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Analysis of The Impacts of R&D Expenditures on Export (An ARDL Bounds Test for Turkey, 2000-2023 Period)

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ABSTRACT

Purpose – Main aim in this study is to determine whether R&D activity has an effect on exports and high-technology exports in Turkey, and to determine its level of effect. In this context, the conceptual framework is presented in the first part of the study, and the interaction between R&D (R&D) activities and exports is examined both theoretically and through literature review.

Design/Methodology/approach – R&D-export relationship is investigated for the period 2000-2023 in Turkey, using the ARDL Boundary Analysis method, following the Augmented Dick&Fulley and Philips-Perron Unit root tests.

Findings – The results obtained from the research show that there is a positive and significant interaction between R&D expenditures and exports in Turkey during the period examined, and a positive but weak interaction between high-technology exports.

Discussion – The research tested the level of impact of R&D activities on exports in Turkey. Studies in this area are not sufficient. However, it is seen that there is a close connection between exports and R&D both in theory and in practice all over the world. According to this research results, It can say that the increase of R&D activity in the country, the increase in both general exports and high-technology exports will be affected positively.

1.INTRODUCTION

Aim of Research and Questions: This study attempts to determine whether R&D activities have an impact on general exports and advanced technology exports in Turkey for 2000-2023 peroid and, if so, to what extent. Here, first the aim of research, and hypotheses and then the theoretical foundations of the R&D-export relationship and literature review were presented. The main hypothesis of the study is that R&D expenditures will have a positive impact on exports in the long term. Especially, developing to export is very important for external equilibrium and economic development for developing countries.

To analyze the R&D-export relationship, first of all, it is necessary to reveal the basic determinants of exports in an economy. At this point, it can be said that main factor is production. In this condition, it can say that when the demand for the products that are produced and offered to the foreign market increases, exports will also increase. In cases where production is flexible and there is no problem of increasing production, in order for companies to increase their exports in foreign markets, they need to be competitive in the products they export in these markets. The most well-known method for companies to be competitive in foreign markets is for these companies to have a cost/price advantage/attraction in the products they export according to their classical comparative advantages. However, being permanent in the markets in this way is a difficult situation considering that another company offering at a lower cost/price may come. Another way to exist in foreign markets is to produce newer, more attractive products than competitors, and therefore different products that competitors may have difficulty competing with, in the sense of being more effective than the classical method, and to offer these to foreign markets. The possibility of this for companies depends on their ability to provide production techniques, production processes, and product development. The way for companies to achieve this is to carry out R&D activities and to sustain this in a stable manner. At this point, a connection can be established between R&D and export.

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Hypotheses: A priorially, it can be said that it is possible to develop exports in an economy through R&D activities. And this is a situation that is often accepted in economic theory. However, determining this situation econometrically with the help of data, will support the validity of this a priori assumption. In this surround, in model, series are I(0) and I(1) and based on the unit root test results, the ARDL bounds test model was created. With this test, we can determine whether there are long-term relationships between the independent and dependent variables. Here, within the framework of the ARDL model, the long-term relationship between the dependent variable and the independent variables can be defined as follows:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \, \Delta y_{t-i} + \sum_{j=0}^{q} \gamma_i \, \Delta X_{t-j} + \lambda_1 y_{t-1} + \lambda_2 X_{t-1} + \varepsilon_t$$

Here, hypotheses for Long-Term Relationship as follow down;

H_0 (Null Hypothesis): There is no long-term relationship between R&D and export/HT export. In result, there isn't cointegration between the variables.

$$H_0 : \gamma_1 = \gamma_2 = 0$$

H_1 (Alternative Hypothesis): There is a long-run relationship between R&D and export/HT export and it shows that there is cointegration between R&D and export/HT export.

$$H_1 : \gamma_1 \neq 0 \text{ and/or } \gamma_2 \neq 0$$

These hypotheses can be tested with the ARDL bounds test. In result of test, it can see whether there is a long-term relationship between varabales.

