	DZA	1.04	2.22
45	FIN	1.03	2.06	UGA	0.21	-0.78	GTM	0.79	1.11	HND	0.92	0.05
46	NOR	1	0.7	IRL	0.18	-0.13	CAN	0.77	0.41	SWE	0.8	0.59
47	MWI	0.94	0.27	DOM	0.11	-0.51	PRT	0.76	0.35	EGY	0.74	-0.03

48	MEX	0.85	0.86	CAF	0.05	-0.85	AUT	0.67	1.65	KEN	0.72	0.29
49	JOR	0.79	0.88	MAR	0.05	-0.93	IDN	0.63	0	CRI	0.7	0.4
50	CIV	0.78	0.05	IDN	0.03	0.64	GAB	0.6	-0.58	CHE	0.69	0.53
51	JPN	0.73	0.25	NZL	-0.23	-0.21	NPL	0.59	0.08	ISR	0.62	0.56
52	TUR	0.68	-0.32	CIV	-0.25	-0.82	TZA	0.57	0.12	NPL	0.62	-0.33
53	PER	0.65	-0.46	SEN	-0.4	-0.96	HKG	0.52	0.46	NER	0.52	0.09
54	DOM	0.64	-0.03	NPL	-0.44	-1.71	TUR	0.49	-0.2	FIN	0.5	-0.24
55	ISR	0.58	-0.15	MEX	-0.47	-1.5	FRA	0.48	0.96	AUT	0.49	0.24
56	CHL	0.51	-0.1	COD	-0.5	-1.5	PAN	0.42	1.34	JPN	0.45	0.16
57	IND	0.49	-0.21	CHE	-0.57	-0.36	BGD	0.42	0.14	BDI	0.44	-0.23
58	CAN	0.48	0.1	GAB	-0.64	-1.16	RWA	0.42	-0.45	CAF	0.24	-0.07
59	PAK	0.47	-0.06	HND	-0.67	-0.89	JAM	0.33	0.8	NAM	0.12	-0.04
60	SWE	0.44	-0.17	ZAF	-0.7	-1.62	HTI	0.31	0.31	COG	0.1	-0.03
61	KEN	0.44	-0.99	ZMB	-0.73	-1.28	LSO	0.29	-0.25	AUS	0.09	-0.07
62	MRT	0.44	0.07	NLD	-0.73	-1.06	PAK	0.27	0.1	NOR	0.07	-0.33
63	ARG	0.43	-0.25	COL	-0.86	-1.6	CRI	0.23	1.19	GRC	0.06	-0.74
64	USA	0.4	-0.17	GRC	-0.9	0.01	VEN	0.17	-0.29	BEL	0.04	-0.13
65	CRI	0.39	-0.1	BDI	-0.92	-1.19	NAM	0.15	0.32	CHL	0.02	-0.47
66	DNK	0.36	0.05	BRB	-0.96	0.2	MAR	-0.07	0.83	NZL	-0.02	-0.26
67	EGY	0.32	-0.83	MRT	-1.01	-1.54	PHL	-0.01	0.97	NLD	-0.07	-0.21
68	BDI	0.3	-0.05	NAM	-1.01	-1.77	JOR	-0.01	0.46	GTM	-0.08	-0.6
69	BEN	0.28	-0.04	PRY	-1.06	-1.71	GMB	-0.06	-0.83	NIC	-0.18	-1.08
70	PAN	0.21	-0.77	MOZ	-1.07	-1.02	MRT	-0.06	-0.77	FRA	-0.19	-0.65
71	LSO	0.04	0.45	PHL	-1.22	-1.79	ZAF	-0.21	-0.96	GBR	-0.2	-0.58
72	AUS	0	-0.63	NIC	-1.24	-0.87	CHE	-0.22	-0.18	CMR	-0.21	-0.64
73	SLV	-0.01	-0.72	URY	-1.37	-1.93	PER	-0.26	0.56	USA	-0.27	-0.44
74	CHE	-0.2	-0.92	GTM	-1.45	-2.13	SEN	-0.33	-0.2	VEN	-0.3	-1.07
75	MOZ	-0.3	-0.39	BRA	-1.5	-1.95	KEN	-0.42	-1.15	CYP	-0.32	-0.45
76	ZAF	-0.43	-0.76	ECU	-1.55	-2.32	BRB	-0.42	-0.61	TGO	-0.35	-0.98
77	SEN	-0.61	-1.11	MWI	-1.59	-2.14	ECU	-0.43	-0.58	CAN	-0.38	-0.8
78	MAR	-0.69	-1.41	PNG	-1.67	-2.52	JPN	-0.44	-0.84	BRB	-0.38	-0.68
79	GHA	-0.69	-0.75	BGD	-1.69	-2.56	CIV	-0.47	-1.45	SLV	-0.39	-1.32
80	VEN	-0.72	-0.8	DZA	-1.83	-2.62	MEX	-0.54	-1.39	BEN	-0.43	-0.38
81	NER	-0.73	-0.91	BOL	-1.91	-3.11	ISL	-0.58	-0.98	DNK	-0.62	-0.78
82	TZA	-0.81	-1.6	ARG	-1.96	-0.84	NER	-0.6	-0.91	BWA	-0.66	-1
83	RWA	-0.91	-1.38	SLV	-2.07	-1.99	BRA	-0.63	-1.89	JAM	-0.7	-1.05
84	NAM	-0.99	-0.69	LSO	-2.22	-2.54	COG	-0.65	-0.95	MEX	-0.72	0.5
85	NZL	-1	-1.3	ROU	-2.22	-2.67	NIC	-0.69	-1.39	SEN	-0.73	-1.39
86	TGO	-1.05	-2.79	CMR	-2.25	-2.46	DZA	-0.77	-1.97	GAB	-0.75	0.37
87	CAF	-1.13	-1.84	FJI	-2.29	-1.63	CMR	-0.91	-1.63	HTI	-0.8	-1.27
88	PNG	-1.14	-1.84	SYR	-2.37	-2.42	BWA	-0.94	-0.65	ITA	-0.84	-1.17
89	NPL	-1.63	-2.06	CRI	-2.42	-3.25	CAF	-0.99	-1.56	LUX	-0.86	-1.09
90	GMB	-1.72	-2.07	PER	-2.68	-3.37	ROU	-1.05	-1.33	CIV	-0.96	-0.39
91	BGD	-1.91	-2.64	JOR	-2.88	-4.15	MWI	-1.11	-1.72	MRT	-0.99	-0.81
92	COD	-2.5	-3.16	RWA	-2.89	-3.31	TGO	-1.36	-1.23	FJI	-1.04	-1.18
93	JAM	-2.85	-3.66	HTI	-2.97	-4.32	COL	-1.55	-2.14	PRT	-1.12	-1.57
94	IRN	-3.13	-4.29	TGO	-3.09	-4.32	PRY	-1.7	-1.96	IRL	-1.53	-1.88
95	BRB	-3.78	-5.15	VEN	-3.74	-3.59	HND	-2.29	-3.09	ESP	-1.63	-2.11
96	UGA	-4.47	-5.23	NER	-4.36	-4.69	BDI	-2.82	-3.5	ISL	-1.92	-2.46
97	ZMB	-5.12	-5.15	IRN	-5.52	-5.79	ZWE	-3.29	-4.19	ZWE	-2.85	-3.28
98	NIC	-6.18	-6.77	TTO	-5.6	-6.01	COD	-7.68	-8.02	GMB	-4.66	-5.44