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# An Empirical Analysis of the Causal Relationship between R&D Expenditures and Exports in Türkiye and Selected EU Countries

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**Abstract**

In today's global economic environment, where competition is becoming increasingly intense, countries' export performance is closely associated with their level of competitiveness. In this context, research and development (R&D) activities play a critical role in creating and sustaining competitive advantage. The aim of this study is to examine the relationship between R&D expenditures and exports for 20 European Union (EU) member states and Türkiye, an EU candidate country, using annual data covering the period 1996–2022. In the empirical analysis, GDP per capita, the official exchange rate, and trade openness are included as control variables. The dynamic interactions among the variables are investigated within a Panel Vector Autoregression (PVAR) framework, and the direction of causality is assessed using panel Granger causality tests. The empirical findings reveal a unidirectional causal relationship running from R&D expenditures to exports after controlling for economic growth, exchange rates, and trade openness. These results suggest that R&D activities constitute an important determinant of export performance and contribute to strengthening international competitiveness.

**Keywords**
Exports, R&D Expenditures, Panel Causality

**JEL Classification**
F10, F14, C23

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# Türkiye ve Seçilmiş AB Ülkelerinde AR-GE Harcamaları ile İhracat Arasındaki Nedensellik İlişkisinin Ampirik Analizi

**Öz**

Küresel rekabetin giderek yoğunlaştığı günümüz ekonomik konjonktüründe, ülkelerin ihracat performansı büyük ölçüde rekabetçilik düzeyleriyle ilişkilidir. Bu bağlamda, rekabet avantajının oluşturulması ve sürdürülebilirliğinin sağlanmasında araştırma ve geliştirme (AR-GE) faaliyetleri kritik bir rol üstlenmektedir. Bu çalışmanın amacı, 20 Avrupa Birliği (AB) üyesi ülke ile AB aday ülkesi Türkiye için 1996–2022 dönemine ait yıllık veriler kullanılarak AR-GE harcamaları ile ihracat arasındaki ilişkinin incelenmesidir. Analizde ekonomik büyüme, döviz kuru ve ticari açıklık değişkenleri kontrol değişkenleri olarak modele dahil edilmiş; değişkenler arasındaki dinamik ilişkiler Panel Vektör Otoregresif (PVAR) model çerçevesinde Panel Granger nedensellik testi ile araştırılmıştır. Elde edilen ampirik bulgular, kontrol değişkenlerinin etkisi dikkate alındığında AR-GE harcamalarından ihracata doğru tek yönlü bir nedensellik ilişkisinin bulunduğunu göstermektedir. Sonuçlar, AR-GE faaliyetlerinin ülkelerin ihracat performansının önemli belirleyicilerinden biri olduğunu ortaya koymaktadır.

**Anahtar Kelimeler**
İhracat, AR-GE Harcamaları, Panel Nedensellik

**JEL Kodları**
F10, F14, C23

## 1. Introduction

In today's economies, for countries adopting an export-led growth strategy, maintaining a sustainable export structure is of critical importance in order to ensure the sustainability of economic growth and welfare gains, and to increase resilience against external economic shocks. Under conditions of intensified global competition, achieving sustainable export performance depends on exporting firms' innovation capacity and on the efficiency of the national R&D infrastructure that supports this capacity. Within this framework, endogenous growth models emphasize increasing competitiveness through improved R&D activities and supporting economic growth by raising gains from foreign trade as among the fundamental determinants of growth.

In economic theory, the relationship between exports and R&D expenditures (RDE) is addressed within three main frameworks. The first approach examines if RDE enhances firms' innovation capacity and thereby leads them to engage in export activities. The second approach focuses on whether export activities stimulate R&D investment by improving firms' knowledge accumulation and technological capabilities. The third approach investigates whether there is bidirectional causality between exports and RDE, and whether these two activities exhibit a complementary structure (Neves et al., 2016).

Using firm-level data, Esteve-Pérez & Rodríguez (2013) demonstrate the existence of strong interdependence between exports and R&D activities. Accordingly, having engaged in

export activities in the previous period increases the expected return from R&D activities in the current period; similarly, having undertaken R&D activities in the previous period raises the expected return from export activities in the current period. This dynamic interaction results in a mutually reinforcing structure over time and leads to simultaneous increases in both exports and R&D activities in the current period.