Theoretical Base of Research and Literature Review: A significant portion of developing economies, as in the 20th century, are experiencing in increased consumption levels, the process called the vicious cycle of underdevelopment in the 21st century, as Ragnar Wilhelm Nurkse said. There are two main problem sources and determinants in this vicious cycle of underdevelopment. The first of these is the savings bottleneck. The second problem source and determinant is the foreign exchange bottleneck. The essence of both bottlenecks is the inability to increase production and therefore income, i.e. income insufficiency according to consumption levels. It is seen that many things have changed from the 20th century to the 21st century. However, these two problems still exist in growing scales for developing economies. There is this problem at the backside of their crises. These economies experience these problems in a cyclical manner, similar to each other but different from the economies of developed countries. Previously, (at the 1980s and before) international credit/funding opportunities were weak and these economies were dragged from bottleneck to crisis in shorter periods of time. Today, thanks to the international credit/funding opportunities brought by globalization, because these economies can postpone possible crises for longer periods. In a sense, international funding opportunities have extended the sustainability of growth in bottlenecks for these countries.

It is clear that the level of economic development that developed economies have is not the case in most developing economies, and this situation indicates a great differentiation between the two groups of economies. This differentiation, in which economic performance, population, and even international political/military factors are the main determinants for countries, separates the two groups of economies from each other. However, it should be noted that there are other factors in this differentiation in economic development. For example, social consumption patterns, social perspectives towards innovation, and social cultural-religious-moral-courage behaviors are also important factors in affecting the development of economies and especially in affecting economic performance. These factors can also greatly affect population growth rates (which somehow affect economic development) as an intermediary factor in certain cases. These factors somehow affect both the savings bottleneck and the foreign exchange bottleneck and the bottleneck levels in the economic development processes of countries.

Developing/underdeveloped economies are in a tendency to accelerate their economic growth and overcome their bottlenecks with the resources, they plan to obtain from these to overcome these bottlenecks or to maintain their current balance. At this point, these economies can resort to foreign sources/funds, which are external income, as an option to accelerate economic growth. Undoubtedly, in an economy with low economic vitality, an income transfer, even from abroad, can create a spark effect in these economies and support economic revival. The increase in economic vitality can cause new income flows and support the income increase/growth that the country needs. In today's global world, it is seen that developing economies have such an expectation even from short-term financial capital movements - although it may cause adverse effects. However, how successful this method can be and the level of possible success, and its limits can also be discussed. The main thing in increasing the economic growth and therefore the development of a country is that the country can increase its production, production capacity, and the quality and variety of its products by using its own idle resources. To the extent that this can be done, while production increases, the ability to turn the products produced into exports can play a key role in overcoming the foreign exchange bottleneck of such countries.

In general, for economies, an increase in exports means an increase in the income of that country, while an increase in imports means spending its income. Well, for economies, an increase in exports means an increase in production, while an increase in imports means an increase in consumption. From this point of view, while other factors in an economy are unchangeable (ceteris paribus), activities that increase exports mean activities that increase production predictively and indirectly. In this context, export growth can be defined as an activity that supports the country's income and, in general terms, its economic growth and economic development, and prevents foreign exchange bottlenecks, as long as it originates from production.

A company's ability to sell a product it produces to foreign markets indicates that the company can produce competitive products, if it is not among a limited number of sellers of the relevant product. However, this competitive ability may be based on cost advantage, or it may mean being ahead of the competition by making the product produced better than its competitors with innovation as a result of R&D or by producing new products. In today's global economy, competition based on cost advantage in the products produced requires being more competitive than countries such as China, which are producing on a world scale. For this reason, starting from businesses originating from developed countries (and multinational companies), all economies and businesses make R&D investments with a focus on developing existing products and/or creating new products to be able to compete and gain competitive advantage. In other words, a significant portion of companies competing in global markets focus on R&D and innovation in order to eliminate competition in these markets and make more sales.

