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The effects of capital and labor reallocation on total factor productivity in Türkiye, 2000–2024☆

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ABSTRACT

This paper calculates the contribution of the reallocation of capital and labor to aggregate TFP for the 2000–2024 period in the Turkish economy. While the reallocation effect is generally positive for labor (except for crisis years), there are two separate periods for capital. In the period 2000–2014, the reallocation effect for capital is positive, while in the period 2015–2024 it became consistently negative. The paper also takes into account improvements in schooling over time while calculating sectoral TFP growth. Leaving aside the crisis periods of 2000–2002 and 2008–2010, I find that the TFP growth is positive in the 2003–2007 and 2011–2014 periods. However, aggregate TFP growth is almost zero in the 2015–2024 period where there is no economic crisis. TFP growth is very volatile and low on average in the construction sector. The services sector is characterized by negative TFP growth. Agriculture has the smoothest trends and the highest average TFP growth.

1. Introduction

Since the year 2000, the Turkish economy has undergone significant changes in investment composition. At the risk of oversimplification, we can say that the lion's share of investment went to the construction sector, while the lion's share of employment went to the services sector. We can see these changes by looking at the two directly observable inputs of production, employment and investment. While there has been a 4-fold increase in aggregate real investment during this period, the sectoral distribution of this investment has changed dramatically over time. Investment in construction increased 5.1-fold, investment in services 3.3-fold (Table 1).[1] Between 2000 and 2011, the share of construction investments in total investments was approximately 30 percent. This percentage rose rapidly and reached 42 percent in 2014. From 2014 to 2020, it remained around 40 percent before declining slightly to approximately 36 percent in the last two years (See also Fig. A.6 in Appendix). Following the rapid increase after 2014, the construction sector now has the highest investment at current prices. For a sector whose share in national income lags far behind that of industry and services, this is not what one would expect. Similarly, total employment increased by a factor of 1.7. However, sectoral employment dynamics again show large differences (Table 2). Employment in the services sector increased by about 2.3 times, and construction employment by 1.7 times.[2]

Naturally, one would have expected the share of construction and services in GDP to increase with such a large slice of the pie. As Table 2 shows, this is not really the case. Over a 24-year period, the share of construction in GDP at current prices went from 5.9 percent to 6.6 percent, while the share of services went from 58.9 percent to 64.7 percent. This contrasts with industry, which fell from 24 percent to 22.2 percent over the same period. So, why did the share of the two sectors that attracted the largest share of inputs not increase as much as expected? And what is the implication of directing most of the resources to these sectors for the GDP level and Total Factor Productivity (TFP)? To answer the first question, we need to analyze the *dynamics* of sectoral TFP. To answer the second question, we should study the effect of *resource reallocation* on aggregate TFP.

I find TFP growth to be low in construction and in services on average (compared to industry and agriculture). Thus, the first reason for slight increases in GDP shares for construction and services sectors despite large increases in inputs by these sectors is the low TFP growth rates in these two sectors. Since the aggregate TFP is a function of sectoral TFPs, when low productivity sectors such as construction and services use most of the resources, this also has a direct negative effect on aggregate TFP. This component of aggregate TFP, which is weighted average of sectoral TFPs, is called the *within* component. Directing most of the resources to these low-productivity sectors, unfortunately, has an

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[1] In the same period, investment in industry increased 3.8-fold, and investment in agriculture 1.7-fold.

[2] In the same period, industrial employment increased 1.8-fold, and agricultural employment declined by 20 percent.

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Table 1
Change in real investment and employment: 2000–2024.
Source: TurkStat.

sek	rat_I	rat_L
tot	4.0	1.7
agr	1.7	0.8
ind	3.8	1.8
ser	3.3	2.3
con	5.1	1.7

Note: *rat_I* and *rat_L* are the multiples of the increase in investment and employment, respectively, between the years 2000 and 2024. *agr*, *ind*, *ser*, *con* refer to agriculture, industry, services and construction, respectively.

Table 2
Shares in GDP, investment and employment: 2000–2024.
Source: TurkStat.

sek	y_00	y_24	i_00	i_24	e_00	e_24
agr	11.2	6.6	4.2	2.0	31.0	14.8
ind	24.0	22.2	26.4	22.2	19.4	20.7
ser	58.9	64.7	40.9	32.4	43.0	57.9
con	5.9	6.6	28.4	43.4	6.6	6.6

Note: *y*_20 and *y*_24 show the share of each sector in GDP in 2000 and 2024, respectively. Similarly, *e*_20 and *e*_24 show the share of each sector in employment, while *i*_20 and *i*_24 show the share of each sector in investment in the same years. *agr*, *ind*, *ser*, *con* refer to agriculture, industry, services and construction, respectively.

additional negative effect on aggregate TFP through the *reallocation* of capital and labor. This second component is called the *reallocation* (or between) component.[3]

The key contribution of this paper is the decomposing of aggregate TFP into *within* and *input specific reallocation* components for the 2000–2024 period for the Turkish economy. Assuming that output is produced by capital and labor in each sector, I am able to calculate the input specific reallocation effects. While the reallocation effect is generally positive for labor (except for crisis years), there are two separate periods for capital. In the period 2000–2013, the reallocation effect for capital is positive, while in the period 2014–2024 it becomes consistently negative.

This is the first paper studying the effect of the reallocation of capital and labor across sectors on aggregate TFP in Turkey. Some earlier studies such as Rodrik (2010) and Üngör (2016) only analyze the reallocation of labor across sectors, not on TFP, but on labor productivity. The only work that analyzes the reallocation of resources on TFP using sectoral data is Altug and Filiztekin (2006). However, since they define aggregate TFP as the weighted sum of sectoral TFPs where weights are shares of the factor-input composite, ($K^{\alpha}L^{1-\alpha}$), they are unable to distinguish between capital and labor reallocation separately. Instead, they report the "share effect", which is the total reallocation effect due to the allocation of factor-input composite from low to high productivity industries between 1970 and 2000. They show that the share effect (interpreted as total reallocation effect) is positive in the period immediately following the trade liberalization,1981–1988, but mostly negative in other subperiods. The World Bank (2019) uses firm-level data to calculate and decompose TFP growth for the Turkish economy between 2006 and 2015. The report shows that TFP levels were mostly flat in manufacturing but declined in construction and services. It also reports a total reallocation effect of inputs, as it is unable to distinguish between capital and labor reallocation effects separately, a limitation also found in Altug and Filiztekin (2006). The report indicates that allocative efficiency in manufacturing improved between 2005 and 2011 but deteriorated between 2011 and 2015. Furthermore, the report notes that the capital-labor ratio is especially high in large manufacturing firms and suggests exploring whether this capital is invested in productive or unproductive assets, as this directly affects long-term productivity. Our results imply that it is mostly unproductive capital, which is consistent with the report's concerns.

