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ECONOMIC EFFICIENCY ANALYSIS OF LOGISTIC PROCESSES

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Abstract

This study aimed to evaluate the economic productivity of businesses in the BIST SME index and to determine the relationship between them and stock return rates. The economic productivity was calculated by taking the ratio of sales in the Income Statement to the cost of goods sold. The return rates of the businesses were analyzed based on the natural logarithm of the year-end closing prices of their stocks compared to the closing prices from the previous year. For this purpose, the financial statements containing the financial data of the businesses included in the research were obtained from the Public Disclosure Platform (PDP) from 2011 to 2024. The productivity and returns of the businesses were computed from the gathered data. The relationship between productivity and returns was investigated using panel data regression analysis in the study. When assessing the analysis results while considering the model's significance level, it was determined that there was a statistically significant and positive relationship between the economic productivity ratio and the rate of return (RoR). In other words, it was concluded that an increase in the economic productivity rate of businesses (P) included in the SME index by one unit would lead to an increase in the rate of return by 0.91.

Keywords: Economic Efficiency, Logistics, Panel Data Regression, Rate of Return
JEL Classification: D24, C23, O47, G17

LOJİSTİK SÜREÇLERDEKİ EKONOMİK VERİMLİLİK ANALİZİ

Öz

Bu çalışmada, BIST KOBİ endeksinde yer alan işletmelerin ekonomik verimliliklerinin değerlendirilmesi ve hisse senedi getiri oranları ile aralarındaki ilişkinin belirlenmesi amaçlanmıştır. İşletmelerin ekonomik verimlilikleri gelir tablosundaki veriler kullanılarak hesaplanmıştır. İşletmelerin hisse senedi getiri oranlarının doğal logaritması alınarak analize dahil edilmiştir. Araştırmaya dahil edilen işletmelerin 2011-2024 yıllarını kapsayan finansal verilerini içeren finansal tabloları Kamu Aydınlatma Platformu'ndan (KAP) temin edilmiştir. Toplanan verilerden işletmelerin ekonomik verimlilikleri ve hisse senedi getiri oranları hesaplanmıştır. Çalışmada ekonomik verimlilik ile getiri oranı arasındaki ilişki panel veri regresyon analizi kullanılarak incelenmiştir. Analiz sonuçları modelin anlamlılık düzeyi dikkate alınarak değerlendirildiğinde, ekonomik verimlilik oranı ile getiri oranı (ROR) arasında istatistiksel olarak anlamlı ve pozitif bir ilişki olduğu belirlenmiştir. Başka bir ifadeyle KOBİ endeksinde yer alan işletmelerin ekonomik verimlilik oranında (P) bir birimlik artışın, getiri oranında 0,91 oranında artışa yol açacağı sonucuna varılmıştır.

Anahtar kelimeler: Ekonomik Verimlilik, Lojistik, Panel Veri Analizi, Hisse Senedi Getiri Oranı
JEL Sınıflaması: D24, C23, O47, G17

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1. Introduction

In recent years, due to the challenges arising from developments in logistics processes, businesses have pursued new strategies to reduce rising costs and gain a competitive advantage in the global marketplace. This shift has heightened interest in logistics, leading to significant advancements in the field. In this context, factors such as the globalization of trade, increasing mobility of goods, changing consumer behaviors, diversity in production, the importance of production planning and related techniques, the trade-off between meeting customer expectations and managing inventory, the challenge of delivering high-value products across various regions, rising transportation costs, administrative and technological advancements, and the influences of military logistics on commercial logistics and current trends are all affecting the evolution of logistics (Acar, 2020: 7).

In general, productivity refers to the relationship between the output produced by a production or service system and the input utilized to create this output. It can also be defined as the effective use of resources (labor, capital, land, materials, energy, information) in producing various goods and services. In a narrow sense, productivity represents the ratio of output to input or the total of inputs, reflecting the relationship between the amount of goods and services produced and the quantities of input used in this production. It serves as a measure of the effectiveness of resources that are limited in nature and used in production to satisfy human needs. High productivity indicates the ability to produce more with a certain number of resources or to achieve greater output with a specific amount of input. Productivity can be expressed as a ratio using the formula: Productivity = Output / Input. The definition of productivity remains consistent regardless of the type of production or the political or economic system in place. Consequently, the relationship between the quantity and quality of goods and services produced and the resources used to generate them stands as the focal point of productivity (Ozbek, 2007: 3).

Productivity is the most widely used measure in the performance evaluation of production systems. When comparing business departments, industry sectors, or national economies, productivity is primarily considered (Kobu, 2003: 673). This study aimed to examine the impact of supply and production logistics productivity on the financial performance and returns of the businesses included in the BIST SME Index. For this purpose, financial statements containing the financial data of the businesses included in the research were obtained from the Public Disclosure Platform (PDP) between 2012 and 2022. The effect of businesses' productivity on their returns was examined with the panel data regression analysis.

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In this study, the economic productivity of the businesses included in the BIST SME index was evaluated, and the relationship between them and stock return rates was established. The economic productivity of businesses was calculated by taking the ratio of sales on the Income Statement to the cost of goods sold. Data for the model were sourced from the Public Disclosure Platform Financial Statements. The analysis of the relationship between the economic productivity of businesses and stock return rates utilized a panel data regression model. Upon evaluating the analysis results and considering the model's significance level, it was determined that there is a statistically significant and positive relationship between the economic productivity ratio and the rate of return (RoR). In other words, it was concluded that an increase in the economic productivity rate of businesses included in the SME index by one unit would lead to an increase in the rate of return by 0.91.

The study explored the relationship between the economic productivity of businesses and their stock return rates, aiming to determine both the direction and degree of impact of this relationship, if any. Given the lack of prior research in this area, the study is expected to make a significant contribution to the literature. Furthermore, the findings are anticipated to greatly inform the decisions of both executives and shareholders, particularly regarding the link between productivity and stock return rates.

