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Sources of Labor Productivity Growth in the Turkish Economy: A Sectoral Decomposition Analysis

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ABSTRACT

Purpose: This paper examines the sectoral contributions to aggregate labor productivity growth in Türkiye from 2002 to 2023.

Methodology: The analysis applies both conventional decomposition techniques (TRAD and CSLS) and more recent exactly additive approaches (GEAD and extended GEAD) to identify the sources of labor productivity growth at the aggregate and sectoral levels.

Findings: The results indicate that within-sector growth effects are the primary drivers of aggregate labor productivity growth, while reallocation level and reallocation growth effects play a more limited role. Although the methods yield broadly consistent results at the aggregate level, they generate notable differences in sectoral contributions. Manufacturing and trade services contribute positively to aggregate productivity growth under the TRAD, GEAD, and extended GEAD frameworks, whereas the CSLS approach produces more heterogeneous sectoral outcomes. The FSGR analysis reveals a negative Baumol-type growth effect in agriculture and construction, which is partially offset by positive contributions from other sectors.

Originality: By combining conventional and recent decomposition methods within a unified framework, the study provides additional evidence on the sensitivity of sectoral productivity assessments to methodological choice in the Turkish context.

Keywords: Labor Productivity Decompositions, Sectoral Contributions, FSGR, The Turkish Economy.
JEL Codes: E24, L16, O47.

Türkiye Ekonomisinde İşgücü Verimliliği Artışının Kaynakları: Sektörel Ayrıştırma Analizi

ÖZET

Amaç: Bu çalışmanın amacı, 2002-2023 yılları arasında, Türkiye’de toplam işgücü verimliliği artışına sektörlerin katkılarını incelemektir.

Yöntem: Ekonomi genelinde ve temel sektörler düzeyinde verimlilik artışının kaynaklarını belirlemek ve karşılaştırmak amacıyla geleneksel (TRAD ve CSLS) ile daha yeni, tam toplanarak ayrıştırılabilir (GEAD ve genişletilmiş GEAD) ayrıştırma yöntemleri uygulanmıştır.

Bulgular: Bulgular, toplam emek verimliliği artışının esas olarak sektör içi büyüme etkileri tarafından belirlendiğini, yeniden tahsis düzeyi ve yeniden tahsis büyüme etkilerinin ise daha sınırlı bir rol oynadığını göstermektedir. Yöntemler toplam düzeyde büyük ölçüde benzer sonuçlar üretmekle birlikte, sektörlerin katkıları açısından belirgin farklılıklar ortaya koymaktadır. TRAD, GEAD ve genişletilmiş GEAD yaklaşımlarına göre imalat sanayi ve ticaret hizmetleri toplam verimlilik artışına olumlu katkı sağlarken, CSLS yöntemi sektörler arasında daha heterojen sonuçlar üretmektedir. FSGR analizi, tarım ve inşaat sektörlerinde Baumol tipi olumsuz bir büyüme etkisine işaret etmekte; bu etki diğer sektörlerden gelen sınırlı olumlu katkılarla kısmen dengelenmektedir.

Özgünlük: Bu çalışma, Türkiye ekonomisini hem geleneksel hem de modern ayrıştırma yaklaşımlarını bir araya getirerek karşılaştırmalı bir analizle incelemektedir.

Anahtar Kelimeler: İşgücü Verimliliği Ayrıştırması, Sektörel Katkılar, FSGR, Türkiye Ekonomisi.
JEL Kodları: E24, L16, O47.

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1. INTRODUCTION

Factor accumulation and productivity are the two primary sources of economic growth. However, factor accumulation eventually faces diminishing marginal returns. Therefore, enhancements in productivity emerge as the main driver of economic growth and well-being over the long run. Additionally, productivity establishes the economic foundation for investments in education, infrastructure, and industrial upgrading. Given the socioeconomic importance of productivity, it is essential to monitor both productivity growth and levels from an economic policy perspective. A strong correlation exists between competitiveness and productivity. Competitiveness is typically defined as the ability of firms, industries, or nations to handle international competition while ensuring sustainable, relatively high returns on their production factors. Increased productivity is often viewed as synonymous with enhanced competitiveness.

Productivity growth depends on several factors, particularly innovations, investments in high-tech sectors, and human capital development. Human capital, especially in technology-driven industries, boosts productivity by enabling the accumulation and sharing of knowledge. In other words, economic development and productivity growth stem from having a well-educated workforce. The knowledge and skills necessary to effectively utilize that knowledge are crucial for a nation's competitiveness. Rises in labor productivity and hours worked, which indicate the potential or trend growth rate, serve as essential indicators of production capacity. Macroeconomic policies strive to align the economy's production capacity with aggregate demand. Without this balance, the economy may encounter an inflationary or deflationary gap. The trend growth rate reflects the economy's long-term potential growth and corresponds with the non-accelerated inflation rate of unemployment (NAIRU). Therefore, accurate productivity estimates are essential for effective monetary and fiscal policy (Blinder, 1997).

Understanding the factors driving aggregate productivity growth is crucial. It requires a comprehensive grasp of each industry's contributions. The significance of some industries in overall productivity growth has recently attracted attention. This interest has largely arisen in advanced nations due to the productivity growth observed after the 1990s, particularly in the U.S. and Canada. IMF studies indicate that more than half of the slowdown in economic growth is associated with slower increases in total factor productivity since the global financial crisis of 2008. If this trend persists for another decade, it could considerably lower living standards and jeopardize economic and social stability (Bhatt, 2024). Differences in labor productivity growth among sectors may be linked, for example, to how intensively they utilize capital (including physical, human, and knowledge-based capital) and skilled labor in production, as well as to opportunities for product and process innovation, economies of scale, and participation in global value chains (OECD, 2017:58). This potential outcome emphasizes the importance of focusing on the contributions of industries to overall productivity.

It is essential to elaborate on sectoral productivity growth to understand the impact of industrial productivity on aggregate labor productivity growth. This analysis can uncover important variations among sectors in terms of labor productivity levels and growth. The objective of this study is to decompose the sectoral contributions to aggregate labor productivity growth in Turkey, using annual data from 2002 to 2023 sourced from the Turkish Institute of Statistics, specifically the "National Accounts" and the "Employment, Unemployment, and Wage" databases. The analysis of labor productivity growth will achieve two main objectives. First, it will help figure out which industries have contributed the most to aggregate labor productivity over time. By employing these decomposition techniques, we can investigate productivity growth through within-sector effects, static and dynamic reallocation effects, and the influence of relative prices. Second, it aims to determine whether the sources of the productivity slowdown in the Turkish economy are due to specific sectoral declines or a misallocation of resources across sectors.

Additionally, methods for measuring economic activity have evolved. Many statistical agencies now utilize chain-weighted price indices instead of constant base-year prices. Except for Mexico, all OECD countries apply chained volume indexes that employ various index number formulas (Laspeyres, Paasche, Fisher, etc.) (OECD, 2023: 19). The Turkish Statistical Institute (TurkStat) began compiling GDP figures in a chain-linked volume series in 2016 to align with the UN System of National Accounts (SNA-2008) and the European System of Accounts (ESA-2010). This new series extends back to 1998, with 2009 as the reference year. Due to its characteristics, the chain method presents practical challenges, the most significant of which is the additivity problem related to aggregate GDP and its components. Consequently, in the production approach, this additivity issue arises concerning sectoral contributions to the aggregate volume in real series derived from the chain method. This complicates the assessment of growth figures and hampers accurate calculations of contributions to growth or productivity when outdated methods are used (Bakış, 2018).

However, productivity decomposition analysis continues to rely on traditional methods. Recently, new approaches to productivity decomposition have been developed and applied to data from advanced countries like the U.S. and Canada. This study integrates both traditional and modern methods for a comparative analysis of the Turkish economy. The traditional shift-share method (TRAD) and a technique from the Centre for the Study of Living Standards (CSLS) in Canada serve as conventional methods. In contrast, the generalized exactly additive decomposition (GEAD) method developed by Tang and Wang (2004), along with its subsequent extension by Diewert (2015), represents the new approaches.

This paper makes a valuable contribution to the existing literature by examining the sectoral sources of labour productivity growth in Turkey between 2002 and 2023. This period encompasses significant structural changes and the transition to chain-linked national accounts. Both conventional shift-share techniques and more recent exactly additive decomposition methods are employed, enabling a comparison of alternative approaches using chain-linked data. By distinguishing among within-sector productivity dynamics, reallocation effects and relative price changes, the analysis provides additional empirical evidence on the composition of productivity growth and slowdown. This evidence could inform discussions on productivity-oriented, selective industrial policy in Turkey and other middle-income economies.