Unlike earlier studies (Bakis and Acar, 2020; Atiyas and Bakis, 2020, 2023) this paper takes into account improvements in schooling over time while calculating sectoral TFP growth. This is the second contribution of the paper. Since schooling dynamics follow different patterns in each sector, depending on the characteristics of workers in the sector, this avoids any bias in TFP calculations due to rising schooling levels. Unaccounted schooling improvements show up in the TFP growth, which is likely to inflate TFP growth rates.[4] Aggregate TFP growth is negative in the 2000–2002 and 2008–2010 periods, but positive in the 2003–2007 and 2011–2014 periods. Surprisingly, aggregate TFP growth is zero in the 2015–2024 period, where there is no economic crisis. TFP growth in the industry has the same pattern as aggregate TFP growth. TFP growth is very volatile and low on average in the construction sector. The services sector is characterized by negative TFP growth. Agriculture has the smoothest trends and the highest TFP growth on average. World Bank (2019) shows that TFP levels are mostly flat for manufacturing, but declining for construction and services. Akarsu (2025), who focuses on spillover effects of frontier firms on other firms, shows that the manufacturing TFP level increased steadily between 2009 and 2021, with a slight decline in 2022. Unfortunately, he reports TFP levels only for the manufacturing sector; he neither reports TFP levels for other sectors nor TFP growth rates. This makes it impossible to directly compare my results with his.[5]

Empirical studies that estimate TFP relying on aggregate production function and aggregate data are unfortunately silent about the magnitude of the reallocation effect (Feenstra et al., 2015; Hall and Jones, 1999; Caselli, 2005; Hsieh and Klenow, 2010). To answer this important question, one needs to use either sectoral or firm-level data. There are many firm-level studies that study aggregation and reallocation issues (Olley and Pakes, 1996; Basu and Fernald, 2002; Petrin and Levinsohn, 2012; Bartelsman et al., 2013; Aw et al., 2001; Foster et al., 2001; Baqaee and Farhi, 2020; World Bank, 2019; Akarsu, 2025). I will not discuss firm-level studies because I want to focus on papers using sectoral data that are closely related to this paper.

There are two separate approaches to study the effect of reallocating resources across sectors using sectoral data: those employing gross-output-based TFP and those relying on value-added-based TFP. Jorgenson and his coauthors (Jorgenson et al., 2003; Cao et al., 2009; Jorgenson and Schreyer, 2013) are examples of the first approach. The gross-output-based TFP approach has two advantages. First, it relies on standard production functions where capital, labor, and intermediate goods are used as inputs. Second, by distinguishing input-specific reallocation effects, it enables the separate analysis of capital and labor movements across industries. However, the Jorgenson methodology

[3] To better understand how these two components complement each other, let us use the following example from Massell (1961). Consider a simple economy with 2 time periods, t_0 and t_1, and 2 firms (or sectors), A and B, and a constant level of inputs that can be used by firms (sectors). Going from t_0 to t_1, there will be changes both in the technology of each firm (sector) and in the allocation of resources (capital and labor). Even though both happen simultaneously, to decompose them, we can think of them as happening sequentially, in 2 steps. In the first step, for a given allocation of resources, there is a change in technology that causes a change in output. This is the *within* component. In the second step, resources are reallocated for a given technological capacity. As long as there are productivity differences between firms, this will cause a second change in the level of output. This is the *reallocation* component that can be calculated for each input separately.

[4] For instance, Bakis and Acar (2021) show that the annual average bias is approximately 0.5 percentage points between 1990–2019 for the aggregate economy.

[5] Since firm-level and sector- or macro-level TFP estimations differ significantly in their methodologies and scope, one should not expect to get the same results from these two levels of analysis.

requires detailed input–output tables, which poses significant practical challenges. Input–output tables are typically compiled only every five to ten years, precluding the assessment of annual productivity dynamics. Additionally, changes in industrial classification over time complicate intertemporal comparisons.

The second approach, which uses value-added based TFP measures, aligns more closely with the national accounts framework, since sectoral value-added data are published typically quarterly and annually by national statistical agencies. Thus, input–output tables are not required to compute sectoral TFP growth rates. A recent application of this second approach can be found in Diewert (2015, 2016). Unfortunately, Diewert's framework does not distinguish between factors of production; his analysis treats inputs as an aggregate. This limitation prevents the separate study of capital and labor reallocation. Moreover, Diewert's formulation is ambiguous regarding what constitutes the reallocation effect, as the latter is typically linked to changes in the relative sizes of industries, measured either by output or input shares. In Diewert's decomposition, three terms could be interpreted as part of the reallocation effect: one reflecting changes in real output prices, another reflecting changes in real input prices, and a third reflecting changes in input cost shares. The inclusion of output and input prices complicates the interpretation.

This paper can be considered as a mixture of the Jorgenson and Diewert approaches. Like the Diewert approach, it does not require input–output tables, but also like the Jorgenson approach, it allows one to calculate the effect on aggregate TFP due to the reallocation of capital and labor separately. The outline of the paper is as follows. Section 2 discusses how aggregate TFP can be calculated as a function of sectoral TFPs and the reallocation effect, which captures improvements in TFP due to the reallocation of factors of production across sectors. Section 3 presents the data compilation process and how this paper deals with the additivity problem inherent in chain volume indices. Section 4 presents the main results. Finally, Section 5 concludes the paper.

2. From sectoral TFP to aggregate TFP

Let us note current price sectoral aggregates by $P_{it}Y_{it}$ in industry i. Assuming that there exists an aggregate price level P_t and quantity level Y_t, as suggested by Jorgenson and Griliches (1967), we can write $P_tY_t = \sum P_{it}Y_{it}$. If we take the derivative of both sides with respect to time and divide it by the corresponding total value, we get the following equation

$$\frac{\dot{Y}_t}{Y_t} + \frac{\dot{P}_t}{P_t} = \sum_i s_{it}\frac{\dot{Y}_{it}}{Y_{it}} + \sum_i s_{it}\frac{\dot{P}_{it}}{P_{it}}$$

Then we can define real GDP growth and price growth as

$$\frac{\dot{Y}_t}{Y_t} = \sum_i s_{it}\frac{\dot{Y}_{it}}{Y_{it}}, \quad \frac{\dot{P}_t}{P_t} = \sum_i s_{it}\frac{\dot{P}_{it}}{P_{it}} \tag{1}$$

where s_i is the nominal shares of sector i: $s_i = \frac{P_iY_i}{\sum_i P_iY_i}$. Aggregate and sectoral production functions are given as

$$Y_t = A_tK_t^{\alpha}H_t^{1-\alpha}, \quad Y_{it} = A_{it}K_{it}^{\alpha_i}H_{it}^{1-\alpha_i}$$

where K is the (aggregate or sectoral) capital stock and H (aggregate or sectoral) is the number of workers adjusted for "quality". The proxy of quality I use is the average human capital h that each worker has. Following Hall and Jones (1999), the human capital is constructed as

$$H = Lh = Le^{\phi(q)}; \quad H_i = L_ih_i = L_ie^{\phi(q_i)}$$

where L refers to number of workers, q to average years of schooling.