2. Supply and Production Logistics Productivity

Businesses need a supply strategy and a production strategy to gain a competitive advantage in the market. Supply logistics encompasses functions that add value to the business by continuously organizing processes for selecting suppliers, purchasing, storing, and shipping raw materials and semi-finished products to the production line. The goal of supply logistics is to provide raw materials that meet required standards while minimizing costs. It includes all logistics activities that contribute to procuring pre-production resources, such as purchasing and transporting these resources to the production line.

In the facilities that make up the country's industry, supply logistics must ensure and guarantee that the raw materials required for production are effectively routed to the right place with minimum storage and transportation costs, providing operational support. When supply logistics is well planned and process activities (supplier selection, stock management, combination of load flow, etc.) are evaluated with scientific methods, it provides significant advantages in terms of reducing pre-production costs.

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Production logistics involves preliminary planning that includes market research and sales forecasting, product design, facility and investment policies, workplace layout activities, and production management tasks such as material, workforce, machine, and method planning; routing; time estimates; programming; and control processes that begin concurrently with production activities (Kobu, 2003). Often referred to as internal logistics, production logistics encompasses the preparation of materials in production centers, the movement of raw materials and semi-finished products within the factory during their transformation into products when required, and the storage of finished products at the end of the process (Acar, 2021: 48).

Overall, it aims to ensure performance criteria such as flexibility, time, and quality to meet customer needs at the desired standards in production activities, achieving this through a low-cost strategy. The most common indicator used to measure the success of production activities in this context is productivity. Productivity is typically defined as the ratio of output to input used in its production. While the output in organizations can be goods or services, the input comprises labor, raw materials, energy, and other resources. The more effectively an organization utilizes human and machine resources, the higher its productivity can be. Productivity is generally calculated with the following ratio (Aydin, 2012: 47):

$$Total\ Productivity = \frac{(Value\ of\ Production)}{(Total\ Cost\ of\ Production)} \qquad (1)$$

Productivity is the focus of strategies developed in the fields of business management and engineering. To evaluate their activities, all businesses assess the data generated in the production system and utilize the resources directly or indirectly related to production in productivity calculations. Increases in productivity within enterprises can help minimize costs. In other words, scarce resources are utilized effectively. The effective use of resources and cost minimization play a significant role in the economic development and welfare levels of both businesses and countries (Ileri, 2014: 9).

3. Literature

The scarcity of resources elevates the importance attributed to the phenomenon of productivity in terms of maximizing benefits while minimizing resource waste. Studies on productivity indicate that increases in productivity are crucial for business growth, assist countries in achieving higher income levels, and enhance the welfare of individuals. In fact, some studies emphasize productivity as a key factor in the disparities between developed and underdeveloped countries. The success of a business in selecting the most appropriate inputs by considering input costs and output prices is termed economic or cost efficiency. In other words, economic efficiency involves reducing production or service costs without compromising the quantity and quality of output. Alongside technical efficiency and transfer efficiency, Farrell introduces a measure known as overall efficiency, which is also referred to in literature as "Economic Efficiency." Economic efficiency is further identified as cost efficiency according to the literature (Seckiner and Sofuoglu, 2024: 8).

In his study, Yildirim (1989) applied the growth accounting technique for the periods 1963-1967, 1967-1972, and 1972-1977 within the Turkish manufacturing industry and found that the average annual growth rates of the TFP level remained very low at 5.9%, 1.5%, and 1.6%, respectively. Similarly, Ozmucur and Karatas (1990) discovered a negative TFP contribution to growth in the manufacturing sector of -2.1%, while Eser (1991) reported it at -2.8% for the period 1973-1979 (Vergil and Abasiz, 2008: 172).

Solow (1988), Kuznets (1973), Denison (1962), and Abramovitz (1962) argue that the development of the West relies on new factors, such as increased knowledge and education levels, as well as advancements in technology, which are not physical but lead to significant productivity gains, rather than on physical factors like labor and capital. They reveal that increases in productivity play a crucial role in helping countries achieve higher income levels and enhance people's quality of life. Oney (1968) highlighted productivity's significance as the reason for the discrepancies between economically underdeveloped and developed countries (Suicmez, 2008: 7,8).

In his study, Akan (2001) demonstrated how the input and output relationship developed for the Turkish manufacturing industry during the 1970-1999 period, utilizing the Collins-Bosworth Model in terms of per capita values and a production function with constant elasticity of substitution. According to the results obtained from the production function for the 1970-1999 period, increasing returns to scale were evident in the manufacturing industry ($\alpha+\beta=1.49$), and the rate of technological change remained as low as 0.65%. The TFP level, which represents the portion of production increase that cannot be attributed to factors, was attributed to scale size rather than technological development, and it was observed that the labor factor significantly contributed to growth based on output elasticity.

In his study investigating the relationship between capital structure and firm productivity, Yenice (2001) used data from 37 businesses operating in the "Main Metal Industry" and "Metal, Goods Machinery, and Equipment Manufacturing Industry," which are sub-industries of the ISE

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Manufacturing Industry, during 1999-2000. According to this study, no significant relationship was found between capital structure and firm value. An inverse relationship was observed between capital structure and firm productivity. Accordingly, as companies increase their use of debt, their productivity decreases, and when they reduce their debt usage, their productivity increases.

In his study, Deliktas (2002) employed Malmquist and data envelopment analysis for the manufacturing sector during the 1990-2000 period. The results indicated that the sub-sector with the highest annual average technical efficiency level was the paper and paper products manufacturing industry, with a rate of 93.7%. Conversely, the sector with the lowest resource utilization efficiency was the stone and soil-based industry, with a rate of 69.4%. Based on the total factor productivity change index, the sectors demonstrating the highest technological progress were the forest products industry (1,025) and metal goods (1,013) sub-sectors, respectively.