It should be noted here that R&D and innovation activities are not only for product improvement and/or new product development, but also for process improvement and reducing production levels and production costs. Because thanks to R&D activities, not only new products are developed, but also new production techniques can be developed, thus reducing production levels and production costs. When R&D activities are analyzed in the export development processes of countries, it can be said that especially the creation of new products and the development of old products are very important in increasing exports. Because the creation of new products and the transformation of old products into new faces and forms can generally create new demand and increase exports. However, on the other hand, it should be said that cost-cutting technological developments emerging with the effect of R&D activities can reduce product prices and these developments can increase export success. In the relationship between high-tech exports and R&D expenditures, the choices of countries regarding the types of R&D research they will conduct are of great importance in the export success of these countries. Therefore, when considered from this perspective, the choices of countries according to their R&D types may exposure wrong results in the relationship between R&D activities and high-tech exports. This situation should be taken into consideration as a precautionary factor in analyse.

According to the OECD definition, Research and Development (R&D) activities include creative and systematic studies carried out with the aim of increasing the knowledge stock created by humanity and designing new areas of use of existing knowledge. (OECD,2015:44-45). Research and development activities are the main determinant and feeder of technological development. Technological development stimulates and improves production through innovation (Balkanlı,2024:41-42;Kibritçioğlu,1998). However, in

neoclassical growth models, technological change (created/developed by R&D activity) was seen as an external factor for a very long time (Sungur, et. al., 2016:174). After the neoclassical approach, in economies, statistical innovations in GNP are produced by economic innovations, which are determined by the amount of research. This description meant that technology shocks are endogenous (Aghios and Hovitt,1990:2). According to new approaches, technology accepted as an endogenous factor. After defining technological development as an endogenous factor, technological development, knowledge, and human capital elements have taken place as the main sources of economic growth in growth models. These theories have been able to better analyze today's world economic developments within the framework in which they prioritize knowledge, technology and human capital (Balkanlı, 2019:120).

In the world economy, technology has come to the forefront in production more in the 2000s compared to before. It is now possible to see the effectiveness of technology not only in the economy but also in every area of life. When viewed from this point, it can be said that the 1970s and 1980s were the years of transformation in the technological development process. Schumpeter's "Creative Destruction term", emphasizes the transformative nature of technology (Aghion and Howitt, 1990:1). Aghion and Howitt in another study, published in 2009, they have claimed that international trade support to innovations (R&D) for firms. According to them, this interaction shows that innovation (created by technology) and export have causality (Aghion and Howitt, 2009). The following results have been obtained in many studies that R&D activities are the most important source of change in output in production (Sungur,et.all, 2016:175).

Global economy doesn't support only developed countries's economic growth proceses, but the internationalization of developing economies in the global economy has also created new growth opportunities for export-oriented businesses. And this internationalization is very important for economic growth process of these countries. However, in these conditions, it is also true that exporting is more difficult than selling to local customers in the home country and requires effort. To sell in a country other than the home country, -although it is a costly business- exporting companies must know the preferences of consumers in the countries they will export to, the rules and regulations of the foreign country, and market conditions (Dong, et.al.,2022). Therefore, it can be said that the first dimension of a company's export success is to have knowledge about export markets and consumers, and the second dimension is to be able to produce competitive products that meet the demands of consumers in these markets with this information.

In a globalized world, at the result of decrease of custom protectionism, possibilities of export, the size of the national economy and the purchasing power of local consumers no longer restrict the growth potential of dynamic firms. To successfully enter a foreign market, the exporter needs to develop an export strategy for products and services that are tailored to the conditions in the destination market (Dong,et.all., 2022). Here, the main theme is to supply competitive and taking-demand products. Here, different, new, and innovative products are important to able to present. The presence of different, new, and innovative products is related to R&D activity.

Innovations don't only support higher productivity, but innovations are also essential for responding to technological changes and environmental uncertainties. Over time, innovative firms according to other standard firms will be more able to take advantage of technological progress and improve their processes and products, shifts their export demand curve upwards at the world markets (Ref. Dong,et al., 2022; Dohse and Niebuhr,2018). According to Paul Krugman's (1979) innovations and R&D activities are the motive and main power of industrialized countries' exports and international trade (Krugman,1979). In his article, Paul Krugman constructs to his model, trade between two countries (as North and South).