Taking the derivative of both sectoral and aggregate production functions with respect to time and rearranging for TFP growth, we get

$$\begin{aligned}
\frac{\dot{A}}{A} &= \frac{\dot{Y}}{Y} - \alpha\frac{\dot{K}}{K} - (1-\alpha)\frac{\dot{H}}{H} \\
&= \sum_i s_{it}\frac{\dot{Y}_{it}}{Y_{it}} - \alpha\frac{\dot{K}}{K} - (1-\alpha)\frac{\dot{H}}{H} \\
&= \sum_i s_{it}\left(\frac{\dot{A}_{it}}{A_{it}} + \alpha_i\frac{\dot{K}_{it}}{K_{it}} + (1-\alpha_i)\frac{\dot{H}_{it}}{H_{it}}\right) - \alpha\frac{\dot{K}}{K} - (1-\alpha)\frac{\dot{H}}{H} \\
&= \underbrace{\sum_i s_{it}\frac{\dot{A}_i}{A_i}}_{WE} + \underbrace{\sum_i s_{it}\alpha_i\frac{\dot{K}_i}{K_i} - \alpha\frac{\dot{K}}{K}}_{RK} + \underbrace{\sum_i s_{it}(1-\alpha_i)\frac{\dot{H}_i}{H_i} - (1-\alpha)\frac{\dot{H}}{H}}_{RL}
\end{aligned} \tag{2}$$

Please note that the only assumption required for this derivation is that production functions exhibit constant returns to scale. Later, when estimating this equation, I rely on the perfect competition assumption to calculate labor and capital shares from the data.

WE is the contribution due to the changes in sectoral TFP growth, usually called the within effect. WE is a measure of intra-industry technological change, which is nothing more than a weighted average of the rates of technological change within each industry. This component, by construction, excludes any improvements due to the reallocation of resources among industries. This is why many see the within component as a proxy for "pure technological change". But this would be wrong because the value of all components depends on the number of industries used in the analysis. RK and RL show the contribution from the reallocation of capital and labor. The reallocation effect is due to the interindustry shift of factors of production.

Here, I should remind the reader that because my decomposition uses only 4 sectors, like any other decomposition, it yields a within effect that is larger than the true value. If I used a more detailed industry classification (such as 2-digit NACE industry classification) the TFP growth of each broad sector would be further decomposed into 3 components as in Eq. (2). With 4 broad sectors, we can say that the reported WE should be interpreted as an upper bound for the true effect, while the reported RK and RL should be seen as lower bound for the true effect.

Following Massell (1961), we can show that RK and RL come from productivity differences across industries. For this, we need to rewrite (2) using marginal productivities. For this, let us show that (using $\alpha Y/K = F'_K$ and $\alpha_iY_i/K_i = F'^i_K$)

$$\begin{aligned}
\alpha_is_{it}\frac{\dot{K}_i}{K_i} &= \alpha_i\frac{P_iY_i}{PY}\frac{\dot{K}_i}{K_i} = \frac{\frac{\alpha_iY_i}{K_i}}{\frac{\alpha Y}{K}}\frac{\alpha P_i}{PK}\dot{K}_i \\
&= \alpha\frac{P_iF'^i_K}{PF'_K}\frac{\dot{K}_i}{K}
\end{aligned}$$

$$\Rightarrow RK = s_{it}\alpha_i\frac{\dot{K}_i}{K_i} - \alpha\frac{\dot{K}}{K} = \alpha\left(\frac{P_iF'^i_K}{PF'_K}\frac{\dot{K}_i}{K} - \frac{\dot{K}}{K}\right) = \alpha\left(\frac{P_iF'^i_K\dot{K}_i - PF'_K\dot{K}}{PF'_KK}\right)$$

And similarly for labor (using $(1-\alpha)Y/H = F'_H$ and $(1-\alpha_i)Y_i/H_i = F'^i_H$)

$$\begin{aligned}
(1-\alpha_i)s_{it}\frac{\dot{H}_i}{H_i} &= (1-\alpha_i)\frac{P_iY_i}{PY}\frac{\dot{H}_i}{H_i} = \frac{\frac{(1-\alpha_i)Y_i}{H_i}}{\frac{(1-\alpha)Y}{H}}\frac{(1-\alpha)P_i}{PH}\dot{H}_i \\
&= (1-\alpha)\frac{P_iF'^i_H}{PF'_H}\frac{\dot{H}_i}{H}
\end{aligned}$$

$$\begin{aligned}
\Rightarrow RL &= s_{it}(1-\alpha_i)\frac{\dot{H}_i}{H_i} - (1-\alpha)\frac{\dot{H}}{H} = (1-\alpha)\left(\frac{P_iF'^i_H}{PF'_H}\frac{\dot{H}_i}{H} - \frac{\dot{H}}{H}\right) \\
&= (1-\alpha)\left(\frac{P_iF'^i_H\dot{H}_i - PF'_H\dot{H}}{PF'_HH}\right)
\end{aligned}$$

Reallocation effects exist only when marginal returns are not equal across sectors. So, in a sense, the above equation is a measure of the difference between marginal returns across sectors. If reallocation effects are negligible, then we can conclude that marginal returns are close to each other across sectors. A similar derivation can be found in Massell (1961) and in the works of Jorgenson and his coauthors (see for instance Cao et al., 2009; Jorgenson and Schreyer, 2013). In the Jorgenson approach, TFP is based on gross output, while in this paper it is derived from value added. Using value added instead of gross output simplifies the derivation. In Massell (1961), TFP is based on value added, but all aggregates are compiled using constant price national accounts methodology. In this paper, I use Divisia index numbers to derive aggregate productivity measures, which are consistent with the chain-linked volume measures used by TurkStat.

In the above derivation of aggregate productivity, there is no explicit role for changes in relative prices. And this makes complete sense because weights are continuously changing in the Divisia approach. Continuously updated weights will already reflect changes in relative prices. However, in the literature we see both papers where relative prices have an explicit role[6] and papers where there is no role for changes in relative prices.[7] Diewert (2015) finds that while the effect of the change in relative prices can be fairly large for some industries, when we sum across industries, the overall effect of changes in relative prices is approximately zero in each year. The reason behind this puzzle is answered in Diewert (2016): the use of index numbers (Laspeyres, Paasche, Fisher, Törnqvist) to define aggregate outputs and inputs leads to a cancellation of changes in relative prices in the aggregate decompositions.