The following sections of this paper are organized as follows: Section two provides a concise review of the relevant literature on labor productivity decomposition and examines the factors that contribute to productivity growth. Next, we present the decomposition methods, outline the measurement challenges, and provide an overview of the data. Next, we utilize various decomposition methods on the annual data categorized by NACE Rev. 2 to assess the sectoral contributions to the aggregate labor productivity growth of the Turkish economy from 2002 to 2023. We analyze each sector's contribution to identify the impacts of within-sector productivity gains (WSE), the reallocation level effect (RLE), the reallocation growth effect (RGE), and the relative price effects on aggregate labor productivity growth. The concluding section summarizes the findings and analyzes the policy implications for the Turkish economy.

2. BRIEF REVIEW of the LITERATURE

“Productivity” is evaluated by comparing an output index to an input index. Economists prefer to work with real variables as they offer a more precise assessment of economic welfare. However, national income accounts assess value added or output in nominal terms. Consequently, economists need a suitable price index to adjust the nominal output into the real volume measures. Likewise, when transitioning from individual sectors to the aggregate (productivity), decisions need to be made regarding how to process the data for measuring productivity: Should the nominal output be deflated using a separate output price index for each sector, or should a single aggregate price deflator be utilized? Another decision concerns the sectoral weights that should be used to achieve aggregate productivity. Should the sector's share of nominal output, real output, or employment be used as a weight in aggregation? These will differ significantly when the changes in relative prices vary among sectors (Coyle and Mei, 2023). Due to these and similar questions, the methods for measuring productivity have sparked various controversies and evolved over time. As a result, diverse measurement methods spread throughout the productivity literature. The traditional decomposition (TRAD) method represents the standard shift-share analysis. This conventional method implicitly assumes that price changes across different sectors are identical. Under this assumption, the nominal output share-weighted sum of sectoral labor productivities is exactly additive to aggregate labor productivity (Fabricant 1942; Fagerberg 2000; Timmer and Szirmai 2000).

Tang and Wang (2004) discuss the flaws of earlier conventional decomposition methods and introduce the “Generalized Exactly Additive Decomposition” (GEAD) method. The GEAD approach applies to any index number, including chained-fisher indices, and maintains accuracy over prolonged periods. It is also base-year invariant. Decomposing individual industries’ contributions to aggregate productivity growth requires exactly additive output and/or value-added figures. Statistical agencies in industrialized countries like Canada and the U.S. utilize chained indexes in national income accounts, which are not additive. Thus, they cannot measure industry contributions using traditional methods. The GEAD method decompose industry contributions to productivity into three components: the *pure productivity growth effect*, the *relative size change effect*, and the *interaction term*. Results showed that the overall labor productivity growth gap between Canada and the U.S. was attributed mainly to manufacturing and services’ pure productivity growth effect from 1987 to 1998. However, the changes in relative size render services the primary factor behind the labor productivity growth gap. They also provide evidence suggesting that resources did not shift from low to high productivity growth. This finding aligns with Baumol’s cost disease phenomenon in stagnant industries. In his paper “The Macroeconomics of Unbalanced Growth,” William J. Baumol (1967) argues that in sectors where productivity is increasing, such as manufacturing, wage rates are also rising at a similar pace to those in industries with slower productivity growth, like services. As a result, costs and prices rise more quickly in the less productive sectors, leading to a larger share of total spending coming from these sectors. This phenomenon is known as “cost disease.”

Tang and Wang (2015) present a new framework that assesses industry contributions based on output quantity and value compared to other industries. This framework challenges traditional methods that neglect the price effect, leading to underestimating demand-driven and overestimating supply-driven industries in aggregate measures. Between 1981 and 2007, demand-driven businesses such as financial intermediation, real estate, and other business services were the main drivers of real GDP growth in Canada and the U.S. business sectors. While supply-driven manufacturing and service sectors—including electrical and optical goods, wholesale trade, retail trade, and post and telecommunications—positively contributed to real GDP growth, the decline in their relative output prices partially reduced these benefits. Demand-driven sectors played a significant role in the overall growth during this period. They demonstrate that this method indicates a higher contribution from demand-driven industries compared to traditional decompositions.

Building on the Tang and Wang (2004) decomposition, Diewert (2015) examines labor productivity growth by breaking it down into sectoral components. The overall labor productivity growth of the economy depends on the productivity growth rates of various sectors, fluctuations in real output prices, and changes in sectoral labor input shares. Similarly, the decomposition of economy-wide TFP growth into its components follows a comparable approach. However, his analysis includes additional terms related to changes in real input prices.

Dumagan (2013) compares the traditional TRAD and standard GEAD methods using real output data with fixed base year prices and chain-linked volumes. The paper show that GEAD is more accurate in decomposing labor productivity growth when real output is measured either in constant prices or chained volume measures. On the other hand, TRAD is additive only when sectoral output data is deflated using a single price deflator. The main implication is that traditional methods should be replaced by GEAD, yet recent studies continue to utilize TRAD.

De Avillez (2012) used traditional decomposition methods (TRAD and CSLS) and GEAD to assess sectoral contributions to aggregate labor productivity growth in Canada's business sector from 2000 to 2010. There is significant agreement between traditional methods and GEAD at the macroeconomic level. Both methods clarify most developments in labor productivity through the within-sector effect. However, the estimated contributions at the sector level vary significantly. Specifically, the contributions from the construction, manufacturing, mining, and oil and gas extraction industries vary considerably. The author asserts that the discrepancies arise because the classical decomposition formulas (TRAD and CSLS) reflect only the impact of real variables, while the GEAD method takes into account the changes in relative prices on the growth of aggregate labor productivity.

Nishi (2019) analyzed the decomposition of aggregate labor productivity growth in Japan from 1970 to 2010 and examined whether Baumol’s growth disease (BGD) impacts Japanese economic performance. The author uses three decomposition methods: the generalized exactly additive decomposition (GEAD), Diewert’s GEAD, and the Centre for the Study of Living Standards (CSLS) decomposition. The study indicated that the CSLS decomposition is the most appropriate method for analyzing BGD in Japan.

Montebello and Darmanin (2021) examined the sectoral contributions to the growth of aggregate labor productivity in Malta. The study employed the GEAD method and annual data from 2000 to 2020. The findings indicate that labor productivity growth in Malta averaged 1.2% from 2000 to 2019, double the Euro area rate. During this period, productivity growth in Malta was primarily driven by the services sector, with manufacturing contributing negatively and only a minimal impact from trade and construction. The results indicated increased variability when analyzed in sub-periods. In the pre-financial crisis period from 2000 to 2007, productivity growth was robust, fueled by the reallocation of resources from low- to high-productivity sectors. The productivity slowdown from 2008 to 2012 appears to stem from within-sector effects, whereas the acceleration in productivity from 2013 to 2019 is attributed to the reallocation of labor across sectors.

Coyle and Mei (2023) employed the Tornqvist technique to analyze the decline in labor productivity of some developed countries. The study examined the decrease in labor productivity growth by investigating intra-sector productivity growth and labor reallocation between sectors. The within sector effect seems to be the source of the slowdown. Analysis of trends before and after 2008 shows that the manufacturing and information and communication sectors mainly drove the drop in overall productivity. The decline in productivity growth in the UK was primarily driven by transport equipment, pharmaceuticals, electronic and optical products in the manufacturing sector, along with consulting and related activities, computer programming, and telecommunications in the information and communication sector. The authors additionally employ the shift-share and GEAD methods. The GEAD approach suggests that reallocation effects play a more significant role in the slowdown of aggregate productivity. In contrast, the shift-share method suggests that reallocation effects are relatively insignificant, aligning closely with the findings of the Tornqvist approach. The alternative methods highlight the importance of various weights in decomposition.

The authors argue that the overlooked quality variation is also significant, alongside the selection of weights and output price deflators.

Voyvoda and Yeldan (2001) investigated productivity in Turkey, focusing specifically on the manufacturing sector. Their analysis covered two distinct periods: 1969-1976, referred to as the import substitution period, and the post-1980 period, which included structural adjustment reforms aimed at integrating Turkey into global markets. The findings showed minimal changes in the sectoral composition and only slight contributions to productivity gains following the structural adjustments of the post-1980 era. Notably, these productivity gains did not result in increases in wage labor. Ultimately, the research concluded that the post-1980 structural adjustment reforms were ineffective in boosting productivity and unsustainable as a strategy for export-led industrialization.