In the literature, the effect of RDE on exports was examined more extensively than that of export activity on RDE. Nevertheless, both theoretical and empirical studies suggest that RDE is expected to enhance export performance, while export activity is also expected to stimulate R&D investment. Exporting firms improve their innovation capacity in adapting to intense competitive conditions in foreign markets and may increase domestic R&D activities accordingly. Firms operating in international markets acquire knowledge about foreign technologies through interaction with international competitors and exhibit a stronger tendency to invest in such technologies. Moreover, meeting the more sophisticated product demand associated with heightened competition in global markets encourages the internalization of foreign technologies, contributing to the strengthening and updating of the domestic knowledge base (Girma et al., 2008).

Firms that engage in exporting can increase export volumes by undertaking the necessary R&D investments to compete in foreign markets. In addition, exporting firms can spread the fixed costs of R&D investments over a larger scale of production due to increased output, thereby reducing the unit cost of such investments. These leads exporting firms to be more willing to undertake R&D activities compared with firms operating solely in domestic markets (Esteve-Pérez & Rodríguez, 2013).

This study aims to empirically investigate the causal relationship between exports and R&D expenditures for 20 European Union (EU) member states and Türkiye, an EU candidate country, using annual data covering the period 1996–2022. In addition to R&D expenditures and exports, GDP per capita, the official exchange rate, and trade openness are included in the analysis as control variables in order to account for key macroeconomic factors that may influence the relationship between the two variables. The dynamic interactions among the variables are examined within a Panel Vector Autoregression (PVAR) framework, and the direction of causality is assessed by means of panel Granger causality tests.

While a considerable part of the existing literature focuses primarily on the bivariate relationship between exports and R&D expenditures, relatively limited attention has been paid to the role of macroeconomic control variables within a dynamic panel setting. By incorporating these control variables and employing a PVAR approach, this study provides a more comprehensive assessment of the relationship between R&D expenditures and exports. In this respect, the study contributes to the literature by offering updated evidence based on a long and recent dataset and by adopting a broader analytical framework that explicitly accounts for major macroeconomic determinants of export performance. The remainder of the study is organized as follows. The second section reviews selected empirical studies. The third section presents the econometric methodology and dataset and illustrates the evolution of exports and R&D expenditures in EU countries over time prior to the empirical analysis. The fourth section reports the empirical findings, and the conclusion provides an overall evaluation and discusses the policy implications of the results.

## 2. Literature Review

This section reviews selected empirical studies investigating the relationship between exports and RDE. These studies are systematically evaluated in terms of authors, countries covered, period of analysis, methodology employed, and key findings, and a summary of this evaluation is presented in Table 1.

Table 1

*Literature Review of Selected Empirical Studies*

| Author | Country | Period | Methodology | Results |
|---|---|---|---|---|
| Braunerhjelm & Thulin (2008) | 19 OECD countries | 1981-1999 | Panel econometric methods | An increase in RDE leads to an increase in high-technology exports. |
| Bojnec & Fertő (2011) | OECD countries | 1995-2003 | Panel econometric methods | R&D has been found to be positively associated with manufacturing trade from the perspective of exporting countries. |
| Göçer (2013) | 11 developing Asian countries | 1996-2012 | Dumitrescu and Hurlin (2012) panel causality test | No causality has been identified between exports and RDE. |
| Kılıç et al. (2014) | G-8 Countries | 1996-2011 | Dumitrescu and Hurlin (2012) | Bidirectional causality has been identified between RDE and high-technology exports |