To see how changes in relative prices lead to a cancellation in the aggregate decompositions, we can start with the accounting identity where aggregate VA (GDP) is equal to the sum of sectoral VA (GDP) in current prices. Again, as in Jorgenson and Griliches (1967), I assume that aggregate quantity and price indexes exist. More specifically, Y_t denotes the real (chain-indexed) GDP while P_t is the GDP deflator. I will use V_t to denote the nominal GDP. Then, by definition, we have $V_t = Y_t P_t$ for the aggregate economy and $V_{it} = Y_{it} P_{it}$ for each sector, where P_{it} is the sectoral GDP deflator.

$$Y_t = \frac{V_t}{P_t} = \frac{\sum_i V_{it}}{P_{it}} = \frac{\sum_i P_{it} Y_{it}}{P_t} = \sum_i p_{it} Y_{it}$$

Taking the time derivative of both sides and dividing by real GDP we get

$$\frac{\dot{Y}_t}{Y_t} = \sum_i s_{it} \frac{\dot{Y}_{it}}{Y_{it}} + \sum_i s_{it} \frac{\dot{p}_{it}}{p_{it}} \tag{3}$$

Compared to GDP growth given in Divisia approach in (1) there is an extra term, $\sum_i s_{it} \dot{p}_{it}/p_{it}$ in (3). Actually, this extra term is approximately zero in discrete time and exactly zero in continuous time. To see this, let us rewrite the weighted average of relative price changes as

$$\sum_i s_{it} \frac{\dot{p}_{it}}{p_{it}} = \sum_i s_{it} \frac{\dot{P}_{it}}{P_{it}} - \sum_i s_{it} \frac{\dot{P}_t}{P_t} = \sum_i s_{it} \frac{\dot{P}_{it}}{P_{it}} - \frac{\dot{P}_t}{P_t}$$

where we used $p_{it} = P_{it}/P_t$ and $\sum_i s_{it} = 1$. When time is continuous, the above expression is exactly equal to zero by the definition of the growth rate of the price component in Divisia approach given in (1). However, since real data is collected for discrete time periods, the result is approximately zero: $\sum_i s_{it} \frac{\dot{p}_{it}}{p_{it}} \approx 0$. Please note that this approximation error is also present in volume component as well. This explains why Diewert (2015) finds a very small (close to zero) effect for the contribution of the real input and output price changes to the aggregate TFP growth.

3. Data

To estimate TFP growth, we need GDP, capital, and human capital series, and the values of the parameters of production functions. All GDP and employment data are obtained from the TurkStat and the Presidency of Strategy and Budget websites. Sectoral GDP data have been available since 1998 from the TurkStat website. Sectoral employment data have been available since 1988 from the TurkStat website. The capital stock is derived from investment series. Sectoral investment data are obtained from the Presidency of Strategy and Budget.[8] Historical data on employment, GDP, and investment are also available from the Presidency of Strategy and Budget.[9]

Historical employment and GDP data are available for nine sectors. But the classification used for investment is not consistent with the one used for employment and GDP. This makes it impossible to construct sectoral capital stocks for nine sectors. However, the investment series includes "housing", which is part of the "construction" sector. Because of this problem, earlier literature on TFP analyzed only three sectors (agriculture, industry, and services). This is unfortunate given the importance of the construction sector for the Turkish economy. I follow Bakis and Acar (2020) to separate housing investment from other construction data. This yields an imperfect measure of capital stock for the construction sector.[10] Since it is not possible to construct capital stock for all nine sectors, I limit my analysis to four broad sectors: agriculture, industry (mining, manufacturing, and public utilities), construction, and all remaining sectors regrouped as services.

Once we have an investment serie (sectoral or aggregate), we can use the perpetual inventory method (PIM) to derive capital stock series. Given an estimate of initial capital stock, I derive capital stock as follows

$$K_t = (1-\delta)K_{t-1} + I_{t-1}$$

where δ is the depreciation rate. Since I rely on the steady state assumption to compute initial capital stock using investment data, it is suggested to compute it as early as possible (in my case this is 1948) so that any error made in initial capital stock disappears in the long run.[11] For the aggregate economy I set $\delta = 0.06$ as most of the literature does. Since there are sectoral differences regarding the depreciation rate (Jorgenson, 1996; Hulten and Wykoff, 1981) I set $\delta = 0.04$ for agriculture, $\delta = 0.08$ for construction and $\delta = 0.06$ for industry and services.

For sectoral capital stocks, I use PIM method as well. The only difference is the way I estimate initial level of capital stock and the value of the depreciation rate. Following Caselli (2005), I use the non-arbitrage condition between sectors (marginal firm should earn the same rate of returns in each sector)

$$\frac{\alpha_a P_{a0} Y_{a0}}{K_{a0}} = \frac{\alpha_i P_{i0} Y_{i0}}{K_{i0}} = \frac{\alpha_s P_{s0} Y_{s0}}{K_{s0}} = \frac{\alpha_c P_{c0} Y_{c0}}{K_{c0}}$$

Combining the above equations with

$$K_0 = K_{a0} + K_{i0} + K_{s0} + K_{c0}$$

I obtain initial capital levels for each of 4 sectors.

Another important parameter is the output elasticity of labor (human capital). Empirical studies generally use the labor share to set this parameter. However, especially in developing countries such as Türkiye, there is a non-negligible amount of unpaid family workers and self-employed individuals (owners of unincorporated enterprises). In 2022, the share of unpaid workers was approximately 30 percent. As a result, the reported share of labor is biased. To correct for this, we need to impute a wage for those unpaid workers. To deal with the same problem, Feenstra et al. (2015) assume that the share of labor income in mixed income (income earned by self-employed workers, where capital and labor incomes are not separated) is the same as in the rest of

[6] Ohanian (2001), Diewert (2015, 2016) and Tang and Wang (2004).

[7] Jorgenson et al. (2003), Cao et al. (2009) and Jorgenson and Schreyer (2013).

[8] https://www.sbb.gov.tr/temel-ekonomik-gostergeler.

[9] https://www.sbb.gov.tr/ekonomik-ve-sosyal-gostergeler.

[10] Bakis and Acar (2020) show that assumptions on initial capital stock, depreciation rates and input shares have minor effects on the estimated sectoral capital stocks.