Kılıçaslan and Taymaz (2005) used the conventional shift-share method to examine the effect of structural change on manufacturing in several economies across the Middle East, North Africa, and Asia from 1965 to 1999. Their findings suggest that structural change had a minimal impact on productivity growth for most countries, including Turkey, especially after the 1980s. Akkemik (2006) utilized the conventional shift-share method to analyze how structural changes in Turkish manufacturing industries affected productivity from 1970 to 2000, encompassing 19 manufacturing sectors. The study indicates that, before 1980, labor shifts positively affected manufacturing labor productivity during the import substitution era. However, after 1980, in the export-oriented phase, this influence became negative.

Altıok and Tuncer (2006) used traditional shift-share analysis to investigate the impact of structural changes on labor productivity in the Mersin Province, the Mediterranean Region, and Turkish manufacturing industries from 1980 to 2008. Their findings indicate that structural change has only a limited impact on labor productivity growth. Another study on structural change and productivity growth in the Turkish economy is conducted by Rodrik (2010). It examines two periods, 1990-2005 and 1999-2008, with findings showing that structural change contributed 45 percent and 38 percent to aggregate productivity growth, respectively. Therefore, structural change has significantly influenced overall labor productivity growth.

Atiyas and Bakış (2015) analyze Turkey's industrial policy and structural transformation from 1981 to 2010, with a particular focus on the 2000s. Their assessment uses the traditional shift-share method and reveals a notable increase in labor productivity, driven by structural changes resulting from labor reallocation across sectors. They emphasize the diversity of firm sizes, the composition of exports, the technological content of exports, and the import dependence of exporting industries. Despite enhancements in Turkey's export mix, it remains limited compared to countries like China, Mexico, Romania, and Thailand. Furthermore, the incentive framework in the Turkish economy shows minimal sectoral selectivity during a time of significant structural change. The paper asserts that industrial policy did not directly affect this structural transformation, highlighting the considerable shortcomings of the incentive regime.

Tuncer and Moalla (2020) demonstrate that the structural transformation of Turkey's three-digit industry and service sectors hinders rather than facilitates growth. This adverse structural shift lowers average productivity and exacerbates disparities in sectoral productivity levels. Productivity gains primarily arise from the within-growth effect, which is largely driven by improvements in physical and human capital, innovations, and research initiatives. The slowdown in growth attributed to this unfavorable structural shift is mainly due to macroeconomic and microeconomic policies. For example, a competitive or undervalued real exchange rate is crucial for promoting structural changes that foster growth. However, empirical studies on the Turkish economy, including the IMF (2015), indicate that the real effective exchange rate has consistently been 10–20% higher than what medium-term fundamentals suggest for the Turkish economy during the first decade of the 2000s. Furthermore, the lack of selectivity of the Turkish economy's incentive system and government policies negatively impacts aggregate productivity. The findings also indicate variability in results across sectors, suggesting a focus on total factor productivity when examining the relationship between structural change and productivity development.

This paper analysis applies both conventional decomposition techniques (TRAD and CSLS) and more recent exactly additive approaches (GEAD and extended GEAD) to identify the sources of labor productivity growth at the aggregate and sectoral levels. By integrating traditional and more recent decomposition techniques within a unified analytical framework, the study offers further evidence that sectoral productivity assessments in Turkey are highly sensitive to the choice of methodology.

3. METHODOLOGY

Traditional methods for calculating industrial contributions to aggregate labor productivity growth assume that real output or value added is additive. When real output is additive, aggregate productivity equals the weighted sum of productivity across its sectors. This assumption allows the traditional decomposition methods (TRAD and CSLS) to be applied without drawbacks. However, in this scenario, selecting the base year may introduce ambiguities because output prices in various industries can change by different magnitudes over time.

The simplest and oldest method for decomposing sectoral contributions to aggregate productivity growth within a constant price framework is known as “traditional decomposition” (TRAD). This study refrains from deriving conventional methods, such as TRAD and CSLS decomposition, because these methods are well-documented in the literature. According to Dumagan (2012:5) and IMF (2006:24), the traditional method (TRAD) dates back to Denison (1962 and 1967). It continues to be employed in various studies, including those by Bloom et al. (1999), IMF (2006), Asian Development Bank (2010), Usui (2011) and De Vries et al. (2015). We focus entirely on the essence and application of these methods.

Suppose the nominal value-added, real value-added, and labor are denoted by Y, VA, and L, respectively. Consider two periods: the base year (t-1) and the end year (t). By definition, the labor productivity (LP_i^t) of any sector *i* at time *t* would be $LP_i^t = \frac{VA_i^t}{L_i^t}$. Also, let LP^t be the corresponding measure of aggregate labor productivity, and let $l_i^t = L_i^t/L^t$ be the share of the arbitrary industry *i* in aggregate employment, where L^t is the total over all industries of L_i^t. Next, by combining the definitions stated above, the decomposition of TRAD labor productivity growth is represented as in Equation 1:

$$G_{LP}^t = \sum_i \left[\frac{VA_i^{t-1}}{VA^{t-1}}\ G_{LP_i}^t + \frac{LP_i^{t-1}}{LP^{t-1}}(l_i^t - l_i^{t-1}) + \frac{LP_i^{t-1}}{LP^{t-1}}(l_i^t - l_i^{t-1})G_{LP_i}^t\right] \quad (1)$$

Equation 1 is the TRAD decomposition formula, which breaks down aggregate productivity growth into three components. On the left-hand side is the aggregate labor productivity growth. The first term on the right side of the equation indicates the within-sector effect (WSE), quantifying the contribution resulting from productivity increases within individual sectors. The other two terms illustrate the impacts of labor shifts across sectors. The second term of the equation represents the change in aggregate labor productivity as labor shifts to sectors with above-average productivity levels, even if productivity within sectors remains unchanged. This is referred to as the reallocation level effect (RLE). The third term refers to the reallocation growth effect (RGE), which indicates the tendency of labor to shift toward sectors where productivity is stagnant or declining (de Avillez 2012).

Like the TRAD formula, the CSLS decomposition formula is additive under the assumption of real output in constant prices. By definition of additivity, the aggregate labor productivity (LP^t) is equal to the labor share (l_i^t) weighted sum of individual sector labor (LP_i^t) productivities, i.e., $LP^t = \sum_i^n LP_i^t\ l_i^t$. From this definition, the absolute change in labor productivity between two periods is: $LP^t - LP^{t-1} = \sum_i^n (LP_i^t\ l_i^t - LP_i^{t-1} l_i^{t-1})$ adding, subtracting and rearranging terms will give the CSLS formula for labor productivity growth decomposition (Equation 2):

$$G_{LP}^t = \frac{\sum_i(\Delta LP_i^t\ l_i^{t-1})}{LP^{t-1}} + \frac{\sum_i(LP_i^{t-1} - LP^{t-1})\ \Delta l_i^t}{LP^{t-1}} + \frac{\sum_i(\Delta LP_i^t - \Delta LP^t)\ \Delta l_i^t}{LP^{t-1}} \quad (2)$$

The CSLS equation (Equation 2), like the TRAD equation (Equation 1), shows that the aggregate labor productivity growth G_{LP}^t can be broken down into the within-sector effect (WSE), the reallocation level effect (RLE), and the reallocation growth effect (RGE) (de Avillez, 2012; Nishi, 2019).

The within-sector effect (WSE) is the same in the TRAD and CSLS methods of productivity decomposition. The reallocation effect in the TRAD formula implies that above-average labor growth in a sector always positively contributes to aggregate productivity growth, provided that the sector’s labor productivity is positive. Equating employment growth with productivity growth in any sector in this manner is intuitively problematic. However, the labor reallocation effect can be evaluated by quantifying each industry's productivity level relative to the mean productivity, yielding economically meaningful insights (Reinsdorf 2015). This modification of the traditional decomposition method was developed by the *Center for the Study of Living Standards* (CSLS) in Canada and referred to as “the CSLS decomposition” by de Avillez (2012).

This study also employs the Generalized Exactly Additive Decomposition (GEAD) method for productivity decomposition, as developed by Tang and Wang (2004). The GEAD method accommodates variations in real output prices across sectors, breaking down labor productivity growth into three components: sector-specific labor productivity growth, the share of total employment by sector, and the sector's terms of trade (the output price index of the sector relative to the aggregate output price index) (Diewert, 2014). This method is the best choice because it highlights each sector’s performance and contributions to overall labor productivity growth, independent of the price index used in compiling the data. This study succinctly derives the GEAD and its extended version proposed by Diewert (2015).