| | | | | |
|---|---|---|---|---|
| | | | panel causality test | |
| Sandu & Ciocanel (2014) | 26 EU member countries | 2006-2010 | POLS, Multiple linear regression | A positive correlation has been found between RDE and high-technology exports |
| Şahbaz et al. (2014) | 17 EU countries and Türkiye | 1996-2011 | Panel cointegration and panel causality test | Bidirectional causality has been identified between RDE and high-technology exports |
| Çetin & Cincera | EU member countries | 1990-2005 | Probit model | Mutual dependence between R&D and export has been identified. |
| Çetin (2016) | 7 Newly industrialized countries | 1996-2013 | Panel econometric methods | A unidirectional causal relationship was identified from RDE to high-technology exports |
| Yüksel (2017) | 28 EU member countries | 1996-2014 | Dumitrescu and Hurlin (2012) panel causality test | A unidirectional causal relationship running from exports to RDE has been identified. |
| Özkan & Yılmaz (2017) | 12 EU member countries and Türkiye | 1996-2015 | Panel cointegration and Dumitrescu Hurlin panel Granger causality test | A unidirectional causal relationship running from high-technology exports to RDE has been identified. |
| Karasaç & Sağın (2018) | 35 Europe countries | 2008-2015 | Panel econometric methods | Public and private sector RDE increase countries' high-technology goods exports. |
| Dumrul & Kilicarslan (2018) | 16 OECD countries | 2000-2015 | Panel cointegration tests, Panel FMOLS and DOLS | The effect of RDE on exports is positive. |
| Sözen & Tufaner (2019) | 25 OECD Countries | 1997-2016 | Dumitrescu and Hurlin (2012) panel causality test | Bidirectional causality has been identified between RDE and high-technology exports. |
| Canbay (2020) | Türkiye | 2004-2017 | ARDL | RDE increase exports in both the short run and the long run. |
| Yavuz & Uysal (2020) | 15 OECD counties | 1991-2016 | Panel econometric methods | RDE had positive and significant effect on high-tech product export. |
| Altıner et al. (2022) | 11 Emerging economies | 1996-2018 | Panel quantile regression analysis | RDE had positive and significant effect on high-tech product export. |

*Note.* POLS: Pooled Least Squares, ARDL: Autoregressive Distributed Lag Model, OECD: Organisation for Economic Co-operation and Development, G-8: Group of Eight (G8), R&D: Research and Development, EU: European Union, FMOLS: Fully Modified Ordinary Least Squares, DOLS: Dynamic Ordinary Least Squares.

When the reviewed studies are assessed collectively, it becomes evident that the relationship between exports and RDE was predominantly examined using panel-data econometric

methods, depending on differences in countries and time periods. The selected studies mainly aimed to identify either the effect of RDE on exports or the causal relationship between exports and RDE. In the literature, the export variable has been considered by researchers within the framework of indicators such as total exports or high-technology exports. It appears that the period under investigation and the countries included in the analysis are decisive in whether exports are evaluated in terms of total exports or high-technology exports.

The literature does not yield a consensus regarding the causal relationship between exports and RDE. Therefore, classifying the studies investigating this causal relationship is also important for the current study. In this regard, Kılıç et al. (2014), Şahbaz et al. (2014), and Sözen & Tufaner (2019) identify bidirectional causality between exports and RDE. In contrast, Çetin (2016) finds a unidirectional causal relationship running from RDE to exports, while Yüksel (2017) & Özkan and Yılmaz (2017) report unidirectional causality from exports to RDE. Göçer (2013), on the other hand, does not identify any statistically significant causal relationship between exports and RDE.

A substantial part of the existing literature investigates the relationship between exports and R&D expenditures within a bivariate framework, without explicitly accounting for macroeconomic factors that may simultaneously affect both variables. In particular, relatively limited attention has been paid to the role of economic growth, exchange rates, and trade openness within a dynamic panel setting. By incorporating these control variables and employing a PVAR approach, the present study extends the existing literature and provides a more comprehensive analysis of the dynamic interactions between R&D expenditures and exports.

## 3. Data Set and Methodology

In this study, the relationship between exports and RDE is analyzed using annual data covering the period 1996–2022 for 20 EU member states (Austria, Belgium, Bulgaria, Czechia, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, and Spain) and Türkiye, an EU candidate country. In addition to exports and RDE, GDP per capita, the official exchange rate, and trade openness are included in the analysis as control variables. This section first presents the definitions of the variables employed in the empirical analysis and reports their descriptive statistics. It then introduces the econometric model constructed to examine the relationship between exports and RDE and describes the panel Granger causality methodology employed within the PVAR

framework. Finally, prior to the presentation of the empirical results, the evolution of exports and RDE s over time for the countries included in the model is illustrated in Figure 1 and Appendix 1.