[11] The steady state assumption used to estimate initial level of capital stock is $K_0 = \frac{I_0}{\bar{g}+\delta}$ where $\bar{g}$ is the growth rate of capital and output in the steady state. As an approximation, I use the average growth rate of GDP over 1949–1959.

the economy. Since mixed income is only available for 60 countries, they assume that all value added in agriculture is the labor income of the self-employed. Since the labor income of the self-employed outside agriculture is ignored in this approach, I prefer another solution. I assign the average sectoral wage to unpaid workers in each sector. This process yields what we call the "adjusted labour share" (ALS). Assuming perfect competition, we have

$$ALS_j = 1 - \alpha^j = \frac{w^j L_j}{P_j Y_j} \frac{N_j}{L_j}$$

where L_j refers to the number of employees (paid employment) and N_j to the total number of employees in the sector j. Using these adjusted labor shares, I find the following values for sectoral capital shares

$$\alpha^a = 0.47, \quad \alpha^i = 0.63, \alpha^s = 0.49, \quad \alpha^c = 0.64$$

The capital share for the aggregate economy, $\alpha = 0.53$, is simply found as a weighted average of sectoral capital shares where weights are GDP shares.

When constructing GDP and investment series going back to 1948, one needs to deal with changes in activity classification. I follow the steps described in Bakis and Acar (2020) to generate these series. Another problem that one has to deal with is the lack of additivity introduced with the adoption of chain indices in 2016. GDP or investment in current prices is equal to the sum of its components. But this is not true for chain-linked volume series (real GDP or investment series) published by TurkStat. This is problematic because our analysis requires us to regroup either 21 sectors into 4 in the case of GDP series or 10 sectors into 4 in the case of investment series. In order to deal with this problem, I follow the OECD practice, explained in Lequiller and Blades (2014).[12] The idea is to express all volumes in prices of the previous year instead of chain-linked volume levels because accounts in previous year prices preserve additivity, as TurkStat uses chained Laspeyres indices to derive volume indices. For this, I apply the growth rate of each component to the lag of the values in current prices as $v'_t = v_{t-1}(1+g_t)$. Here, v_t is the value added in year t in current prices, while v'_t is the value added in year t in prices of the previous year. Both v and v' refer to one of 20 industries defined by NACE Rev.2 economic activities. Then, I regroup both series in current and in the previous year prices into 4 sectors. Finally, the growth rate for our broad sectors is calculated as $(x'_t/x_{t-1} - 1)$, where x_t is the value added in year t in current prices and x'_t is the value added in year t in previous year's prices for each of the 4 broad sectors: industry, construction, services, and agriculture. Iterating this process for all years, I get the time series of the chained volume index for our 4 broad sectors.

Employment series are easier to construct compared to GDP and investment series. Both sectoral and aggregate employment data can be freely downloaded from the TurkStat website.[13] The major hurdle is the jump introduced in 2004 when the Address Based Population Registration System (known as ADNKS in Turkish) was adopted. I follow the steps described in Bakis and Acar (2020) to generate a consistent employment series. The idea is to use the growth rates from the old series to extend the new series backwards.

While Atiyas and Bakis (2023) adjust for improvements in schooling at the aggregate level, they use raw labor at the sectoral level. I extend their study by applying the formulation of Hall and Jones (1999) to create a human capital index from raw labor and average years of schooling for each individual sector. The idea is to create the human capital index as a function of average years of schooling (q_t): $h_t = e^{\phi(q_t)}$. Hall and Jones (1999) assume that $\phi(q)$ is a piecewise linear function of q:

$$\phi(q) = \begin{cases} 0.13 \times q & \text{if } q \leqslant 4 \\ 0.13 \times 4 + 0.10 \times (q-4) & \text{if } 4 < q \leqslant 8 \\ 0.13 \times 4 + 0.10 \times 4 + 0.07(q-8) & \text{if } q > 8 \end{cases}$$

To calculate the human capital index for each broad sector, I downloaded "Employed persons by educational status and branch of economic activity" from the TurkStat website. Then, given the number of employed people in each sector by education level, it is straightforward to assign appropriate years of schooling to each education level, calculate h for each sector, and thus obtain the human capital index as $H = Lh$ for each sector.

4. Results

Before presenting the results, I should discuss the periodization that I prefer in this paper for 2000–2024. The first period, 2000–2002, covers the home-made crisis years. The second period, 2003–2007, corresponds to the reform years. The period 2008–2010 covers the global economic crisis years. For both crisis periods, I include the rebound year in the crisis period to avoid an artificially high performance for the following period, as this year reflects a rebound from a low base. The fourth period, 2011–2014, is mainly a transition period in which we observe the first authoritarian signs. Finally, I group the years 2015–2024 as a period of stagnation/slowdown.

The periodization I use is very close to the one proposed by Atiyas and Bakis (2020, 2023). The only difference between this paper and the Atiyas and Bakis papers is regarding the year 2014. While they group 2011–2013 as a period, in this paper, I prefer 2011–2014. The reason for this slight change is as follows. Even if we agree that 2014 is a turning point, we can still see it as the continuation of the period that started in 2011 because the presidential election was held on August 10, 2014, and there were only four months of the calendar year remaining. I prefer to associate 2014 with the "old regime" rather than the new one. This choice of periodization is, of course, arbitrary, but it reflects major changes that have occurred in the preferences of political authorities in Turkey. For example, Turan (2019) and Insel (2021) both argue that the 2014 presidential election was a turning point in the change of political regime in Turkey.[14]

Fig. 1 shows the contribution of capital, human capital and TFP growth to overall GDP growth in Turkey between 2000 and 2024. TFP growth is especially high in the 2003–2007 and 2011–2013 periods, where TFP growth can explain more than 25 percent of the overall GDP growth. TFP growth is, as expected, negative in crisis years, 2000–2002 and 2008–2010 periods. The last period (2015–2024), where there is no TFP growth, is more interesting. To better understand what is happening one should compare the 2015–2024 period with the 2003–2007 period. Even if capital and human capital growth are very similar in both periods, because of a lack of any improvement in TFP, GDP growth is lower by 2.2 percentage points (only 4.8 percent instead of 7 percent). With almost the same inputs, Turkey has produced far less output than expected.

Fig. 2 shows the TFP index for the aggregate economy and 4 broad sectors. The year 2000 value is normalized to 1 for all indexes. The most striking finding is the huge volatility in the construction sector.

[12] See Section 2, Exercise 6 for a concrete example.

[13] For the 1988–2013 period: https://biruni.tuik.gov.tr/isgucuapp/isgucu.zul?dil=2, and for the post-2014 period: https://biruni.tuik.gov.tr/medas/?kn=72&locale=en.

[14] Another option would be to use the 2018 Turkish presidential election as a turning point. Although this is attractive at first glance, because the parliamentary system of government was replaced by a presidential system with the 2017 referendum, it would ignore the fact that the regime change began in 2014.