Since each industry produces different types of outputs, an aggregation problem occurs. To overcome this aggregation problem, the output of each sector would be weighted by its price index to find the values in terms of monetary units, summing to see the aggregate value of output, and dividing this sum by a general price index. When various price indexes or chain-linking methods are used to measure output or value added, the weighted sum of each sector's real value added (VAi) does not equal the total real value added (VA). The GEAD equation defines growth in aggregate labor productivity (G_{LP}^{t}) as a function of each (i) sector's labor productivity growth ($G_{LP_i}^{t}$), its labor share (l_i), and its relative prices (p_i) (Equation 3).

$$G_{LP}^{t} = \sum_i \left[\frac{Y_i^{t-1}}{Y^{t-1}} G_{LP_i}^{t} + \frac{LP_i^{t-1}}{LP^{t-1}}(p_i^t l_i^t - p_i^{t-1} l_i^{t-1}) + \frac{LP_i^{t-1}}{LP^{t-1}}(p_i^t l_i^t - p_i^{t-1} l_i^{t-1}) G_{LP_i}^{t}\right] \quad (3)$$

On the left side of the equation is the aggregate labor productivity growth. The first term on the right-hand side is the *pure productivity growth effect* (PPGE). This effect highlights productivity gains in various sectors resulting from technological advancements, automation, industrial upgrading, and workforce upskilling. This isolation of pure productivity growth is essential as it captures the impact of productivity changes independent of non-efficiency factors, such as shifts in the sector's relative size (Tang and Wang, 2004).

The second and third terms of the GEAD collectively illustrate the effects of resource reallocation or structural changes on overall labor productivity growth. The second term is the *reallocation level effect* (RLE), which reflects the impact of labor movement among sectors resulting from shifts in the relative size of each sector. Aggregate labor productivity can rise even if within-sector productivity stays the same as long as labor shifts to sectors with high productivity. For instance, the shift of labor from low- to high-productivity sectors will improve overall labor productivity (Montebello and Darmanin, 2021).

The third term is an interaction term that encompasses the effects of both real productivity growth and labor reallocation, commonly known as the *reallocation growth effect* (RGE). This effect evaluates whether resources flow toward stagnant sectors, suggesting that the economy is facing Baumol's cost disease (De Avillez, 2012).

Diewert (2010) refined the GEAD methodology proposed by Tang and Wang (2004) to distinguish the effect of price changes as a separate term. By treating all elements of the decomposition symmetrically, Diewert (2010) expressed the total contribution of any industry (*i*) to aggregate productivity growth as the sum of three components. First, productivity growth within the sector, while keeping the sector's price and labor growth constant; second, price growth, while maintaining the same sector productivity growth and labor share; and third, growth in labor share, while keeping productivity and price growth constant, respectively (Equation 4):

$$G_{LP}^{t} = \sum_i (S_{VA_i}^{t-1})(G_{LP_i}^{t}) + \sum_i (S_{VA_i}^{t-1})(G_{p_i}^{t}) + \sum_i (S_{VA_i}^{t-1})(G_{l_i}^{t}) + \sum_i (S_{VA_i}^{t-1})(G_{p_i}^{t})(G_{l_i}^{t}) +$$

$$\sum_i (S_{VA_i}^{t-1})(G_{LP_i}^{t})(G_{l_i}^{t}) + \sum_i (S_{VA_i}^{t-1})(G_{LP_i}^{t})(G_{p_i}^{t}) + \sum_i (S_{VA_i}^{t-1})(G_{LP_i}^{t})(G_{l_i}^{t})(G_{p_i}^{t}) \quad (4)$$

The productivity decomposition equation (Eq.4) comprises seven explanatory terms on the right-hand side. All these terms can be calculated for each sector and contribute to the overall growth of labor productivity. Usually, researchers might find it challenging to consider so many explanatory factors. Moreover, in most cases, only the first-order terms, $\sum_i (S_{VA_i}^{t-1})(G_{LP_i}^{t}) + \sum_i (S_{VA_i}^{t-1})(G_{p_i}^{t}) + \sum_i (S_{VA_i}^{t-1})(G_{l_i}^{t})$, are found to be important in magnitude. Thus, Diewert (2014) proposed consolidating these seven components into the following three (Equation 5, 6, 7).

$$\Delta X_i = S_{VA_i}^{t-1} G_{LP_i}^{t}\left[1 + (1/2)G_{p_i}^{t} + (1/2)G_{l_i}^{t} + (1/3)G_{p_i}^{t} G_{l_i}^{t}\right] \quad (5)$$

$$\Delta P_i = S_{VA_i}^{t-1} G_{p_i}^{t}\left[1 + (1/2)G_{LP_i}^{t} + (1/2)G_{l_i}^{t} + (1/3)G_{LP_i}^{t} G_{l_i}^{t}\right] \quad (6)$$

$$\Delta L_i = S_{VA_i}^{t-1} G_{l_i}^{t}\left[1 + (1/2)G_{LP_i}^{t} + (1/2)G_{p_i}^{t} + (1/3)G_{LP_i}^{t} G_{p_i}^{t}\right] \quad (7)$$

It can be shown that the above contributions sum up to the aggregate labor productivity growth G_{LP}^{t} defined by (Eq. 4); that is, $G_{LP}^{t} = \Delta X_i + \Delta P_i + \Delta L_i$. For *i = 1, …, N*, the contributions of industry *i* to total labor productivity growth are defined by the change in an industry *i* labor productivity, ΔX_i; the change in sector *i* real output prices, ΔP_i ; and the changes in the industry *i* labor input shares, ΔL_i. Diewert (2014) simplified (Eq. 4) by assigning the second and third-order components in (Equation 7) to their corresponding first-order terms symmetrically.

4. DATA and APPLICATIONS

This study analyzes the sectoral contributions to the overall growth of labor productivity in the Turkish economy, utilizing annual data from the Turkish Institute of Statistics (TurkStat). We primarily utilize the "National Accounts" and the "Employment, Unemployment, and Wage" databases for the period from 2002 to 2023. This period encompasses crucial changes in the sectoral composition of the Turkish economy, especially after the economic and financial crisis of 2000 and 2001. The main findings are presented for the years 2002 to 2023, with the exception of 2009, when the global financial crisis impacted Turkey's real economy; this year is excluded as it could have a severely distortionary effect on output and productivity.

The national income database contains gross output data from 1998 to 2023, classified according to the single-digit NACE Rev. 2, which is essential for estimating the economic activities of 20 industries of the Turkish economy. The analysis aggregates 20 subsector classifications into 10 main sectors due to the lack of reliable employment data at the 20 industry classification level. Furthermore, the period from 2002 to 2023 was divided into three sub-periods: 2002 to 2008, 2010 to 2016, and 2017 to 2023. We begin by examining productivity growth trends in the sub-period following the 2000-2001 crisis, before the global financial crisis of 2008-2009, and the period that followed the crisis.

5. FINDINGS for the AGGREGATE ECONOMY

From 2002 to 2023, labor productivity in Turkey grows by an average of 3.94% annually. This labor productivity growth averaged 5.33% from 2002 to 2008, 3.34% from 2010 to 2016, and 3.15% from 2017 to 2023. Different methods (TRAD, CSLS, GEAD, and Diewert's GEAD) were used to decompose this labor productivity growth. Table 1 summarizes the results of these decompositions for the aggregate economy.