Tuncer and Ozugurlu (2004) aimed to identify the sources of growth in Turkey from 1982 to 2000 by employing the growth accounting technique in their study. The results indicated that the impacts of capital and productivity (TFP) contributions on output growth were significantly high. In contrast, the contribution of the labor factor to growth was limited, except in the infrastructure and services sector. Kalaycı and Karataş (2005) noted in their study that research conducted in Turkish banks between 2002 and 2016 had three main objectives: (i) to assess the Total Factor Productivity (TFP) of deposit banks operating in Turkey; (ii) to compare the productivity changes of banks listed on the stock exchange with those not listed; and (iii) to analyze the relationship between changes in productivity and shareholder returns for banks listed on the stock exchange. In line with these objectives, the hypothesis that "banks with increased productivity also increase their shareholder returns" was tested, and the productivity changes of 22 banks during the study periods were measured using the Malmquist TFP index. No significant difference was found between the productivity changes of banks listed on the stock exchange and those not listed. Subsequently, the shareholder returns and productivity changes of 10 banks listed on the stock exchange were calculated from 2007 to 2016. While no significant relationship was identified between total factor productivity and shareholder returns, it was noted that changes in technical efficiency had a positive and significant effect on total factor productivity.

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In their study, Vergil and Abasız (2008) analyzed the estimation of Total Factor Productivity and its effect on economic growth in Turkey, using annual data from 1968 to 2006 with the Collins-Bosworth Variance Decomposition method. The three-stage Least Squares method was employed to estimate TFP, leading to the conclusion that the TFP level positively affects growth. It was found that, on average, 30% of economic growth results from TFP increases, and calculations from various models indicate that growth primarily arises from physical capital accumulation compared to other production factors.

Sevinç and Eren (2016) conducted a productivity analysis using the data envelopment analysis method on 82 automotive sub-industries and casting companies that cater to the automotive industry at the SME scale. As a result of the analysis, they identified effective and ineffective companies and provided suggestions for improvement to help the ineffective companies become effective.

Unal, Kecek, and Kestane (2017) evaluated the profitability performance efficiency of five companies operating in the chemical sector of Borsa Istanbul for the period from 2010 to 2015 using the Malmquist Total Factor Productivity Index. The analysis revealed that the profitability efficiency of the enterprises in the chemical sector displayed a general upward trend in all years except for the years 2011 to 2013.

In a study conducted by Delibalta (2023), the productivity and economic contribution level of Turkey's mining sector was analyzed. Technological developments lead to fundamental changes in the socio-economic lives of societies. In this regard, the mining sector is significantly affected by these changes. The productivity level of mining enterprises in Turkey is much lower compared to developed countries. The USA and Australia produce coal about eight times more efficiently than Turkey. A similar pattern is evident in the value added per worker between EU member states and Turkey.

In their study, Yasar and Yavuz (2023) measured the total factor productivity of manufacturing enterprises traded in BIST 100 with the Malmquist total factor productivity (MTFP) index. The results of the study, in which financial rates of thirty-seven enterprises were utilized in the study period covering the years 2010-2017, showed that the average total factor productivity values of manufacturing enterprises decreased in the periods 2012-2013 and 2016-2017, while increasing in the other periods. The most efficient period for the enterprises was the 2013-2014 period. Based on the Malmquist total factor productivity index, manufacturing enterprises showed an average annual productivity increase of 26.9% in the 2010-2017 period.

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In their study, Seckiner and Sofuoglu (2024) assessed the efficiency of twenty digital hospitals based on stationery expenses across eight different scenarios using the data envelopment analysis technique in line with the "zero paper" criterion and subsequently analyzed these efficiency scores statistically. The data envelopment analysis and statistical analyses indicated that in all scenarios, the average efficiency of seventh-level hospitals exceeded that of sixth-level hospitals concerning stationery expenses. However, given that the sixth-level hospitals also demonstrated high efficiency, no statistically significant difference was found between the hospital-based efficiency scores of sixth- and seventh-level hospitals.

Amirteimoori, Allahviranloo, and Nematizadeh (2024) conducted a study in which they first calculated the technical efficiency scores of banks using classical data envelopment analysis (DEA). In the second stage, they applied a double-loading DEA model to identify the independent variables affecting bank traffic. They then implemented a procedure for a two-objective efficiency change process that involved estimating stochastic technical changes in the first stage and regressing the efficiency measurement scores on a set of explanatory variables, including performance metrics, in the second stage. Their empirical analysis focused on the Iranian banking sector, encompassing 120 bank-year observations from 15 banks between 2014 and 2021, to assess efficiency and changes in efficiency over time. The findings indicated that the explanatory variables, specifically the bad loan ratio and the number of branches, had an inverse relationship with stochastic technical efficiency and efficiency change. Furthermore, the results showed that these factors significantly influence the transformation of components and the overall productivity of banks.

Kara and Eryiğit (2024) studied the relationship between firm efficiency scores and stock returns as indicators of firm performance, utilizing data from 104 firms in the Borsa Istanbul (BIST) Industrial Index between 2000 and 2019. They employed Data Envelopment Analysis (DEA), a non-parametric method, to calculate efficiency scores for the firms. In determining these scores with DEA, total assets, cost of sales, and operating expenses were treated as inputs, while sales and net profit served as outputs, resulting in annual efficiency scores for each firm. The panel regression method was used to examine whether firm efficiency influenced stock returns. Furthermore, the 104 firms in the BIST Industrial Index were categorized into five sub-sectors to assess differences among sub-sectors and between them and the main sector. The analysis results indicated that efficiency scores have explanatory power regarding stock returns in the BIST Industrial Index. However, the analysis based on sub-sectors concluded that efficiency scores did not have explanatory power over stock returns.

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Karaca and Karaca (2025) investigated how the productivity values of enterprises in the BIST Wholesale and Retail Sector affect market values using financial data from 2012 to 2023. After evaluating the analysis results, they concluded that a one-unit increase in the productivity rate of enterprises would result in an increase of 0.5954 in stock market performance value, with these changes being statistically significant. Consequently, it was determined that the productivity values of logistics enterprises in the wholesale and retail sector positively influenced stock market performance values. The logistics productivity of enterprises was at its lowest level in 2019 and reached its highest value in 2022, while the stock market performance values of enterprises hit their lowest point in 2018 and their highest point in 2022.