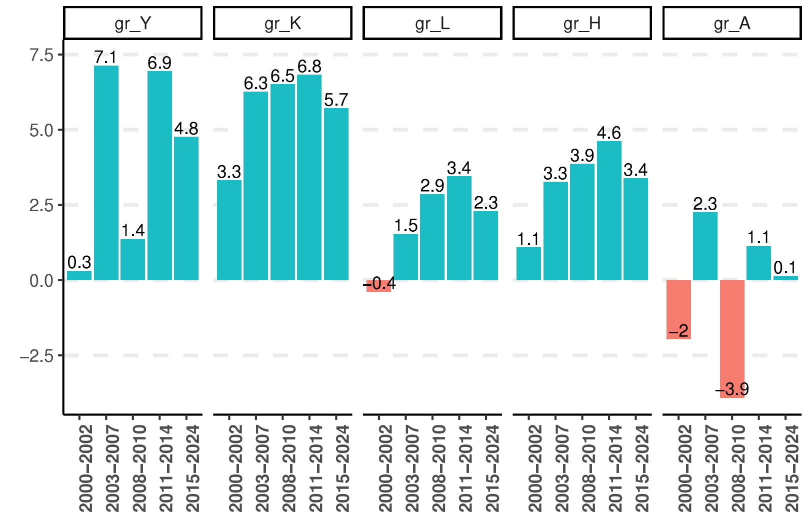

Fig. 1. GDP growth and factor accumulation.
Note: g_X is the average growth rate of X over the period where X is one of Y, K, L, H and A.

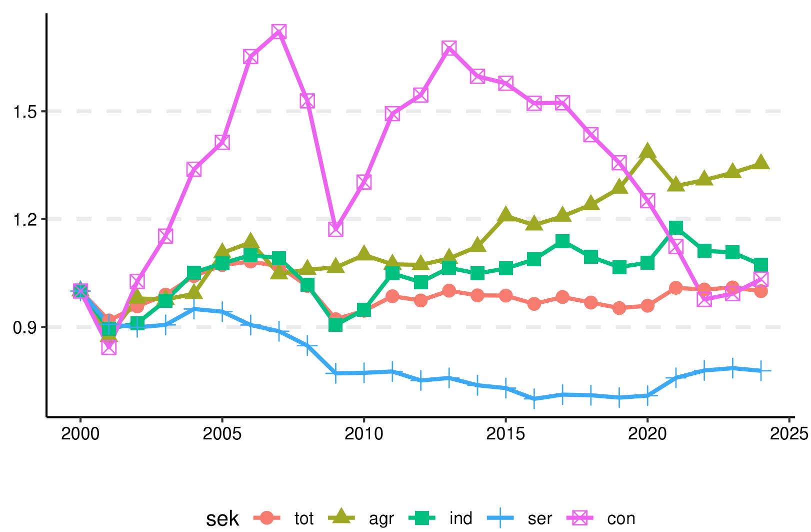

Fig. 2. Aggregate and sectoral TFP indexes.
Note: *tot* refers to aggregate economy; *agr*, *ind*, *ser*, *con* refer to, agriculture, industry, services and construction, respectively.

Between 2000 and 2009 we can say that TFP in construction is going in the same direction as other sectors but has far more volatility. Nevertheless, after 2010, productivity dynamics in the construction sector are completely independent of other sector dynamics. First, while TFP index in other sectors is almost horizontal in the 2010–2014 period, for construction there is a very strong and steady increase. Second, while other sectors keep their pace from the earlier period in the 2015–2024 period, for construction we observe very large declines. Another important finding is that compared to the year 2000, agriculture is the best performing sector while industry is the second one. Services and construction has TFP levels in 2024 that are below their 2000 levels. If we analyze the last 40 years (say post 1980 era) as in Atiyas and Bakis (2020) or Bakis and Acar (2020) then the industry becomes the best performing sector. The reason is the good performance of industry in 1980s and 1990s compared to other sectors.

Fig. 3 analyzes sectoral TFP growth by sector using our preferred periodization as well. Several observations can be made. First, as expected during crisis years — 2000–2002 and 2008–2010 — TFP growth is usually negative. The exception is positive TFP growth for construction in the 2000–2002 period. However, even in normal, non-crisis years, TFP growth is not always positive. While it is generally positive in the 2003–2007 and 2011–2013 periods, it is around zero or negative in the most recent period, 2015–2024.

Second, TFP growth tends to be positive in agriculture and negative in services. In industry and construction, it is volatile and follows a zigzag pattern, with higher volatility in construction. Third, the decline in TFP is more pronounced in construction and services than in agriculture. Fourth, low (or even negative) TFP growth in services likely reflects measurement problems in this sector.[15]

[15] A typical example is the valuation of non-market output produced by government units that is supplied free or at economically insignificant prices. Such services are valued at total production costs in National Accounts. Several studies highlight difficulties in measuring service sector output (Griliches, 1994; Wolff, 1999; Van Ark et al., 2008). The common point emphasized is that correctly measuring output in services is difficult, with the main challenges being inadequate adjustment for quality improvements and mismeasurement of price deflators.

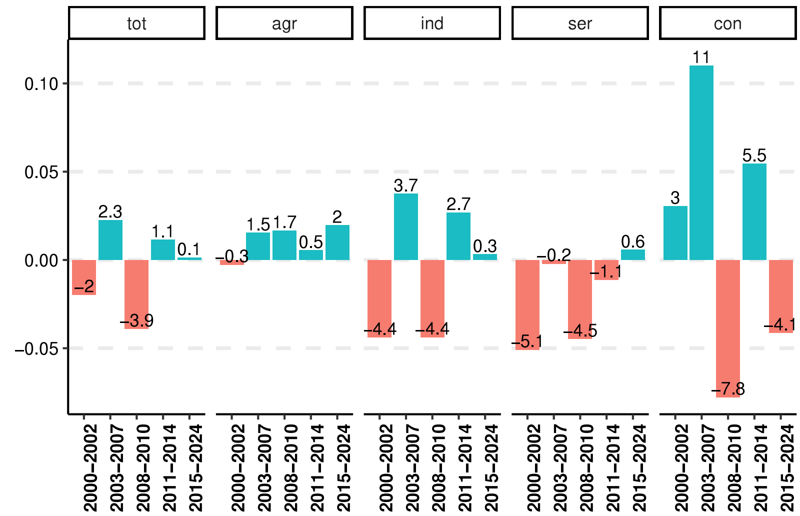

Fig. 3. Aggregate and sectoral TFP growth.
Note: *tot* refers to aggregate economy; *agr*, *ind*, *ser*, *con* refer to, agriculture, industry, services and construction, respectively.