Table 1. Sources of Aggregate Labor Productivity Growth (TRAD, CSLS, GEAD and Diewert's GEAD)

	2002-2008	2010-2016	2017-2023	2002-2023
Aggregate Labor Productivity Growth	5.329	3.343	3.152	3.941
TRAD				
WSE	4.486	2.768	2.970	3.408
RLE	1.084	0.936	0.351	0.791
RGE	-0.122	-0.300	-0.147	-0.190
TE	5.448	3.404	3.174	4.009
CSLS				
WSE	4.486	2.768	2.970	3.408
RLE	1.084	0.936	0.351	0.791
RGE	-0.24	-0.361	-0.169	-0.257
TE	5.329	3.343	3.152	3.941
GEAD				
PPGE	4.606	2.683	2.874	3.388
DE	0.950	1.033	0.564	0.849
BE	-0.226	-0.374	-0.285	-0.295
TE	5.329	3.343	3.152	3.941
DIWERT's GEAD				
DirE	4.360	2.580	2.816	3.252
OPWE	0.005	0.001	0.002	0.002
LIRE	0.963	0.769	0.326	0.686
TE	5.329	3.349	3.144	3.941

The Traditional Decomposition (TRAD) method indicated that the within-sector effect (WSE) is the primary driver of aggregate labor productivity growth, with an annual average increase of 3.4% for the whole (2002-2023) period. The second contribution stemmed from the (0.79 percent) reallocation level effect (RLE). Aggregate labor productivity growth was dampened by a negative (-0.19 percent) reallocation growth effect (RGE). However, the RLE is positive but very small in magnitude compared with the WSE. The magnitude of the WSE and the total effects were higher in the 2002-2008 period than in the following two periods after the global financial crisis (2008-2009). From 2002 to 2008, the magnitude of the RLE remained low, suggesting that productivity gains from the labor shift toward sectors with above-average labor productivity were very small. The poor performance of the RGE indicates that the labor share is decreasing (or increasing) in industries where the labor productivity growth rate is above (or below) average. The negative values can be prominently found in all the sub and the whole periods.

The economic interpretation of the TRAD decomposition is relatively straightforward; however, it is not additive. The weighted sum of sectoral productivity contributions does not equal the aggregate labor productivity growth. In other words, it is not additive unless a single constant base year price deflator is used for inflation adjustments. Many statistical agencies have recently upgraded their national output accounts from fixed-base price indexes to chain-linking indexes. However, the advancements in productivity decomposition methods have been slow to keep pace. The CSLS in Canada has modified and applied the TRAD formula in various studies (Sharpe et al., 2008; Sharpe, 2010; Sharpe and Thomson 2010). This modified TRAD method, called the CSLS formula, also assumes real output at constant base year prices; however, it significantly differs in its methodology for assessing each sector's contribution to aggregate productivity growth.

The main engine of labor productivity growth was the within-sector effect (WSE), which is identical in both the TRAD and CSLS methods across all time periods. Also, the decomposition results of our data point out similar reallocation level effects (RLE) in both the TRAD and CSLS.[2] Furthermore, the WSE and RLE were positive and remained high until the global financial crisis of 2008, after which they declined. The differences between the two formulas appear in the reallocation growth effects (RGE), which are minimal in magnitude and carry a negative sign in both formulas. The reallocation growth effect (RGE) imposes a drag on aggregate labor productivity growth of -0.26 percent annually. The negative (positive) sign of the RGE indicates that the labor share is decreasing (increasing) in sectors with above-average (below-average) labor productivity growth.

When real production is expressed using Fisher-type chain linking indexes, the TRAD and CSLS formulas are no longer exactly additive. Like other European statistical agencies, the Turkish Institute of Statistics (TurkStat) used Laspeyres or Paasche-type chain linking indices to compile GDP figures. Thus, the additivity assumption is not valid for TRAD but remains applicable in CSLS. Tang and Wang (2004) incorporated the relative prices into the decomposition formula to estimate industry growth contributions that sum up to the aggregate labor productivity growth, regardless of whether the output is expressed in constant base year or chain linking indexes. Consequently, the GEAD technique includes both quantity and price effects while upholding the principle of exact additivity.

The primary factor driving labor productivity growth in the Turkish economy, according to GEAD, results from the pure productivity growth effect (PPGE), showing annual growth of 4.61% from 2002 to 2008, 2.68% from 2010 to 2016, 2.87% from 2017 to 2023, and 3.39% for the entire period from 2002 to 2023. The other significant contributor to labor productivity growth is the reallocation level effect (RLE), which occurs when labor shifts from lower to higher productivity sectors, commonly known as the Dennison Effect (DE), with an average annual growth rate of 0.85% from 2002 to 2023. The results indicate consistently positive reallocation level effect (RLE) across all periods. The positive effects of PPGE and DE were somewhat diminished by a negative reallocation growth (RGE) or the Baumol effects (BE). The Baumol effect was negative across all sub-periods but varied in magnitude. The rates are -0.23% for 2002-2008, -0.37% for 2010-2016, -0.29% for 2017-2023, and -0.30% for the entire period. These values were negative and small during the high growth period from 2002 to 2008, while their negative impact increased significantly after the 2008 financial crisis. The negative BE is often interpreted as indicative of the Baumol Growth Disease.

The GEAD accounts for relative price changes along with input share variations. Diewert (2008, 2013) expanded the original GEAD, decomposing aggregate labor productivity growth into three contributing components: within-sector productivity growth, labor share variations, and relative output price changes. This paper refers to the extension of the original GEAD as Diewert's GEAD.

According to Diewert's GEAD formula for the Turkish economy, the primary driver of labor productivity growth stemmed predominantly from the within-sector effect (WSE) or the direct effect (DirE) during the 2002-2008 period (4.36% per annum) and for the entire duration (2002-2023) (3.25% per year). The second largest contributor to overall labor productivity growth was the labor input reallocation effect (LIRE), which showed 0.96% from 2002 to 2008 and 0.69% from 2002 to 2023. The contributions from changes in relative output prices, known as the output price weighting effect (OPWE), are positive but minimal in magnitude, ranging from 0.001% to 0.005% per year for both the overall period and sub-periods.

The GEAD formula provides a unique perspective on how various sectors contribute to overall labor productivity growth. Notably, the within-sector effect (WSE) in the GEAD formula is stronger than that in the TRAD and CSLS formulas, measuring 4.61 percentage points compared to 4.49 percentage points annually from 2002 to 2008. This slight difference arises because the GEAD formula calculates the within-sector effect based on nominal value-added rather than real value-added shares. The primary distinction lies in the reallocation effects. Assuming the labor share remains constant—indicating that labor is immobile across sectors during the relevant period—the reallocation effects in the TRAD and CSLS formulas would be zero. However, in GEAD, as long as relative prices change, the reallocation effects will not be zero. This feature makes GEAD superior in a world where technological advancements result in varying relative prices across sectors. However, these methods may offer quite distinct insights into the sectoral contributions to overall productivity growth.

5.1. Sectoral Analysis

This section examines the contributions of different sectors to overall labor productivity growth using the TRAD, CSLS, GEAD, and extended GEAD decomposition methods. Table 2 summarizes the findings from the TRAD

[2] The CSLS formula appears to define the WSE differently by using sectoral labor shares as weights instead of real output shares; however, the WSE in two formulas (TRAD and CSLS) are equivalent. For a proof see de Avillez (2012).

and CSLS decomposition methods for Turkey's ten main sectors. The TRAD decomposition revealed that the agriculture, manufacturing, and transportation sectors primarily contributed to overall labor productivity growth from 2002 to 2008. During this time, the construction industry also made a modest contribution to labor productivity. Over the years, contributions from manufacturing and agriculture declined while trade services and business services grew. Throughout the entire period from 2002 to 2023, trade services, manufacturing, business services, and transportation served as the primary drivers of aggregate labor productivity growth. The CSLS method produces results similar to those obtained from TRAD decomposition, with minor differences. One notable distinction is that in the CSLS method, agriculture remains the main contributor to aggregate productivity, while it does not in TRAD. This happens because the reallocation level effect (RLE) in the CSLS formula is positively affected when a sector with high labor productivity increases its labor share and when a sector with low labor productivity reduces its labor share. In contrast, in TRAD, RLE is positively influenced only when sectors with high productivity increase their labor share.

The lowest labor productivity sectors were mining, utilities, and other services in the same period. The contributions of the WSE and RLE to aggregate productivity growth in the agricultural sector are positive and significant. From 2010 to 2016, the contributions from the WSE in the business services and other services were temporarily negative, but overall, they were positive during the other two periods. The utilities sector has a negative impact across all periods. Overall, the reallocation growth effect (RGE) is negative, and its magnitude is considerably less than that of the WSE and RLE.

The decomposition proposed by Tang and Wang (2004) ensures that no distinction needs to be made regarding whether value-added or GDP is compiled using the Laspeyres, Paasche, or Fisher indexes. However, its main drawback is that the industry weights used to calculate the reallocation effects depend on shifts in industry shares of total employment and relative output prices, making interpretation somewhat more complicated.

To normalize prices across various industries, the GEAD divides the output price of each sector by the overall output deflator. Above-average growth in an industry's output prices similarly affects the reallocation effect term, just as above-average growth in labor inputs does. When an industry's relative output prices are higher than average, this may be shown in the decomposition analysis as a greater contribution from that sector to aggregate productivity growth. Diewert's GEAD is more flexible in addressing price changes than the original GEAD. This enhanced flexibility provides a valuable solution for analysts aiming to separate the effects of price changes from other contributing factors (Reinsdorf, 2015).