Productivity refers to the degree to which factors of production are effectively utilized in an industry or an economy. The rates are determined by dividing the amount or value of the output produced through the production process by the amount or value of the factors of production employed to achieve this output, which serves as indicators of productivity levels. Various methods can be employed to assess productivity, allowing for criteria to be defined in multiple ways. Productivity can be calculated using different approaches, including physical and monetary measures, average and marginal analyses, micro and macro perspectives, and partial and total productivity (Dastan, 2018: 479).

4. Data and Methods

This study aimed to evaluate the economic productivity of businesses in the BIST SME index and to determine the relationship between these businesses and stock return rates. Economic productivity was calculated by taking the ratio of sales from the Income Statement to the cost of goods sold. The relationship between the economic productivity of companies and stock return rates was analyzed using a panel data regression model. Data from the businesses included in the study was obtained from the BIST (Istanbul Stock Exchange), CBRT (Central Bank of the Republic of Turkey), and the PDP (Public Disclosure Platform) data distribution system. The Stata IC 15.0 software package was used for data analysis.

The stock returns of the businesses are calculated using the logarithmic return. Logarithmic return change series are time series generated by taking the natural logarithm of the ratio of the price level in any period to the price level of the previous period, calculated as follows (Ozdemir, 2011: 126):

$$R_t = \ln(P_t / P_{t-1}) \qquad (2)$$

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The equation for productivity is defined as Output divided by Input. Using this formula, we can calculate productivity indicators at various levels within the system, including activities, workgroups, departments, and the entire enterprise. Input refers to any resource or factor we can control, such as materials, labor, energy, or capital. Output pertains to any product or service that can also be managed by processing or utilizing inputs. (Keskin, 1994: 2). The calculation of economic productivity in businesses is conducted by proportioning the economic values to each other, as illustrated below (Simsek and Celik, 2013: 133):

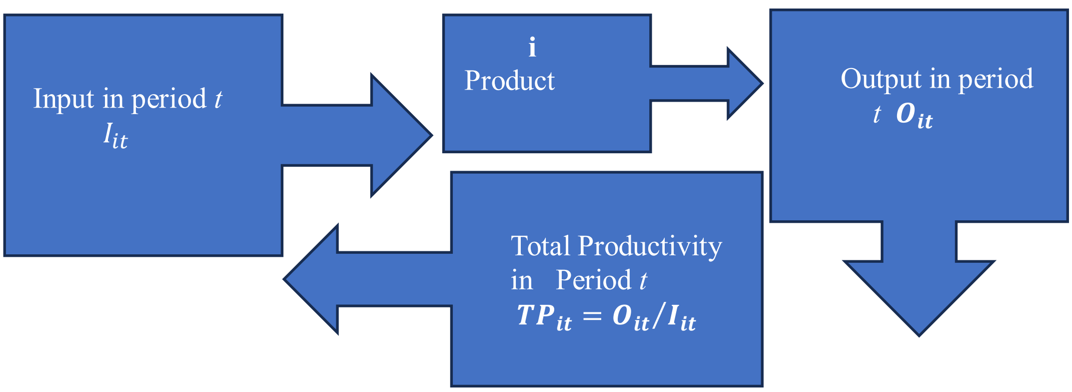
$$Economic\ productivity = \frac{Value\ of\ Production}{Total\ Cost\ of\ Production} \qquad (3)$$

The firm's Total Productivity Index (TPF) for period t is determined by Equation 4.

$$(TPF)_t = \frac{TPF_i}{TPF_o} \qquad (4)$$

Kendrick and Creamer (1961), along with Craig and Harris (1973), advocate for measuring total productivity, thereby establishing a correlation between total output and all input components. From a business perspective, the most effective strategy for managing productivity involves analyzing trends in total productivity alongside partial productivity indices for each input factor (Keskin, 1994, p. 45).

Figure 1. Total Productivity



The total productivity measurement, which relates total output to all input items, is shown in Equations 5 and 6 (Keskin, 1994: 45; Karaca ve Karaca, 2025: 360,361):

$$TP_{it} = \frac{O_{it}}{I_{it}} = \frac{O_{it}}{\sum_j I_{ijt}} = \frac{O_{it}}{I_iH_t+I_iM_t+I_iC_t+I_iE_t+I_iX_t} \qquad (5)$$

In Equation 5, H represents human input; M represents material and purchased parts input; C represents capital input; E represents energy input and X represents other expenses.

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$$TPF = Total\ Productivity\ of\ the\ Firm = \frac{Total\ Output\ of\ the\ Firm}{Total\ Input\ of\ the\ Firm} = \frac{OF_o}{IF_o} \quad (6)$$

The Total Productivity Model discussed in Equation 6 is a third-generation model that originates from the work of Davis (1877). In his research, Davis noted that each industry or firm faces unique challenges that require adapting general productivity measurement principles to the specific contexts of each enterprise. Consequently, various innovations were integrated into the productivity model applied in our analysis.

The enterprises included in the analysis are listed in Table 1. The length of the time series required for panel data analysis was considered during the selection of firms.

Table 1. Businesses in BIST SME Index and Included in Analysis

No	*Kod*	*Companies*
1	CASEL	ACISELSAN ACIPAYAM SELÜLOZ SANAYİ VE TİCARET A.Ş.
2	BFREN	BOSCH FREN SİSTEMLERİ SANAYİ VE TİCARET A.Ş.
3	BURCE	BURÇELİK BURSA ÇELİK DÖKÜM SANAYİİ A.Ş.
4	BURVA	BURÇELİK VANA SANAYİ VE TİCARET A.Ş.
5	DOGUB	DOĞUSAN BORU SANAYİİ VE TİCARET A.Ş.
6	EMKEL	EMEK ELEKTRİK ENDÜSTRİSİ A.Ş.
7	MAKTK	MAKİNA TAKIM ENDÜSTRİSİ A.Ş.
8	PRKME	PARK ELEKTRİK ÜRETİM MADENCİLİK SANAYİ VE TİCARET A.Ş.
9	YAPRK	YAPRAK SÜT VE BESİ ÇİFTLİKLERİ SANAYİ VE TİCARET A.Ş.