Another element supporting this view is that low or negative TFP growth in services is not unique to Turkey. Similar findings are reported for OECD countries and the US (see, among others, Kets and Lejour, 2003; Foerster et al., 2022). Finally, compared to earlier studies (Bakis and Acar, 2020; Atiyas and Bakis, 2020, 2023) — which ignore improvements in schooling over time when calculating sectoral TFP growth — I find that schooling-adjusted TFP growth rates are slightly lower than unadjusted rates. Although my methodology for computing labor shares aligns with these studies, differences in results arise from subsequent data revisions. Part of this discrepancy is attributable to differences in estimated labor shares themselves.[16]

Now, I will analyze the contribution of capital, human capital, and TFP growth to sectoral GDP growth for each of the broad sectors. I start with agriculture. Table 3 shows the growth rates for both GDP and for the factors of production in agriculture. GDP growth is positive in all periods except the 2000–2002 period, which corresponds to local economic crisis. Surprisingly, the highest growth rate is obtained in the 2008–2010 period (5.6 percent), which corresponds to the global economic crisis. One of the reasons for this surprising finding is that TFP growth remains positive in agriculture even during a crisis, unlike other sectors (see also Fig. 3). Another one is the increase in agricultural employment. Compared to 2007, the number of workers was 17 percent higher in agriculture in 2010, while the same figure was 16 percent in construction, 6 percent in services, and 4 percent in industry. Nevertheless, the quality-adjusted labor (human capital) growth is negative in the 2000–2002, 2003–2007, and 2011–2014 periods and almost zero in the 2015–2024 period. The main reason for these decreases is migration out of rural areas into urban areas. This migration process seems to have been reversed during the 2009 crisis. The capital growth rate is always positive and between 1.5 percent and 3.2 percent. TFP growth is slightly negative during the 2000–2002 period but positive and relatively high in other periods (2 percent in the last period). One possible explanation for the good performance of agriculture in terms of TFP is hidden unemployment in agriculture (see Atiyas and Bakis (2014, 2020)).

Growth rates for both GDP and industrial production factors are shown in Table 4. Productivity dynamics in industry are very similar to the aggregate economy. TFP growth is high during 2003–2007 and 2011–2013 periods but negative during 2000–2002 ans 2008–2010 periods, which are crisis years. TFP growth is positive but relatively low in the 2015–2024 period. GDP growth is either negative are very low during crisis years but high in other periods. Capital growth is usually high (around 6 percent or above between 2003 and 2014, and 4.1 percent in the 2015–2024 period). A surprising finding is the contrast between two crisis periods: While during the first crisis the average capital growth is only 1.9 percent, during the second one it is 6.2 percent, which shows that the recovery was very fast after the global economic crisis. Human capital growth is positive and relatively high: above 3 percent in general, and 2.3 percent during the global crisis.

Table 5 shows the growth rates of GDP and of the factors of production for the services sector. Although TFP growth is negative in almost every period, it takes its lowest values in crisis years: −5.1 percent in 2000–2002 and −4.5 percent in 2008–2010. Capital growth is well above the other sectors. Average capital growth is close to 10 percent between 2000 and 2014, while it is 5.8 percent after 2014. Similarly, human capital growth has been well above the economic average, except in the period 2008–2010. The main driver of this continuous increase in human capital is migration from rural to urban areas. Average labor growth (g_L) is higher in the services sector compared to total labor growth with the exception of the 2008–2010 period. Since

Table 3
Growth rates of TFP and factors of production: agriculture.

	g_Y	g_K	g_L	g_H	g_A
2000–2002	−0.5	1.5	−2.0	−1.7	−0.3
2003–2007	1.2	2.2	−3.4	−2.6	1.5
2008–2010	5.6	1.7	5.2	5.8	1.7
2011–2014	1.9	3.2	−1.0	−0.3	0.5
2015–2024	2.9	2.0	−1.3	0.1	2.0

Note: g_X is the average growth rate of X over the period where X is one of Y, K, L, H and A.

Table 4
Growth rates of TFP and factors of production: industry.

	g_Y	g_K	g_L	g_H	g_A
2000–2002	−2.0	1.9	1.9	3.2	−4.4
2003–2007	8.9	6.5	2.1	2.9	3.7
2008–2010	0.4	6.2	1.4	2.3	−4.4
2011–2014	8.2	5.9	4.2	5.0	2.7
2015–2024	4.2	4.1	2.4	3.4	0.3

Note: g_X is the average growth rate of X over the period where X is one of Y, K, L, H and A.

[16] For instance, while Atiyas and Bakis (2023) use a labor share of 0.58 in agriculture, my estimate is 0.53. Similar minor differences exist in other sectors.

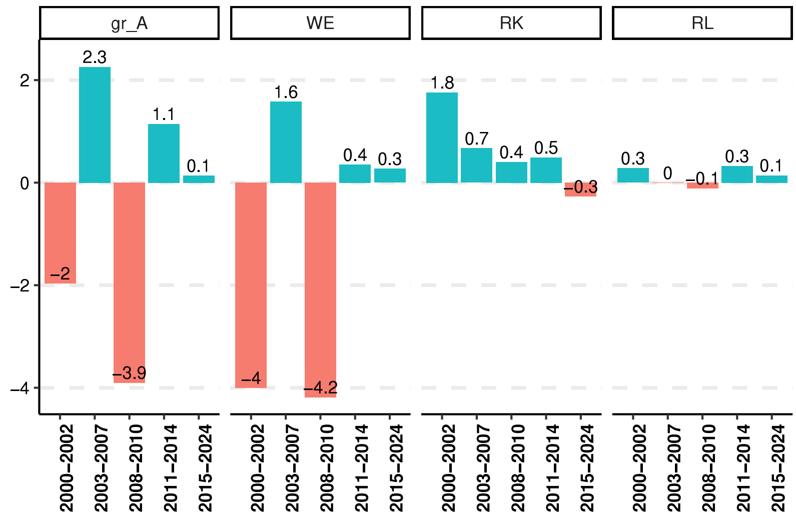

Fig. 4. Decomposing aggregate TFP growth.
Note: Average TFP growth (g_A) is decomposed into within component WE, the reallocation of capital RK, the reallocation of human capital (labor) RL.

Table 5
Growth rates of TFP and factors of production: services.

	g_Y	g_K	g_L	g_H	g_A
2000–2002	1.6	10.8	2.0	2.8	−5.1
2003–2007	6.5	9.5	3.5	4.1	−0.2
2008–2010	1.6	8.8	2.1	3.4	−4.5
2011–2014	6.6	9.7	4.7	5.8	−1.1
2015–2024	5.6	5.8	3.6	4.3	0.6

Note: g_X is the average growth rate of X over the period where X is one of Y, K, L, H and A.