Table 3 presents a summary of the labor productivity decomposition results obtained from the GEAD and Diewert's GEAD for the Turkish economy across the main sectors. Manufacturing demonstrated the most rapid growth in labor productivity, achieving an annual average growth rate of 0.97%. Following this sector, trade services and other services recorded average annual labor productivity growth rates of 0.94% and 0.57%, respectively, from 2002 to 2023. Transportation and storage added a rate of 0.44% annually. In contrast, the sectors with the lowest labor productivity performance were utilities (0.09%), mining (0.05%), and finance and insurance (-0.12%) throughout this period.

In brief, the sources of productivity growth mainly arose from within-sector effects (WSE) and reallocation level effects (RLE) across all periods. The reallocation growth effects (RGE) negatively impacted aggregate labor productivity growth, acting as a drag. The RGE was negative and influenced all sectors except agriculture, and briefly during the 2017-2023 period, in trade services, suggesting that BGD may develop in these areas.

Table 2. Sectoral Contributions to Aggregate Labor Productivity Growth in the Turkish Economy

Industry	*2002-2008*				*2010-2016*				*2017-2023*				*2002-2023*			
TRAD	*TE*	*WSE*	*RLE*	*RGE*	*TE*	*WSE*	*RLE*	*RGE*	*TE*	*WSE*	*RLE*	*RGE*	*TE*	*WSE*	*RLE*	*RGE*
Agriculture (A)	0.195	0.708	-0.448	-0.065	-0.026	0.264	-0.269	-0.021	0.010	0.297	-0.275	-0.012	0.060	0.423	-0.331	-0.033
Mining (B)	0.011	0.018	0.049	-0.055	-0.011	0.008	0.003	-0.022	0.010	0.003	0.016	-0.009	0.004	0.009	0.023	-0.028
Manufacturing (C)	1.251	0.986	0.263	0.002	0.885	0.956	-0.053	-0.018	0.597	0.336	0.263	-0.001	0.911	0.759	0.158	-0.006
Utilities (D&E)	0.118	0.192	-0.025	-0.049	0.139	-0.178	0.510	-0.193	-0.001	-0.054	0.056	-0.002	0.086	-0.013	0.180	-0.081
Construction (F)	0.792	0.730	0.085	-0.023	0.607	0.337	0.263	0.007	-0.236	0.001	-0.179	-0.058	0.388	0.356	0.057	-0.025
Trade Services (G&I)	0.958	0.525	0.421	0.013	0.767	0.959	-0.170	-0.023	1.201	1.067	0.136	-0.002	0.975	0.850	0.129	-0.004
Transportation and Storage (H)	0.797	0.835	-0.032	-0.006	0.168	0.420	-0.223	-0.029	0.278	0.089	0.187	0.002	0.414	0.448	-0.022	-0.011
Business Services (J, M& N)	0.653	0.158	0.505	-0.010	0.437	-0.239	0.730	-0.055	0.439	0.724	-0.228	-0.058	0.509	0.215	0.336	-0.041
Finance and Insurance (K)	0.137	0.091	0.049	-0.003	0.272	0.368	-0.092	-0.004	0.297	0.334	-0.020	-0.017	0.235	0.264	-0.021	-0.008
All Other Services	0.416	0.243	0.217	-0.044	0.106	-0.127	0.236	-0.003	0.555	0.173	0.394	-0.012	0.359	0.096	0.282	-0.020
Total Economy	5.448	4.486	1.084	-0.122	3.404	2.768	0.936	-0.300	3.174	2.970	0.351	-0.147	4.009	3.408	0.791	-0.190
CSLS	*TE*	*WSE*	*RLE*	*RGE*	*TE*	*WSE*	*RLE*	*RGE*	*TE*	*WSE*	*RLE*	*RGE*	*TE*	*WSE*	*RLE*	*RGE*
Agriculture (A)	1.413	0.708	0.699	0.006	0.727	0.264	0.458	0.005	0.690	0.297	0.391	0.002	0.943	0.423	0.516	0.004
Mining (B)	0.004	0.018	0.042	-0.057	-0.007	0.008	0.006	-0.022	0.005	0.003	0.011	-0.009	0.000	0.009	0.020	-0.029
Manufacturing (C)	0.979	0.986	0.007	-0.015	0.940	0.956	0.002	-0.018	0.348	0.336	0.021	-0.009	0.755	0.759	0.010	-0.014
Utilities (D & E)	0.127	0.192	-0.017	-0.049	0.053	-0.178	0.426	-0.195	-0.015	-0.054	0.043	-0.003	0.055	-0.013	0.151	-0.082
Construction (F)	0.760	0.730	0.054	-0.025	0.387	0.337	0.052	-0.001	-0.094	0.001	-0.038	-0.057	0.351	0.356	0.023	-0.028
Trade Services (G & I)	0.471	0.525	-0.031	-0.023	0.983	0.959	0.043	-0.019	1.077	1.067	0.008	0.003	0.844	0.850	0.007	-0.013
Transportation and Storage (H)	0.812	0.835	-0.015	-0.008	0.270	0.420	-0.123	-0.027	0.188	0.089	0.099	-0.001	0.423	0.448	-0.013	-0.012
Business Services (J, M & N)	0.406	0.158	0.270	-0.022	-0.120	-0.239	0.188	-0.069	0.654	0.724	-0.014	-0.057	0.313	0.215	0.148	-0.049
Finance and Insurance (K)	0.119	0.091	0.032	-0.003	0.297	0.368	-0.068	-0.004	0.303	0.334	-0.014	-0.016	0.240	0.264	-0.017	-0.008
All Other Services	0.240	0.243	0.043	-0.046	-0.186	-0.127	-0.049	-0.011	-0.004	0.173	-0.156	-0.021	0.016	0.096	-0.054	-0.026
Total Economy	5.329	4.486	1.084	-0.241	3.343	2.768	0.936	-0.361	3.152	2.970	0.351	-0.169	3.941	3.408	0.791	-0.257

Table 3. Sectoral Contributions to Aggregate Labor Productivity Growth in the Turkish Economy (GEAD and Diewert's GEAD)

	2002-2008				*2010-2016*				*2017-2023*				*2002-2023*			
GEAD	*TE*	*PPGE*	*DE*	*BE*	*TE*	*PPGE*	*DE*	*BE*	*TE*	*PPGE*	*DE*	*BE*	*TE*	*PPGE*	*DE*	*BE*
Agriculture (A)	0.400	0.710	-0.273	-0.037	-0.070	0.258	-0.306	-0.022	0.182	0.288	-0.109	0.003	0.170	0.419	-0.229	-0.019
Mining (B)	0.104	0.012	0.122	-0.029	-0.015	0.009	0.001	-0.024	0.068	-0.009	0.087	-0.009	0.052	0.004	0.070	-0.021
Manufacturing (C)	0.932	1.112	-0.156	-0.024	0.883	0.950	-0.052	-0.016	1.084	0.351	0.716	0.017	0.966	0.804	0.170	-0.008
Utilities (D & E)	0.088	0.185	-0.040	-0.057	0.093	-0.179	0.461	-0.189	0.093	-0.040	0.185	-0.053	0.091	-0.012	0.202	-0.100
Construction (F)	0.762	0.759	0.063	-0.060	0.812	0.352	0.443	0.016	-0.347	0.049	-0.285	-0.111	0.409	0.387	0.074	-0.052
Trade Services (G & I)	1.077	0.533	0.533	0.011	0.717	0.955	-0.216	-0.023	1.024	1.041	0.004	-0.020	0.939	0.843	0.107	-0.011
Transportation and Storage (H)	0.719	0.862	-0.132	-0.011	0.098	0.408	-0.276	-0.034	0.510	0.083	0.424	0.003	0.442	0.451	0.005	-0.014
Business Services (J, M & N)	0.698	0.153	0.546	-0.001	0.357	-0.235	0.647	-0.054	0.207	0.675	-0.390	-0.078	0.421	0.198	0.268	-0.045
Finance and Insurance (K)	-0.479	0.058	-0.552	0.015	0.036	0.296	-0.242	-0.018	0.085	0.234	-0.133	-0.016	-0.120	0.196	-0.309	-0.007
All Other Services	1.029	0.222	0.839	-0.032	0.433	-0.131	0.574	-0.009	0.246	0.202	0.064	-0.020	0.570	0.098	0.492	-0.020
Total Economy	5.329	4.606	0.950	-0.226	3.343	2.683	1.033	-0.374	3.152	2.874	0.564	-0.285	3.941	3.388	0.849	-0.295