Table 2. Economic Productivity Rates of Business in the BIST SME Index

Years	*ACSEL*	*BFREN*	*BURCE*	*BURVA*	*DOGUB*	*EMKEL*	*MAKTK*	*PRKME*	*YAPRK*	*Mean*
2011	1,22	1,27	1,08	1,10	0,99	1,34	1,54	2,63	1,56	1,41
2012	1,15	1,27	1,11	1,07	1,18	1,18	1,41	2,03	1,48	1,32
2013	1,24	1,26	1,29	1,19	1,15	1,33	0,93	1,38	1,47	1,25
2014	1,28	1,21	1,17	1,24	1,06	1,39	1,29	1,12	1,33	1,23
2015	1,22	1,21	1,20	1,34	1,48	1,44	1,40	1,23	1,24	1,31
2016	1,19	1,19	1,24	1,53	1,33	1,43	1,51	1,00	1,15	1,29
2017	1,21	1,22	1,23	1,31	1,39	1,25	1,47	2,42	1,14	1,40
2018	1,29	1,23	1,30	1,30	1,10	1,31	1,49	2,20	1,19	1,38
2019	1,23	1,19	1,29	1,72	0,98	1,49	1,39	4,11	1,22	1,62
2020	1,36	1,16	1,16	1,17	1,18	1,66	1,4	1,36	1,18	1,29
2021	1,28	1,17	1,25	1,32	1,34	1,45	1,71	1,85	1,17	1,39
2022	1,28	1,21	1,36	1,42	1,2	1,25	2,17	2,17	1,38	1,49
2023	1,11	1,05	1,33	1,04	1,12	1,32	1,37	1,61	1,32	1,25
2024	1,07	1,12	1,33	1,47	0,82	1,48	1,80	1,61	1,31	1,34
MEAN	***1,22***	***1,20***	***1,24***	***1,30***	***1,17***	***1,38***	***1,49***	***1,91***	***1,30***	***1,36***
MAXIMUM	***1,36***	***1,27***	***1,36***	***1,72***	***1,48***	***1,66***	***2,17***	***4,11***	***1,56***	***1,85***
MINIMUM	***1,15***	***1,16***	***1,08***	***1,07***	***0,98***	***1,18***	***0,93***	***1,00***	***1,14***	***1,08***

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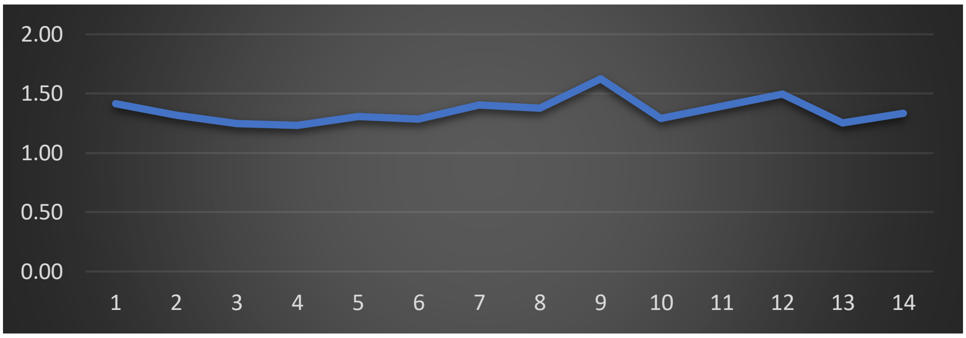
Considering the economic productivity avIn Table 2, the business with the highest economic productivity ratio is PRKME, with an average of 1.91. MAKTK is second with an average of 1.49, and EMKEL comes in third with an average of 1.38.

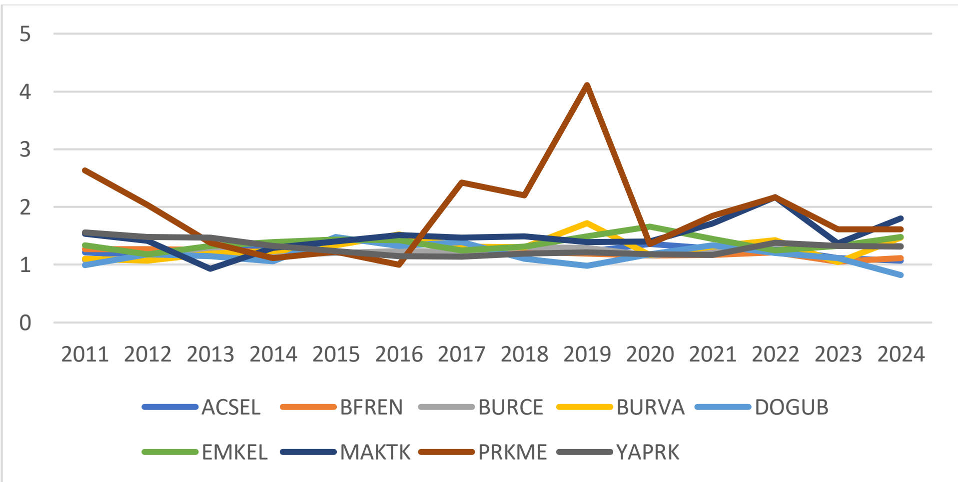
Taking into account the average productivity rates of enterprises each year, the years with the highest productivity were 2019, 2022, and 2011, while the years with the lowest productivity were 2014, 2013, and 2023.

Graph 1. Economic Rates Trend Of Businesses in BIST SME Index by Year



Graph 1 indicates that the return rates of businesses peaked in 2019, saw a significant decline in 2020, and began to recover thereafter.

Graph 2. Economic Productivity Rates Trend Of Businesses in BIST SME Index



Considering the economic productivity trends of the businesses in Graph 2, the business with the highest economic productivity trend is PRKME, with an average of 1.91. MAKTK is second with an average of 1.49, and EMKEL is third with an average of 1.38.