Table 2

*Description of Variables*

| Variable Name | Variable Abbreviation | Variable Description | Variable Data Source |
|---|---|---|---|
| R&D | lnRD | Research and development expenditure (% of GDP) | World Bank |
| Export | lnEX | Exports of goods and services (% of GDP) | World Bank |
| GDP per Capita | lnGDP | GDP per capita (current US$) | World Bank |
| Official Exchange Rate | lnEXC | Official exchange rate (LCU per US$, period average) | World Bank |
| Trade Openness | lnTRO | Trade (% of GDP) | World Bank |

Definitions of the variables are provided in Table 2. The variable lnRD, used as a proxy for R&D activity, represents the share of countries' RDE in gross domestic product (GDP), expressed as a percentage (%). The variable lnEX, included in the analysis as an export indicator, denotes the share of exports of goods and services in GDP, expressed as a percentage (%). In addition, the variables lnGDP, lnEXC, and lnTRO represent GDP per capita (current US$), the official exchange rate (local currency units per U.S. dollar, period average), and trade openness measured as trade as a percentage of GDP, respectively. Data for all variables were obtained from the World Bank's World Development Indicators (WDI) database.

Table 3

*Descriptive Statistics*

| Variable | Number of Observations | Mean | Standard Deviation | Maximum | Minimum |
|---|---|---|---|---|---|
| lnRD | 567 | 0.219 | 0.615 | 1.317 | -1.044 |
| lnEX | 567 | 3.849 | 0.438 | 4.940 | 2.935 |
| lnGDP | 567 | 9.926 | 0.724 | 11.491 | 8.171 |
| lnEXC | 567 | 0.910 | 1.752 | 7.459 | -2.508 |
| lnTRO | 567 | 4.543 | 0.415 | 5.556 | 3.629 |

Table 3 presents the descriptive statistics for the variables used in the empirical analysis. The panel dataset consists of 567 observations for each variable. The mean of lnRD, representing R&D activity, was calculated to be 0.219, with a standard deviation of 0.615. The min lnRD value was observed for Latvia in 1999, whereas the max value was observed for Finland in 2009. The

mean lnEX value, representing exports, is 3.849, with a standard deviation of 0.438. For lnEX, the minimum value corresponds to Türkiye in 1999, while the maximum value was observed for Ireland in 2020. In addition, the descriptive statistics for lnGDP, lnEXC, and lnTRO indicate substantial variation across countries and over time, suggesting that the sample captures considerable heterogeneity in terms of economic development, exchange rate dynamics, and trade openness.

$$\ln (EX)_{it} = \beta_0 + \beta_1 \ln (RD)_{it} + \beta_2 \ln (GDP)_{it} + \beta_3 \ln (EXC)_{it} + \beta_4 \ln (TRO)_{it} + \varepsilon_{it} \quad (1)$$

The model constructed to examine causality between lnEX and lnRD is specified in Equation (1). In this model, $\beta_0$ refers to the constant term, $\beta_1$–$\beta_4$ are the slope coefficients, t to time, i to the country, ln to the natural logarithm of the variables, and ε to the error term.

$$Y_{it} = a_i + \sum_{k=1}^{K} \gamma_i^{(k)} Y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} X_{i,t-k} + \varepsilon_{it} \quad (2)$$

In the empirical analysis, the direction of causality among the variables is assessed using panel Granger causality tests within the PVAR framework. The panel Granger causality approach extends the conventional Granger causality test to panel data settings by examining whether the lagged values of one variable provide statistically significant information for predicting another variable. The general specification of the panel Granger causality model is presented in Equation (2). In this equation, $Y$ denotes the dependent variable, $X$ represents the explanatory variable, $K$ is the lag length, $a_i$ captures country-specific effects, and $\varepsilon_{it}$ is the error term. Reversing the positions of $X$ and $Y$ allows the direction of causality to be tested in the opposite direction and makes it possible to determine whether the relationship is unidirectional, bidirectional, or statistically insignificant.