Researches show that the higher the firms' past level of export breadth, the higher its subsequent R&D compactness and product innovations and process innovations. The higher export levels support learning new market knowledge and different patterns of consumer behavior (Filipescu, et al, 2013:33). Here, this must think: Since the change in exports changes the size of the markets, it affects the firms' tendency towards innovation. When more firms enter the export market, competition in that market increases. This reduces profits and therefore innovation motivation, especially for low-productivity firms. But researches show that a large change in export demand generally encourages innovation in high-productivity firms. On the other hand, a large change in exports in low-productivity firms may negatively affect innovation, contrary to expectations (Aghion,et. al, 2018:39). But in general, it must say that, with the impact of globalization,

increasing of exports can not only support firms to expand their market and arrive at economies of scale, but also give the road to gain international experianence and technological know-how (Cai,et al,2020:483),

Empirical studies on developed economies have shown the positive impact of innovation and R&D developments on exports. However, the literature on the interaction between innovation-R&D developments and exports in developing economies is not as exhaustive as that on developed countries, and the no indisputable results. But it is also the reality that most authors find a positive impact of innovation on exports for developing countries (Dong, et al., 2022). Dong, Kokko and Zhou, in their article, examined the impact of possession on the interaction between R&D/innovation and export for period of 2000-2007 via by Regression Analysis. In their study, they found that state possession has a positive impact on the R&D/innovation–export interaction. According to them, this impact of state-possession firms' is related to access to resources and possibilities (Dong, et al.,2022).

Here, the situation of state-owned companies focusing on innovation and R&D, which is valid for China, should be considered valid for governments that focus their economic policies on innovation and research, as stated by Aghion and Howitt in a study published in 2008 (Aghion and Howitt, 2009:21). In economies where multinational companies have a high share in the economy, and in a situation where multinational companies are expected to carry out their R&D activities in the home country, it would not be surprising for the governments (and companies) of the countries to allocate support and resources to R&D activities. According to Aghion and Howitt, in a situation where technology is seen as an internal factor related to the economic system, the focus of government economic policies on innovation and R&D will increase international trade on the one hand, and support long-term economic growth on the other (Aghion and Howitt, 2009:21).

Regarding the relationship between R&D and export, according to research on Spanian firms by Cassiman, Golovko and Martinez-Ross, (Cassiman, et al. 2010:376) they found important evidences. According to their research, R&D, and product innovation support for small and non-exporting firms encouraged to enter the export markets. This situation is not valid for process innovation. This finding emphasizes the important of innovation promotion policies. On the other meaning, this finding says that innovation and R&D promotion policies are more effective than export promotion policies for increasing exports. Therefore, it can be said that a strong focus on R&D and innovation is more valuable and functional in increasing exports (Cassiman, et al., 2010:376).

Slovenian researchers, Damijan, Kostevc, and Polanec did research Slovenian firms on relation to innovation and export. According to them, the ability of companies to increase their production efficiency and to focus on exports has a close relationship with the innovation capabilities of these companies. In addition, their ability to innovate can be very decisive in the decision of these companies to start exporting. Being successful in exports can rehabilitate process innovation. The causality between innovation and exports for companies in an economy is not one-way but it can be in both directions. They investigated whether there was a bidirectional causal relationship between innovation and export activities for Slovenian companies between 1996-2002. In result, it was not found that product or process innovations increased the probability of becoming first-time exporters, but, as a result of the research, it was found that exports led to productivity improvements in terms of learning through exporting under the effect of process (not product innovation, however) innovation (Damijan, et al., 2010:374-375).

Other researchers, Becker and Egger analyzed the effects of new product and process innovations on the export propensity at the firm level. According to them, product innovation is of great importance for the success of a firm's entry into domestic and export markets, in accordance with the logic of Schumpeterian creative destruction and growth models. Another type of innovation, "process innovation", supports firms both in entering export markets and in securing their position in the market (Becker and Egger, 2013:329-330). According to Becker and Egger, firms that implement both process and product innovation - with product innovation being more determinant - have higher export opportunities than firms that do not innovate. The relative importance of product innovation in exportability also requires firms to have a wide margin in the product/production area. Process innovations can marginally increase firms' export-sales ratio. In terms of economic policy, it can be said that subsidies and other government programs targeting product innovations can support entry into export markets more than expenditures or legal environments that specifically support process innovations (Becker and Egger, 2013:352). On the other side, according to the consequence obtained

by Dohshe and Niebuhr, (analyzed, with dynamic nonlinear unobserved effects models (univariate probit models) for Germany, period 1998–2010)), the increase in product innovations increases the tendency to export; but it is a lagged effect. The effect of the new product on exports occurs with a time lag. A type of innovation, "process innovations" or imitations, has not been seen to have a direct effect on the increase in exports (Dohshe and Niebuhr, 2018:184).