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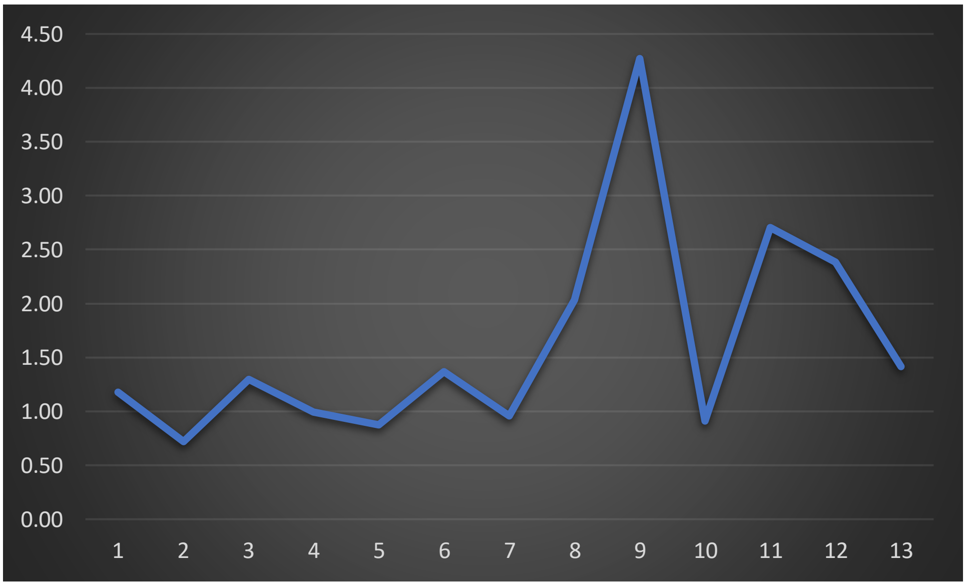
Table 3. Stock Return Rates of Businesses in BIST SME Index

Years	*ACSEL*	*BFREN*	*BURCE*	*BURVA*	*DOGUB*	*EMKEL*	*MAKTK*	*PRKME*	*YAPRK*	*MEAN*
2012	0,58	1,17	1,01	0,66	1,43	1,76	1,41	1,78	0,76	*1,18*
2013	0,84	0,62	0,44	0,54	0,61	1,04	0,75	0,76	0,89	*0,72*
2014	1,81	1,40	1,31	1,13	1,05	1,31	1,59	0,87	1,19	*1,30*
2015	1,36	1,16	0,82	0,75	1,75	0,91	0,77	0,72	0,67	*0,99*
2016	0,63	0,82	1,04	1,13	0,57	0,87	1,44	0,70	0,69	*0,88*
2017	0,86	1,40	1,15	1,22	1,37	1,37	1,34	2,04	1,56	*1,37*
2018	1,23	0,84	0,80	0,83	1,74	0,63	0,86	0,57	1,10	*0,96*
2019	1,94	1,84	1,85	5,59	0,87	1,65	1,17	1,28	2,12	*2,03*
2020	2,71	4,17	3,68	6,09	2,09	3,70	1,80	1,77	12,44	*4,27*
2021	1,05	0,84	1,44	0,47	1,13	0,41	0,93	1,15	0,74	*0,91*
2022	4,29	3,74	1,72	1,77	2,50	2,18	2,25	4,23	1,64	*2,70*
2023	1,38	2,75	2,33	1,74	1,40	5,99	0,74	0,73	4,41	*2,39*
2024	1,09	0,77	1,57	1,60	1,43	0,83	1,40	1,21	2,87	*1,42*
MEAN	***1,52***	***1,66***	***1,47***	***1,81***	***1,38***	***1,74***	***1,27***	***1,37***	***2,39***	***1,62***
MAXIMUM	***4,29***	***4,17***	***3,68***	***6,09***	***2,50***	***5,99***	***2,25***	***4,23***	***12,44***	***4,27***
MINIMUM	***0,58***	***0,62***	***0,44***	***0,47***	***0,57***	***0,41***	***0,74***	***0,57***	***0,67***	***0,72***

Considering the average return rates of the businesses in Table 3, the business with the highest economic efficiency rate is YAPRK with 2.39, BURVA is the 2nd with an average of 1.81, and BFREN is the 3rd with an average of 1.66.

Graph 3. Average Return Rates Trend Of Businesses in BIST SME Index



Graph 3 shows that the return rates of businesses reached the highest average in 2019, experienced a sharp decrease in 2020, and entered the recovery process again.

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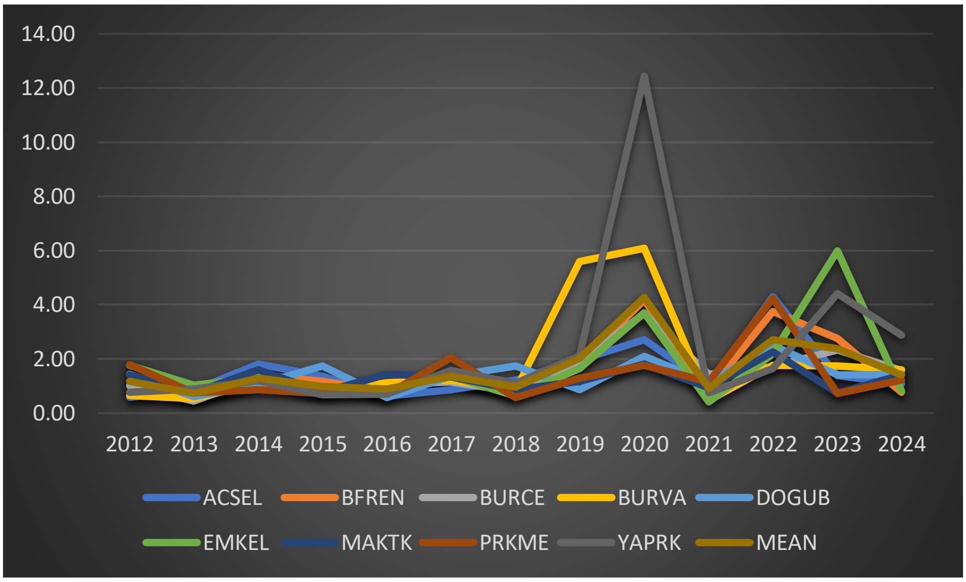
Graph 4. Return Rates Trend of Businesses in BIST SME Index



Panel data analysis offers extensive data, variability, degrees of freedom, and efficiency by merging time series and cross-sectional data (Gujarati, 2016: 406). In panel data analysis, multiple observations are generated for the units by considering individual observations at different time points for those units. While cross-sectional data provide information about a specific time period for a large number of units, time series data offers values for just one unit over a period. If information is needed based on both time and cross-sectional units, panel data analysis should be utilized (Karaca and Çonkar 2022: 117).