	2002-2008				*2010-2016*				*2017-2023*				*2002-2023*			
Diewert's GEAD	*TE*	*DirE*	*OPWE*	*LIRE*	*TE*	*DirE*	*OPWE*	*LIRE*	*TE*	*DirE*	*OPWE*	*LIRE*	*TE*	*DirE*	*OPWE*	*LIRE*
Agriculture (A)	0.206	0.693	0.002	-0.490	-0.022	0.253	0.000	-0.275	0.013	0.299	0.002	-0.288	0.065	0.415	0.001	-0.351
Mining (B)	0.012	-0.006	0.001	0.017	-0.010	-0.003	0.000	-0.007	0.012	-0.002	0.001	0.013	0.004	-0.004	0.001	0.008
Manufacturing (C)	1.234	0.976	-0.004	0.262	0.888	0.947	0.000	-0.059	0.620	0.343	0.004	0.273	0.914	0.755	0.000	0.159
Utilities (D & E)	0.117	0.161	0.000	-0.044	0.138	-0.273	0.000	0.411	-0.024	-0.081	0.002	0.055	0.077	-0.065	0.000	0.141
Construction (F)	0.782	0.704	0.000	0.078	0.616	0.345	0.002	0.270	-0.233	-0.059	-0.001	-0.173	0.389	0.330	0.000	0.058
Trade Services (G & I)	0.960	0.530	0.001	0.429	0.767	0.948	0.000	-0.181	1.193	1.057	-0.001	0.138	0.973	0.845	0.000	0.129
Transportation and Storage (H)	0.791	0.829	-0.001	-0.037	0.169	0.402	-0.001	-0.232	0.284	0.091	0.002	0.191	0.415	0.441	0.000	-0.026
Business Services (J, M & N)	0.656	0.157	0.001	0.498	0.435	-0.266	-0.001	0.702	0.426	0.682	-0.002	-0.254	0.506	0.191	-0.001	0.315
Finance and Insurance (K)	0.136	0.094	-0.004	0.046	0.260	0.359	-0.002	-0.097	0.297	0.323	-0.002	-0.024	0.231	0.259	-0.002	-0.025
All Other Services	0.435	0.222	0.008	0.205	0.109	-0.131	0.003	0.237	0.555	0.164	-0.003	0.394	0.366	0.085	0.003	0.279
Total Economy	5.329	4.360	0.005	0.963	3.349	2.580	0.001	0.769	3.144	2.816	0.002	0.326	3.941	3.252	0.002	0.686

Diewert's GEAD indicates that over two-thirds (82%) of the aggregate labor productivity growth is due to the direct effect (DirE). In contrast, 17% arose from the labor input reallocation effect (LIRE), while only 1% resulted from changes in relative output prices. The main findings of this section indicate that productivity growth is primarily driven by developments within sectors, suggesting that the productivity advancements of each economic sector play a more significant role than the reallocation of resources between sectors. Cross-sector reallocation has contributed little – and, on average, has negatively impacted overall growth. This trend can be attributed to the declining importance of manufacturing in favor of service sectors. Despite its decreasing share of employment, the manufacturing sector accounted for 23.2% of annual aggregate productivity growth from 2002 to 2023. In contrast, aggregate productivity growth in Turkey is significantly driven by trade services, manufacturing, business services, and construction. Heterogeneity in productivity levels and growth rates across sectors indicates that reallocating resources among these sectors can enhance productivity. However, since the global financial crisis, the impact of this reallocation on overall productivity growth has lessened in the Turkish economy.

5.2. Baumol's Growth Disease (BGD) and FSGR Analysis

The findings on labor productivity raise two important questions regarding the Turkish economy. Do the sources of Turkey's productivity slowdown after the global financial crisis originate from Baumol's growth disease? Furthermore, do the expanding service sectors impede labor productivity in the Turkish economy? To elaborate on these questions, we utilize Nordhaus-Baumol's framework to further examine which economic sectors have been affected by Baumol's Growth Disease (BGD).

As seen in equation 8, to measure the Baumol growth effect, Nordhaus (2008) analyzes the growth rate by utilizing the sector's nominal output shares for a specific year, T, and refers to the results as the "fixed shares growth rate" or "FSGR(T)":

$$FSGR(T) = \sum_i^n G_{LP_i}^t \, S_i^T \qquad (8)$$

Where $G_{LP_i}^t$ represents the average annual growth rate of labor productivity for the relevant sector, and S_i^T denotes the nominal output share of industries for different base (or fixed) years. The impact of changes in output shares on productivity growth can be assessed by comparing the FSGR(T) across different base years. If the FSGR is lower for subsequent base years (T), this indicates a negative Baumol growth effect, suggesting that shares are shifting in a way that hinders growth. The aggregate growth rate will decline as the nominal output share shifts toward sectors with slow productivity growth. On the other hand, if the FSGR is higher for later T, the Baumol growth effect is positive (Nordhaus, 2008).

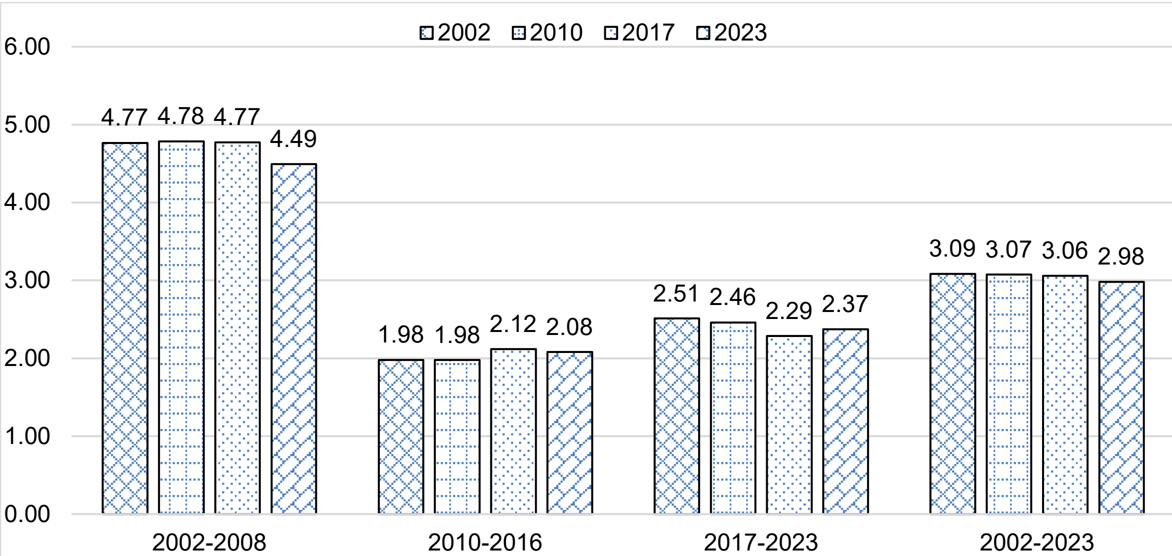

Figure 1. Labor productivity growth based on fixed shares for various periods and base years

Figure 1 shows the annual average growth rate of labor productivity across different periods, utilizing various fixed base year shares. The weights are the nominal value-added share of these sectors for the (fixed) base years 2002, 2010, 2017, and 2023. This illustrates the overall growth rate of labor productivity from 2002 to 2023, with the primary sectors weighted according to nominal value-added shares for the four different base years. Based on fixed shares from 2002, the average annual growth rate of labor productivity is 3.09% for the period from 2002 to 2023. In contrast, by applying the most recent shares from 2023, the average growth rate of labor productivity over the entire period is 2.98 percent per year. When analyzing the sub-periods, a similar trend appears: the bonus or drag on aggregate productivity caused by the shift in sector shares is not significant in either the sub-periods or the entire period. There seems to be no indication of BGD in the Turkish economy. Analyzing the main sectors may provide more insights.

Figure 2 illustrates the FSGR based on the annual average growth rate of labor productivity from 2002 to 2023, highlighting the contributions of agriculture, industry, construction, and services. The weights indicate the nominal output shares of these sectors for the same base years: 2002, 2010, 2017, and 2023.