Caldera, in his paper, investigated the relationship between firms' innovation and export behavior using data (Panel Data Analysis) from Spanish firms covering the years 1991-2002. The econometric results from the study showed that firm innovation had a net positive effect on participation in export markets Caldera's study also showed that product upgrading had a greater effect on firm export participation instead of cost-saving innovations (Caldera,2010:657). Other researchers, Ito and Lechevalier analyzed Japanese large-scale survey for the years 1994-2003 and they found that innovations and exporting strategies are support each other. Their research evidenced that the relationship between innovation/Research&development acitivities and export investments is the main reason of distinctions in performance among firms (Ito and Lechevalier, 2010). On the other side, according to Love and Roper, SMEs with the ability to develop new products have a greater opportunity to focus on exports, increase their exports, and achieve growth from exports than businesses that do not have the opportunity to develop new products (Love and Roper,2015:47-48).

Barrère, Jung, and Karsaclian realized research, using 640 Uruguayian companies, to analyze to interaction between innovation and export. (They applied a bivariate probit regression model). As a result of research, they found that innovation precedes exports/innovation feeds to exports (Barrère, Jung, and Karsaclian,2021). Josep Tomàs-Porres, Agustí Segarra-Blasco, and Mercedes Teruel, in their paper, found that firms with more experience in international trade and those that have previously conducted R&D activities tend to be more persistent in all innovation activities. These researchers, Applied both a multinomial and a random-effects probabilistic approach, and as a result of this analysis observed that the experience of export guarantees stability in innovation activities. (Tomàs-Porre, et al.,2023: 275). Dolores Añón Higón and Nigel Driffield from the United Kingdom investigated the determinants of export propensity SMEs (Small and medium-sized enterprises) in the UK based on the 2004 Annual Small Business Survey. The research particularly emphasized the relationship between product innovation activities and export performance. According to the data obtained, it was found that approximately 17% of the firms sell outside the UK and that these exporting firms are in a high level of innovation effort. The research results show that in the UK, in the companies covered by the analysis,, 43% of the exporters are innovating in products, 27% in processes, and 21% in both areas (Higon and Driffield,2010:4/24).

To define the effects of R&D and innovation on exports, Filipescu, and colleagues analyzed a panel dataset of 696 Spanish firms between 1994 and 2005. They used Tobit and logit regressions and Granger causality tests. According to the study, a weak positive relationship was found impact of innovation on exports. They found in their research that there is also weak relation between process innovation and export depth. According to this research's result, there is a Granger causality between innovationand exports. This relation is a double-causal relationship (Filipescu, et al, 2013:24/34-35). On the other side, Aghion and his colleagues, in a study they conducted, investigated the impact of export increase on innovation for French-based firms. According to the findings of the research, new product development (patenting) initially increased with the increase in demand for more productive firms (domestic and export) (Aghion, et. al, 2018:38).

Yueling Cai, Gongliang Wu, and Dingsheng Zhang tested the interaction between export and innovation, using data from Chinese industrial firms taken by the National Bureau of Statistics of China and customs of China data from 2001 to 2007. The results of the research showed that firms' export activities can significantly increase their product innovation ((Cai, et al.,2020:483). Serena Tandrayen-Ragoobur, in her study to determine the interaction between export behaviour and innovation in Africa' firms, showed that a combination of process and product innovation has a big effect on firms' probability of participating to external markets and their export capability. In her study, with data from 45 African countries for a period of 14 years (2006-2020), She used multinomial probit and two-stage least squares models in her study. In her paper, Tandrayen-Ragoobur offered that the learning activity for improve to is important in exporting capabilities for African firms (Tandrayen-Ragoobur,2022:1/24-25).