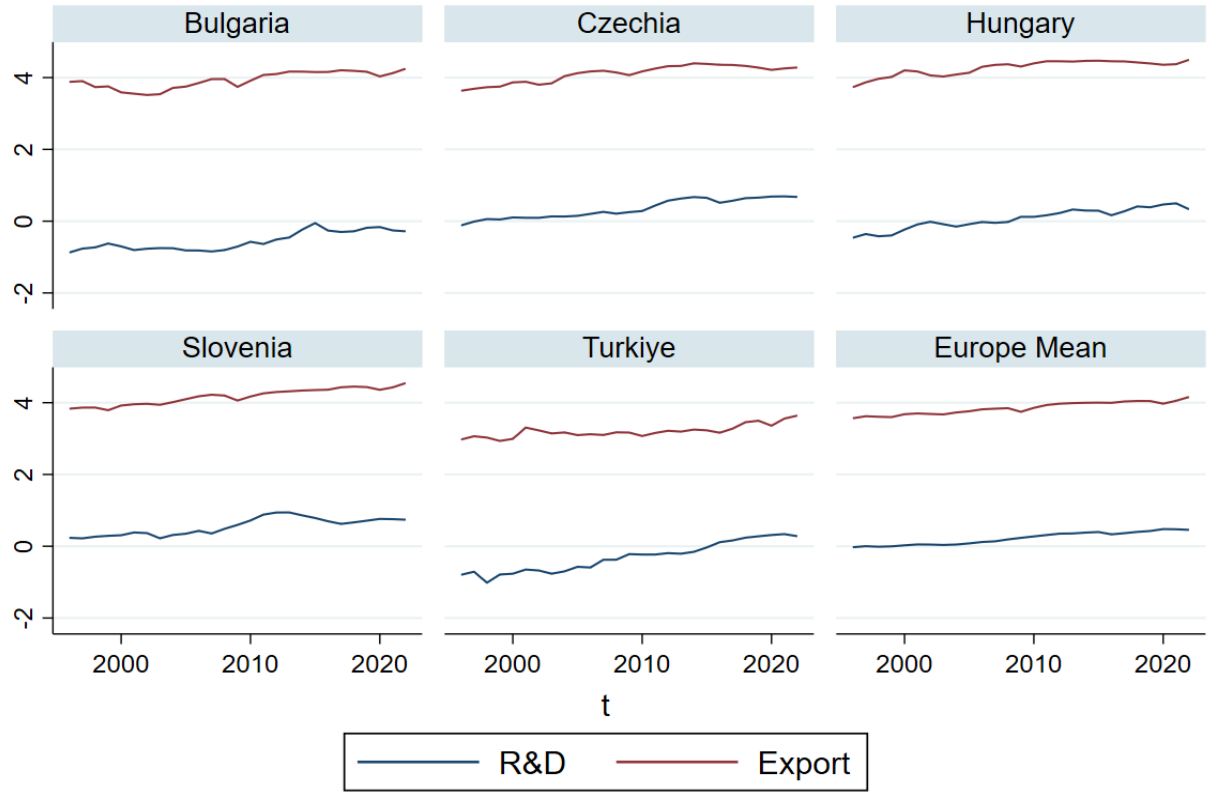


*Figure 1.* Export and R&D Expenditures in Selected Countries

Figure 1 depicts the evolution over time of the R&D expenditure and export indicators used in the econometric analysis for Bulgaria, Czechia, Hungary, Slovenia, Türkiye, and the EU average. For Türkiye, the export indicator exhibits a stable upward trend throughout the period examined; by contrast, RDE remains relatively low at the beginning of the period but enter a marked upward trajectory in subsequent years. With respect to the EU average, exports and R&D indicators largely follow parallel upward trends in the long run. These observations support an empirical investigation of the relationship between exports and RDE and motivate the implementation of causality analysis between the variables.

## 4. Empirical Findings

This section presents the econometric findings regarding the relationship between exports and RDE. The analysis first applies the Swamy S homogeneity test to determine whether the slope coefficients in the model are homogeneous. Next, to examine the presence of inter-unit interaction in the panel data, the cross-sectional dependence test developed by Pesaran (2004) is conducted. To assess the stationarity properties of the series, the Pesaran (2007) CADF (Cross-sectionally

Augmented Dickey-Fuller) unit root test, which addresses cross-sectional dependence, is employed. Finally, the direction of causality among the variables is investigated using panel Granger causality tests within the PVAR framework. All tests were performed using the Stata 17 statistical software package.