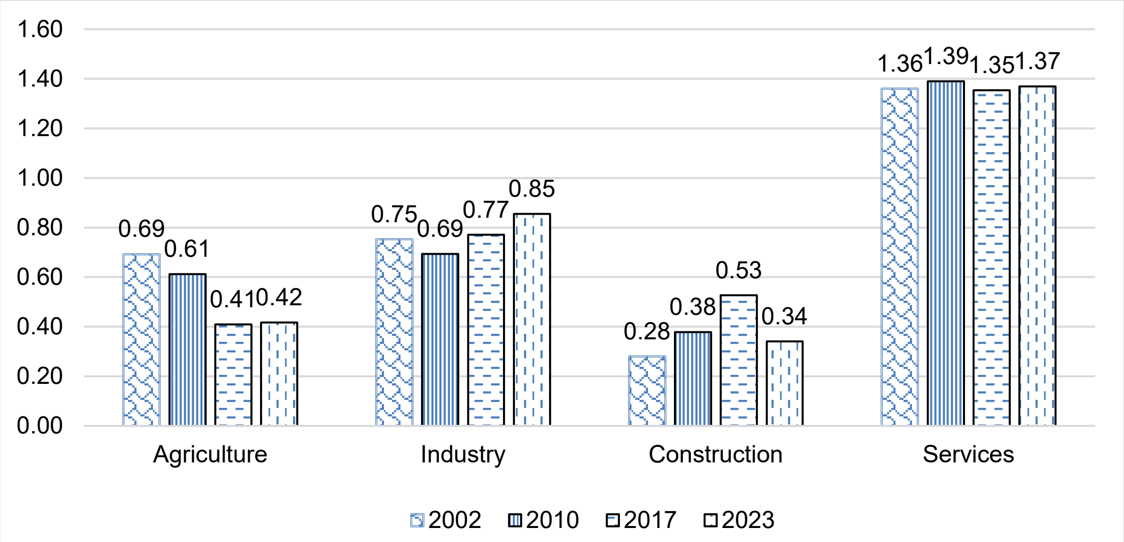

Figure 2. Fixed-share growth rates of labor productivity across various sectors and base years (2002-2023)

The Baumol growth effect negatively impacts agriculture at a low rate across all fixed-year weights. Its influence on the industry is modest, based on output share weights from the 2002 and 2010 base years. Specifically, sectors within the industrial domain that exhibit higher productivity growth have been losing their shares until the financial crisis. When applying value-added shares from 2017 and 2023 as weights, a weak but positive Baumol growth effect is observed in the industry. However, the construction sector demonstrated a positive Baumol growth effect when using the 2002 and 2010 base years. In contrast, a negative Baumol growth effect has been observed in this sector, according to the latest shares from 2023. Nonetheless, the FSGR for services remains stable and relatively flat across all base year weights, suggesting that the services sector appears largely unaffected by the Baumol growth effect. The negative Baumol growth effect is not significant enough to greatly diminish aggregate labor productivity growth in the aggregate economy. The negative Baumol growth effect noted in agriculture and construction (in later base years) seems to be balanced by small but positive contributions from other sectors. This stabilizing effect of structural change may differ depending on more disaggregated level sector classifications.

6. CONCLUSION

Most studies of productivity decomposition in the Turkish economy have employed traditional methods, which are non-additive because of either varying sectoral price deflators or chain-linked volume output data. This study utilized traditional decomposition methods (TRAD and CSLS) along with new decomposition methods (GEAD and Diewert's GEAD) to assess the sources of aggregate labor productivity growth. The results for the whole economy show that the primary driver of productivity growth was the within-sector effect (WSE), which accounted for approximately 85% of aggregate growth of productivity. The reallocation level effect (RLE) positively contributed 19.7% to overall productivity growth, while the reallocation growth effect (RGE) negatively impacted about -4.7% from 2002 to 2023. All decomposition methods present a similar picture with very minor differences. Furthermore, Diewert's GEAD separates output relative price changes as a distinct term alongside sector productivity growth and labor reallocation. It yields figures comparable to the original GEAD regarding the effects of within-sector and labor input reallocation. The impact of relative prices on overall labor productivity growth is positive, although it is relatively small in magnitude.

In conclusion, across all four decomposition methods, growth in aggregate labor productivity primarily stems from within sectors. This suggests that enhancements in productivity within the sector are more influential than the shifting of labor across sectors. While the reallocation level effect contributes positively to overall labor productivity, the reallocation growth effect tends to be negative, creating a drag rather than a boost to overall labor productivity growth. Notably, this is sometimes seen as an indication of the Baumol Growth Disease.

At the economy-wide level, all methods yield similar results. However, the outcomes of these methods show very different results at the sectoral level. In the TRAD method, trade services, manufacturing, and business services were the main contributors to aggregate productivity growth. In contrast, the CSLS method showed that agriculture, trade services, and manufacturing drove aggregate productivity growth throughout the entire period. Transportation and construction moderately contributed to overall labor productivity growth using both the TRAD and CSLS methods. Over time, the roles of manufacturing and agriculture diminished while the importance of trade and business services grew stronger. In contrast to other methods in the CSLS, agriculture is the main contributor to overall labor productivity growth. Although the labor share of agriculture declined over time, this result seems to be very cumbersome. This occurs because the reallocation level effect in the CSLS formula positively impacts productivity when sectors with above-average labor productivity increase their labor share and those with below-average labor productivity decrease their labor share. In contrast, in TRAD, RLE positively impacts labor productivity only when above-average productivity sectors raise their labor share.

The GEAD and extended GEAD decompositions also produce different outcomes in sectoral analysis. Manufacturing, trade services, and other services were the main contributors to overall labor productivity growth in GEAD, whereas in Diewert's GEAD, trade services, manufacturing, and business services were the primary contributors. In contrast, the sectors demonstrating the weakest labor productivity performance were mining, utilities, and finance insurance. However, GEAD differs from TRAD and CSLS in that it incorporates (relative) output prices and labor shares into the decomposition process. While TRAD and CSLS assume zero reallocation effects when the labor share remains constant over time, GEAD shows that changes in relative prices can lead to non-zero effects. Consequently, GEAD is a more effective method for analyzing sectoral productivity contributions and structural change, particularly during technological advancements that affect relative prices across sectors.

Labor productivity growth averaged 5.33% from 2002 to 2008, 3.34% from 2010 to 2016, and 3.15% from 2017 to 2023. This pattern shows strong growth before the global financial crisis and a significant slowdown afterward. To examine this productivity slowdown, the study builds on Nordhaus's (2008) FSGR framework to investigate Baumol's Growth Disease and assess whether the rising share of services has contributed to the decline. The FSGR analysis shows that the negative Baumol growth effect is evident in agriculture over the entire period and in construction during the later sub-periods; however, it is offset by modest but positive contributions from other sectors. Consequently, the negative Baumol growth effect is not substantial enough to significantly impede overall labor productivity growth in the Turkish economy. Furthermore, the expansion of services appears to have little impact on the productivity slowdown.

The results are consistent with the literature on structural change, which emphasises that productivity gains from reallocation depend on allocating resources to activities with strong learning potential and domestic linkages. Although medium-technology sectors have expanded in Turkey, productivity gains have been limited without a government-led selective incentive scheme to steer firms towards higher value-added and capability-building activities. This highlights the importance of designing selective, performance-based industrial policies to actively guide structural transformation, rather than relying on reallocation alone. As within-sector effects (WSEs) are the primary drivers of productivity growth, future research should move beyond labour productivity and employ total factor productivity decompositions and growth accounting frameworks. In this regard, applying GEAD and Diewert's decomposition methods would help to disentangle demand- and supply-side sectoral dynamics. This would enable policymakers to identify where targeted support is warranted and where constraints are primarily macroeconomic or demand-driven.

The change in the method of calculating GDP in Turkey has limited the analysis period in this study. In future studies, the length of the analyzed period will be increased, and more sound policies can be developed based on the results obtained.

Author Contributions

Eylül Ece DEMİR: Literature Review, Conceptualization, Methodology, Writing-original draft, Writing-review and editing.
Tülin TUNÇ: Literature Review, Data Curation, Analysis, Modelling.
İsmail TUNCER: Data Curation, Analysis, Modelling, Writing-review and editing.

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It was declared by the authors that the tools and methods used in the study do not require the permission of the Ethics Committee.

Ethical Statement
It was declared by the authors that scientific and ethical principles have been followed in this study and all the sources used have been properly cited.

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