Ortigueira-Sancheza, et al., in a study conducted, found that innovation sustains competitive advantage and can explain firm heterogeneity, a feature that supports firm export growth. This research tested the interaction between innovation and export in Peruvian small and medium-sized enterprises (SMEs) receiving government innovation subsidies with a theoretical model that includes innovation inputs, types of innovation, and performance. The research was realized with 237 SMEs. (using partial least squares structural equation modeling) The research showed that government innovation incentives have a positive effect on human capital and collaboration. This research, showed that innovation types support overall production and export growth.(Ortigueira-Sancheza,et al.,2022:1/9-10). Palangkaraya, in his article, investigated the direction of causality between companies' participation in the export market and innovation in the case of Australia (with 3,000 Australian small and medium businesses with less than 200 employees). In this study conducted in the case of Australia, a significant positive link between innovation and export was found. Again, in this study, it was seen that being able to carry out product innovation can lead companies to become exporters (Palangkaraya,2012:26-28).

The analysis of the data collected by Ayar and Erdil from 313 exporting enterprises in Turkiye, using the CATI method was carried out and the research showed that there is a positive interaction between R&D activities and export. In this study, it was seen that R&D activities impacted the perception of export performance (Ayar and Erdil, 2018:64-65). In Göçer's research, with data from 1996-2021 for 11 Asian countries and examined the impacts of R&D activities on products's exports, (producing high-technology), informative (information-communication technology) sector exports, total exports and growth, using Panel Data Analysis. As a result of the research, it was revealed that a 1% increase in R&D expenditures in these countries increased HT exports by 6.5%, informatic sector exports by 0.6% (Göçer, 2013:215).

Coşkun and Eygu's research focused on The effects of R&D expenditures on exports in the Turkish economy during 1990-2018 period. For this purpose, an ARDL model was created using annual R&D expenditures, exports, of the 20 countries with the highest export. The existence of a cointegration relationship was investigated with the ARDL bounds test and the direction in which the long-term and short-term dynamics of the variables moved was investigated. Accordimng to research, it was seen that R&D expenditures had a negative effect on exports in the short term, but it had a positive effect in the long term (Coşkun and Eygu, 2020:233). Özer and Çiftçi's research tested the interaction between R&D activities-expenditures and general exports, information and communication technologies exports, and advanced technology exports. The researchers used the panel data technique and as a result of the analysis. Their research area was OECD countries. According to research, there is a positive interaction between R&D and exports in these countries (Özer and Çiftçi, 2009:39). Sofuoğlu, Kızılkaya, and Koçak, in their study, they tested the impact of HT product export on economic growth during the period 1990-2019 for Turkey. According to their cointegration test, they found a long-term interaction between HT product export and economic growth (Sofuoğlu, et al.,2022:205).

According to Özçelik and Taymaz (in their study), it has been confirmed that (process) innovations and R&D activities are very important for the global competitiveness of Turkish manufacturing companies in terms of increasing exports. However, this does not apply to technology transfers through licenses or know-how agreements. Therefore, companies have to develop their own innovations to improve their export capacity and to exist in the markets (Özçelik and Taymaz, 2002:21).

Ballı and Sizege's study tested the relationship between exports and R&D expenditures using data from the World Bank's Turkey-Business Survey in 2013 and 2014 and Probit and Tobit models for the Turkish manufacturing industry. The findings showed that firm size was positively associated with R&D expenditures, but the learning-by-export effect was negligible for firms (at the meaning emphasizing the need for governments to support firms in prioritizing R&D). Again, Ballı and Sizege's study showed that multinational foreign companies wanted to take advantage of Turkey's cheap labor force and that R&D expenditures did not make any positive contribution to innovation activities in Turkey (Ballı and Sizege, 2016:86/90).

Ustabaş and Ersin's research is focused on evaluating the interaction between HT exports and per capita GDP levels for Turkey and South Korea for the period 1989-2014. They used structural unit root tests and cointegration models for research. The tests in the study were carried out using traditional ADF, PP unit root and KPSS stationarity tests. According to the cointegration analysis results, high-tech exports positively affect national income in both countries, Turkey and South Korea. However, for South Korea, the positive effect of

high-tech exports on GDP is clearly present in the long and short term, but for Turkey (except for a limited positive effect in the short term), this relationship cannot be established (Ustabaş and Ersin, 2016:44/53-54).