5. Panel Data Analysis and Findings

Panel data analysis provides a lot of data, variability, degree of freedom, and efficiency by combining time series and cross-sectional data (Gujarati, 2016: 406). In panel data analysis, it is ensured that multiple observations are created for the units by taking into account individual observations for different time points of the units. While cross-sectional data only provide information about a certain time period for a large number of units, time series data provides values of only one unit over a period. If information is required according to both time and cross-sectional units, panel data analysis should be used (Karaca and Çonkar 2022: 117).

Panel data model in general (Gujarati, 2003: 219). can be written as follows. Here, Y (dependent variable), X_{kit} (independent variable), α_{it} is the constant parameter, β_{kit} is the slope parameter and μ_{it} is the error term subscript i indicates units, the subscript t indicates time (Altunisik, 2010; Tafri et al., 2009)

$$Yit = \alpha it + \beta kit\, Xkit + \mu it \qquad (7)$$

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The hypothesis of the study:

H_1: There is a relationship between the economic productivity rates of the businesses in the BIST SME index and the stock return rate.

The model of the study can be expressed by equation (8).

$$Model: RoR = \beta_0 + \beta_{1P} + \mu_{it} \quad (8)$$

In the Model, the Rate of Return (RoR) is included as the dependent variable, while the Economic Productivity Rate (P) is included as the independent variable.

Table 4. Stock Return Rates of Businesses in BIST SME Index

Variables		*Mean*	*Std. Deviation*	*Min*	*Max*	*Number of Observations*
RoR	Overall	1,6232	1,4945	0,4121	12,4402	N = 117
	Between		0,3400	1,2653	2,3920	n = 9
	Within		1,4594	-0,9490	11,6714	T = 13
P	Overall	1,3514	0,3588	0,8213	4,1100	N = 117
	Between		0,2122	1,1790	1,8537	n = 9
	Within		0,2972	0,4977	2,6077	T = 13
log RoR	Overall	0,2626	0,6074	-0,8863	2,5209	N = 117
	Between		0,0814	0,1456	0,4287	n = 9
	Within		0,6025	-0,9156	2,3548	T = 13

When the statistics related to the variables are examined, the average return rate (RoR) of the businesses was calculated as 1.6232 and the standard deviation as 1.4945, while the average economic productivity rate (P) was calculated as 1.3514 and the standard deviation as 0.3588. Other statistics on the variables are detailed in Table 4.

While the null hypothesis of the CD test states that there is no horizontal cross-section dependence, the alternative hypothesis assumes that there is horizontal cross-section dependence. If the probability value is below 0.05 in the test result, the null hypothesis is rejected at a significance level of 5%, and it is concluded that there is horizontal cross-section dependence (Kocbulut and Baris, 2016: 29).

Table 5. Horizontal Cross-Sectional Dependence Test

Metod	*Statistics*	*Probability (p)*
Pesaran CD Test Statistics	11,483*	0,0000
Friedman R	57,143*	0,0000
Frees Q	1,643*	0,0000
Critical values from Frees' Q distribution		
alpha = 0,10: 0,1984		
alpha = 0,05: 0,2620		
alpha = 0,01: 0,3901		

*Note: * shows 1% significance level.H0: There is no dependence between the sections H1: There is a dependency between the sections.*

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Table 5 shows the cross-sectional dependence test results between units. When the test results are examined, all three test results show that there is cross-sectional dependence between units.

Due to the presence of horizontal cross-sectional dependence among the series, the CADF (Cross-sectional Augmented Dickey-Fuller) Unit Root Test developed by Pesaran in 2007 was used to analyze the stationarity of the series. First, the CADF test statistics are calculated for all units in the panel. Then, the CIPS (Cross Sectionally Augmented Im Pesaran Shin) test statistics for the panel are calculated using the arithmetic mean of the CADF tests. In this way, CADF is used for unit-level stationarity and CIPS is used for panel stationarity (Pesaran, 2007: 269-271).

Table 6. Results of Pesaran Panel Unit Root Test

Variable	*Model*	*Pesaran CADF Statistics*	*Lag Length*	*Critical Table Value*			*Probability(p)*
				10%	*5%*	*1%*	
logRoR	With Constant	-4,465*	1	-2,220	-2,370	-2,660	0,0000
	With Constant and Trend	-3,536*	1	-2,760	-2,930	-3,240	0,0000
D.P	With Constant	-3,708*	1	-2,220	-2,370	-2,660	0,0000
	With Constant and Trend	-3,816*	1	-2,760	-2,930	-3,240	0,0000

*Note: * represents 1% significance level, respectively.*

When Table 6 is examined, it is understood from the probability values that the series contain unit roots and are made stationary in the second difference. ($p<0.05$)

The assumptions of varying variance and autocorrelation form the basic assumptions about the error term in panel data analysis. Variable variance implies that the assumption of constant variance is not valid. This means that the variances of the error terms are different for all cross-sections and their covariances are not equal to zero. Variation in the conditional variance of the error term is a common phenomenon, particularly in the analysis of cross-sectional data. The autocorrelation assumption refers to the significant relationship between successive values of the error term. The fact that unit values interact with each other, i.e., unit values are not independent of each other, results in a systematic relationship in panel data analysis. This may lead to deviations and inconsistencies in panel data analysis. The autocorrelation problem is frequently encountered in panel data analyses in which time and cross-sectional dimensions are analyzed (Topaloglu, 2018: 28).