Table 6
Growth rates of TFP and factors of production: construction.

	g_Y	g_K	g_L	g_H	g_A
2000–2002	−2.4	−0.6	−17.7	−14.1	3.0
2003–2007	16.1	4.3	6.3	6.5	11.0
2008–2010	−2.0	5.4	5.0	6.3	−7.8
2011–2014	11.8	5.3	7.2	8.2	5.5
2015–2024	1.1	6.9	1.2	2.1	−4.1

Note: g_X is the average growth rate of X over the period where X is one of Y, K, L, H and A.

$H = Lh$, an increase in L is directly translated into an increase in H. A typical example of this phenomenon would be a person who works in agriculture in the village, moves to a suburb in the city and starts working in the service sector.

Table 6 shows the growth rates for both GDP and the factors of production in construction. TFP growth is phenomenal during 2003–2007 and 2011–2014, respectively 11 percent and 5.5 percent. These exceptionally high TFP growth rates translate into even higher GDP growth above 10 percent (16.1 and 11.8 percent, respectively). In fact, capital growth is similar to industry sector between 2003 and 2014, while human capital growth is higher in the same period. The last period, 2015–2024, is very interesting: we have unusually high capital accumulation (6.9 percent), low human capital growth (2.1 percent) and negative TFP growth (−4.1 percent), resulting in declining GDP growth on average. The period from 2015 to 2024 is similar to the global crisis (2008–2010) for the construction sector.

Fig. 4 shows the results of TFP decomposition found in Eq. (2). Among the 5 periods analyzed, aggregate TFP growth (g_A) is higher than the within component (WE) in 3 periods: 2000–2002, 2003–2007, 2011–2014. They are almost equal in the 2008–2010 and 2015–2024 periods. This implies that the reallocation effect is approximately zero during the 2008–2010 and 2015–2024 periods. While the reallocation effect of labor (RL) is usually positive and low, the reallocation effect of capital (RK) contributed to TFP growth significantly in the past. The magnitude of RK is between 0.4 and 1.7 percentage points between 2000 and 2014. To gauge the significance of this figure, it should be remembered that the average aggregate TFP growth between 2003 and 2007, the best period in terms of TFP performance, was only 2.3 per cent. However, after 2014 average value of RK is small and negative (0.3 percentage points).

To make sure that this average is not driven by any outliers, I prepared Fig. 5. There is a clear declining trend for RK, while there is no clear trend for RL. As a result, we can say that during the period 2000–2022, the reallocation of capital not only worsened over time, but also became consistently negative after 2014. This is in line with previous studies which find that resources were directed to unproductive sectors, especially construction. It is important to note that since only 4 sectors were used for the decomposition, the calculated RK effect represents a lower bound.

5. Conclusion

This paper has two objectives: First, to decompose aggregate TFP growth so that we can separate the effect due to the reallocation of factors of production across sectors from the within component, which reflects technological changes occurring within each sector. Second, to conduct a growth accounting exercise for both the aggregate economy and for agriculture, industry, construction, and services, taking into account improvements in schooling.

An important contribution of the paper is to show that the reallocation effect is generally positive for labor (except during crisis years); however, for capital, there are two separate periods. In the 2000–2014 period, the reallocation effect is positive for capital, whereas it becomes consistently negative in the 2015–2024 period. My analysis shows that expansionary economic policies following 2016 led to some growth in the short run, but their long-term benefits to society are questionable due to the efficiency problems they caused.

Taking into account improvements in schooling, I find that TFP growth is high between 2003 and 2007 and 2011 and 2014, negative during crisis years (2000–2002 and 2008–2010), and almost zero during the 2015–2024 period. TFP growth is relatively low in the construction and services sectors. The construction sector is also characterized by very volatile and unsustainable TFP growth.

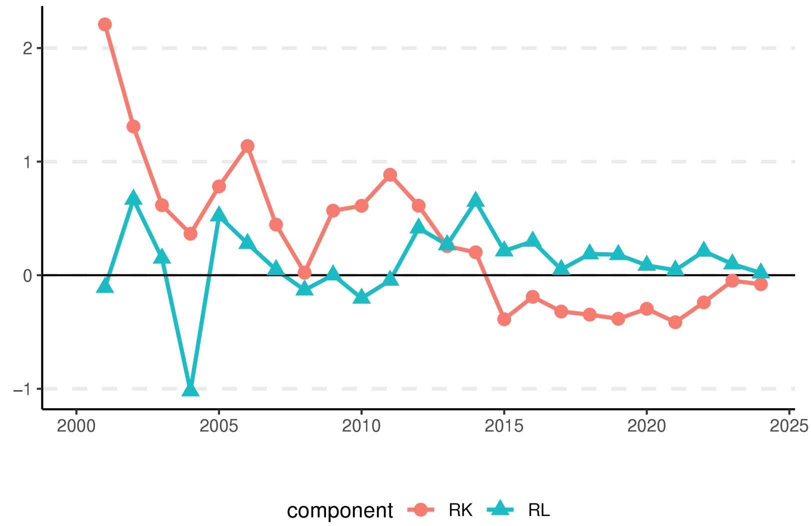

Fig. 5. Reallocation effect of capital and labor. **Note**: RK nad RL refer to the reallocation effect due to capital and human capital over time.

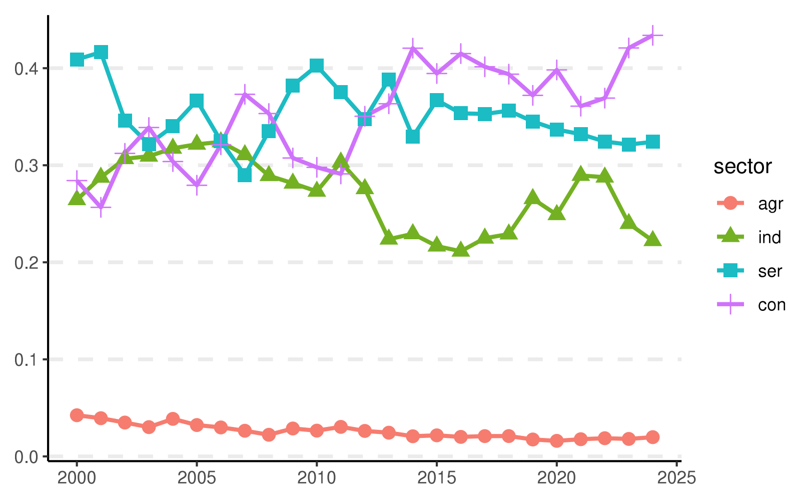

Fig. A.6. Sectoral shares in investment at current prices: 2000–2024.
Note: agr, ind, ser, con refer to agriculture, industry, services and construction, respectively.

Appendix. Additional figures

See Fig. A.6.

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