Table 4

*Homogeneity Test Results*

| Test | Test Statistic | Probability |
|---|---|---|
| Swamy S | 1687.18 | 0.000* |

*Note.* The * symbol indicates statistical significance at the 1% level.

Table 4 reports the results of the Swamy S homogeneity test conducted to determine whether slope coefficients are homogeneous or heterogeneous in the panel. In this test, the null hypothesis ($H_0$) asserts that the slope coefficients are homogeneous, while the alternative hypothesis ($H_1$) posits heterogeneous coefficients. The findings indicate that the p-value is lower the 1% significance level, leading to rejection of ($H_0$). Accordingly, it is concluded that the slope coefficients differ significantly across countries and that the panel exhibits a heterogeneous structure.

Table 5

*Cross-Sectional Dependence Test Results*

| Variables | Test Statistic | Probability Value |
|---|---|---|
| lnRD | 41.94 | (0.000) |
| lnEX | 58.20 | (0.000) |
| lnGDP | 63.85 | (0.000) |
| lnEXC | 15.60 | (0.000) |
| lnTRO | 64.34 | (0.000) |

Table 5 reports the results of the cross-sectional dependence test (CDLM) developed by Pesaran (2004) for all variables included in the model. In the CDLM test, the null hypothesis ($H_0$) states that there is no cross-sectional dependence, whereas the alternative hypothesis $H_1$ indicates the presence of cross-sectional dependence among units. The results show that the p-values corresponding to the CDLM test statistics for lnRD and lnEX are lower than 0.01. These findings indicate rejection of ($H_0$) for both variables at the 1% significance level, implying the presence of cross-sectional dependence among the panel units. The detection of cross-sectional dependence suggests that first-generation panel unit root tests, which do not address inter-unit interaction, are

not appropriate. Therefore, this study employs the Pesaran (2007) CADF unit root test, which accounts for cross-sectional dependence and is considered a second-generation panel unit root test.

Table 6

*CADF Unit Root Test Results*

| Variables | Constant | | | Constant+Trend | | |
|---|---|---|---|---|---|---|
| | t-bar | Probability | Lag Length | t-bar | Probability | Lag Length |
| lnRD | -2.207 | 0.016 | 1 | -2.347 | 0.428 | 1 |
| lnEX | -1.939 | 0.188 | 1 | -1.939 | 0.966 | 1 |
| lnGDP | -2.235 | 0.012 | 1 | -2.390 | 0.346 | 1 |
| lnEXC | -1.823 | 0.366 | 1 | -2.068 | 0.884 | 1 |
| lnTRO | -2.165 | 0.026 | 1 | -2.255 | 0.607 | 1 |
| ΔlnRD | -2.915 | 0.000* | 1 | -3.129 | 0.000* | 1 |
| ΔlnEX | -2.840 | 0.000* | 1 | -2.994 | 0.000* | 1 |
| ΔlnGDP | -2.696 | 0.000* | 1 | -2.624 | 0.061 | 1 |
| ΔlnEXC | -2.575 | 0.000* | 1 | -2.636 | 0.054 | 1 |
| ΔlnTRO | -3.093 | 0.000* | 1 | -3.182 | 0.000* | 1 |

*Note.* The * symbol indicates statistical significance at the 1% level.

Table 6 presents the results of the CADF unit root test used to examine the stationarity properties of the variables. In the CADF test, the null hypothesis ($H_0$) states that the series contains a unit root, whereas the alternative hypothesis ($H_1$) indicates that the series is stationary. The results show that the variables exhibit mixed evidence at levels under both the constant and constant-plus-trend specifications, and several of the corresponding probability values are not statistically significant. Accordingly, the variables are treated as non-stationary in levels. When the first differences of the variables are considered, the probability values become statistically significant at conventional significance levels for all series under at least one specification, indicating that the variables become stationary after first differencing. Overall, the findings suggest that lnRD, lnEX, lnGDP, lnEXC, and lnTRO are integrated of order one, I(1). Since all variables are stationary in first differences, the subsequent empirical analysis is conducted using the differenced series.