Table 7. Varying Variance and Autocorrelation Test

Tests	*Hypothesis*	*Test Statistics*		*Probability*
Levene Brown and Forsythe Test	H_0: $\sigma^2 i = \sigma^2 i$			
W0		*1.23185704*	df (8, 108)	0.2875
W50		*0.96365351*	df (8, 108)	0.4683
W10		*1.11260055*	df (8, 108)	0.3605
Baltagi Wu LBI	H_0: p=0	2,0505		0.6873
Bhargava Durbin - Watson	H_0: p=0	1.9778		0.6873

When Table 7 is examined, it is understood from the probability values that there is no autocorrelation and changing variance problem related to the series ($p>0.05$). According to the results of the Levene Brown and Forsythe Test, the variances of the units expressed as equal H_o: acceptance, that is, the variance does not change according to the units. According to Baltagi Wu LBI and Bhargava Durbin - Watson test, it can be seen from the probability value that there is no autocorrelation problem. The absence of variance and autocorrelation issues is crucial for the selection of the estimator to be used in the estimation of the research model. Before the estimation stage, tests are conducted to decide on the appropriate panel data model type to represent the data optimally (Baltagi, 2005:57-66).

Table 8. Determination of the Estimation Model and F, LM and Hausman Test

Tests	*Test Statistics*	*Probability (P-Value)*
F Test	0,72	0,3976
LM Test (Breusch-Pagan)	0,00	1,0000
Hausman Test Statistics	2,22	0,1360

The F test, Hausman test, and Breuch-Pagan LM (1980) tests are utilized to determine which of the pooled model, fixed effects model, and random effects model is the most efficient estimator among panel data estimation models (Demirtas and Cakırca 2019: 151,152).

The F test is used to distinguish between the pooled model and the fixed effects model (one-way and two-way), while the LM test is used to determine the suitable model between the pooled model and the random effects model (one-way and two-way) under the assumption that there may be a random effect (Baltagi, 2005:57-66). In the random effect model, the hypothesis that the correlation between the unit effect and the explanatory variables is zero ($H0: E(\alpha i, xit) = 0$) is tested with the Hausman test. If this assumption is not fulfilled, the Generalized Least Squares (GLS) estimator, a random effects estimator, is not unbiased and consistent. Therefore, it is essential to choose a suitable estimator under the assumption that the effects are random. As can be seen in the table above, only one-way unit effect models are valid under both fixed

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and random effect assumptions. Under the random effect assumption, the Feasible Generalized Least Squares (FGLS) estimator is used since the condition E (αi ,xit)=0 is satisfied according to the Hausman test result.

Table 9. Analysis Results Regarding the Relationship Between Economic Productivity Ratio and Rate of Return

RoR	*Coef.*	*Std. Deviation*	*z-Statistic*	*Prop.*
P	0,9125	0,2986	3,06*	0,0020
cons	0,0008	0,0277	0,03	0,9740
Wald chi2(1)	9,34*	Number of obs,	99	
Prob.	0,0022	Number of groups	9	
		Model	Random-effects GLS regression	

*Note: * refers to 1% significance level.*

When the estimation results in Table 9 are examined, the statistical probability value of 0.0022 indicates that the model is significant. The significance level of the Wald chi2 value being less than 0.0022 implies that the independent variable productivity (P) among the model's variables has a strong explanatory power for the dependent variable return rate (RoR). When we look at the significance levels of the variables, it can be seen that the cons variable coefficient is not statistically significant, and the P variable coefficient is statistically significant.

When the analysis results were assessed, considering the significance level of the model, it was determined that there was a statistically significant and positive relationship between the economic productivity ratio and the rate of return (RoR). In other words, it was concluded that an increase in the economic productivity rate of businesses included in the SME index by one unit would result in an increase in the rate of return by 0.91.

6. Results and Recommendations

In this study, the economic productivity of the businesses included in the BIST SME index was evaluated and the relationship between them and stock return rates was determined. The economic productivity of businesses was obtained by taking the ratio of sales in the Income Statement and the cost of goods sold. The return rates of the businesses were included in the analysis based on the value obtained by taking the natural logarithm of the year-end closing prices of the businesses' stocks compared to the previous year's closing prices. Data for the model were obtained from the Public Disclosure Platform Financial Statements. The relationship between the economic productivity of businesses and stock return rates was analyzed by the panel data regression model.

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Consequently, it was concluded in the study that the economic productivity rates of the businesses included in the BIST SME index positively affect their return rates.

When the analysis results were evaluated, considering the significance level of the model, it was determined that there was a statistically significant and positive relationship between the economic productivity rate and the rate of return (RoR). In other words, it is seen that a one-unit increase in the economic productivity rates of the businesses (P) in the SME index will create an increase of 0.91 in the rate of return, and the estimated coefficients are statistically significant.

In conclusion, the hypothesis is accepted, as the model results are significant at a 0.01 confidence level. This indicates that a positive relationship exists between businesses' economic productivity and stock return rates. The increase in productivity among businesses leads to higher profitability and stock return rates by reducing the production costs of goods and services. An increase in a business's return rates based on profitability makes it attractive for investments. The appeal of the financial investment instruments offered by the business creates a chain effect, positively impacting resource costs and further enhancing productivity.

The findings from the study align with the results of the studies conducted by Kalaycı and Karataş (2005), Kara and Eryiğit (2024), and Karaca and Karaca (2025). Evaluating this study alongside others adds a new dimension to the literature and sheds light on new ideas for future research. Although existing studies are generally focused on the factors affecting productivity, they fall short of exploring the outcomes produced by productivity. In addition to comparing productivity with its influencing factors, this study also opens a research avenue regarding the impacts of productivity on profitability, efficiency, return rates, market value, growth, and business autonomy.

The study is presented to the attention of researchers with the suggestion that this study can pioneer future research on inter-enterprise and sectoral productivity comparisons and lead to the emergence of creative research ideas regarding this matter.

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