Table 7

*Panel Granger Causality Test Results within the PVAR Framework*

| Hypotheses | Chi-square statistic | Lag Length | p-value |
|---|---|---|---|
| lnRD→lnEX | 5.200 | 1 | 0.023** |
| lnEX→lnRD | 0.065 | 1 | 0.799 |
| lnGDP→lnEX | 8.764 | 1 | 0.003* |
| lnEXC→lnEX | 10.467 | 1 | 0.001* |
| lnTRO→lnEX | 0.368 | 1 | 0.544 |

| | | | |
|---|---|---|---|
| lnEX→lnGDP | 4.318 | 1 | 0.038** |
| lnEX→lnEXC | 0.214 | 1 | 0.644 |
| lnEX→lnTRO | 0.166 | 1 | 0.684 |

*Note.* The * and ** symbols indicate statistical significance at the 1% and 5% levels, respectively.

Table 7 presents the results of the panel Granger causality tests conducted within the PVAR framework to examine the causal relationship between RDE (lnRD) and exports (lnEX) while controlling for GDP per capita, the official exchange rate, and trade openness. The findings indicate that the null hypothesis stating that lnRD do not Granger-cause lnEX is rejected at the 5% significance level. This result reveals a statistically significant unidirectional causal relationship running from lnRD to lnEX. In contrast, the null hypothesis that lnEX do not Granger-cause lnRD cannot be rejected, indicating that exports do not exert a statistically significant causal effect on R&D expenditures.

Among the control variables, GDP per capita and the official exchange rate are found to Granger-cause exports at the 1% significance level, whereas trade openness does not exhibit a statistically significant causal effect on exports. Overall, the results suggest that increases in R&D expenditures contribute to improvements in export performance, while export growth does not appear to stimulate countries' R&D activities.

## 5. Conclusion

In this study, the relationship between exports and RDE was empirically examined for 20 EU member states and Türkiye, an EU candidate country, using annual data covering the period 1996–2022. In addition to exports and R&D expenditures, GDP per capita, the official exchange rate, and trade openness were included in the analysis as control variables. As part of the empirical analysis, the Swamy's S test was first applied to assess the homogeneity of slope coefficients, and the results indicated that the panel exhibits a heterogeneous structure. Next, the cross-sectional dependence test developed by Pesaran (2004) was employed to account for potential interdependence among the cross-sectional units, and the findings revealed statistically significant cross-sectional dependence across countries. In line with these results, the stationarity properties of the variables were examined using the Pesaran (2007) CADF unit root test, which explicitly accounts for cross-sectional dependence. The test results showed that lnRD, lnEX, lnGDP, lnEXC, and lnTRO are non-stationary in levels but become stationary after first differencing.

In the second stage of the empirical analysis, taking the results of these preliminary tests into consideration, the causal relationship between exports and RDE was examined using panel Granger causality tests within the PVAR framework. The findings indicate the existence of a statistically significant and unidirectional causal relationship running from RDE to exports, while no statistically significant causal relationship is identified from exports to RDE. These results suggest that increases in R&D expenditures contribute to improvements in export performance and imply that investments in research and development constitute an important factor in strengthening countries' international competitiveness.

The unidirectional causal relationship identified in this study, running from RDE to exports, is consistent with the findings reported by Çetin (2016). In addition, several empirical studies have documented that RDE exert a positive and statistically significant effect on export performance (Braunerhjelm & Thulin, 2008; Dumrul & Kilicarslan, 2018; Canbay, 2020). The results indicate that policies aimed at increasing RDE can strengthen countries' export performance by enhancing innovation capacity and technological competitiveness. In this context, further research examining the relationship between exports and R&D expenditures using both micro- and macro-level data and considering different country groups, sectors, and time periods would contribute to a more comprehensive understanding of the dynamics underlying this relationship.

## Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

## Researcher's Contribution Rate Statement

Since the author is the sole author of the article, his contribution rate is 100%.

## Declaration of Researcher's Conflict of Interest

There are no potential conflicts of interest in this study.

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Appendix 1: Export and R&D Expenditures in Europe Countries