2. METHOD AND DATASET OF RESEARCH

Method: Here, the ARDL Bounds method used for analysis. In this surround, firstly, Augmented Dick&Fulley and Philips&Pearson root tests realized and then ARDL Bounds test praticed In this research, it was quantitatively investigated whether the change in the Research and Development expenditures/GDP ratio in Turkey in the period 2000-2023 has an effect on exports and, if so, to what extent.
Sample: The sample of this research consists of Turkey's R&D (Research and development) expenditures and exports for a selected period. In the research, it was quantitatively investigated whether the change in the R&D expenditures/GDP ratio in Turkey in the period 2000-2023 had an effect on exports and High Technology exports, and if so, to what extent.

Table 1: Gross R&D Expenditure/GDP and Export/GDP-HT/TM in Turkiye

Years	R&D/GDP	Export/GDP	H.T.E./ T.M.	Years	R&D/GDP	Export/GDP	H.T.E./ T.M
2000	0,48	19,88	-	2012	0.83	24,36	2,16
2001	0.52	27,18	-	2013	0.81	23,79	3,13
2002	0.51	25,11	-	2014	0.86	25,21	3,38
2003	0.47	23,00	-	2015	0.97	24,53	3,44
2004	0.50	23,62	-	2016	1.12	23,08	3,04
2005	0.56	21,88	-	2017	1.18	26,03	3,23
2006	0.55	22,40	-	2018	1.27	31,23	2,67
2007	0.69	21,89	2.17	2019	1.32	33,07	3,03
2008	0.69	23,57	1,89	2020	1.37	29,12	3,15
2009	0.80	23,37	2,03	2021	1.40	35,74	3,28
2010	0.79	21,19	2,20	2022	1.32	38,58	3,61
2011	0.79	22,99	2,11	2023	1.40	32,27	-

Source:www.tuik.gov.tr;www.worldbank.org.tr,(Access:20.07.2024).H.T.E./T.M..:High Tech Export/ Manufactured Export

Dataset: In the process of study, used data of Turkish Statistical Institutue and World Bank. In model, Research and Development expenditures/GDP is independent variable. Export/GDP and HT export/Total Manufactured Export are dependent variables. While the collection of data on Research and Development expenditures and general exports has a relative ease, the collection of high-technology export data has been more difficult due to data supply problems. In addition, high-technology export data could not be obtained before 2007. Therefore, since in establishing the relationship between general exports and R&D expenditures in the research, the period 2000-2023 was analyzed, and the years after 2007 could included in the analysis of the high-technology exports R&D relationship.
Data Analysis: Eviews program was used in data analysis.

3. FINDINGS

3.1. Augmented Dick&Fulley and Philips-Perron Unit Root Tests

Dickey and Fuller improved a method for testing whether a variable has a unit root or, a variable exhibits a random walks. After Dickey and Fuller, Hamilton (in 1994) described the four different cases to which the augmented Dickey-Fuller test can be applied. The null hypothesis says that the variable has every time a unit root (www.stata.com,2024; Dickey and Fuller,1979). In 1988, for analysing unit root test a method developed by P.C. Phillips and P. Perron, named Philips-Perron Test. (Philips and Perron,1988). ARDL bounds test analysis is a cointegration method (Pesaran, et al.:2001). The Autoregressive Distributed Lag (ARDL) approach to cointegration, first proposed by Pesaran in 1997, was later redeveloped by Pesaran, Shin and Smith (1999, 2001).

This method is to test of the long-run relationship between the dependent and independent variables in the model. The approach in the analysis process is used irrespective of whether the series is I(0) or I(1) and it has an unrestricted error correction model (ECM). ARDL bounds test approach has both short-run and long-run Dynamics (Çetin, et al., 2015;Yakubu, et al., 2015:11). Here, for testing cointegration, the Autoregressive Distributed Lag (ARDL) may give advantage. Because, as said by Pesaran, ARDL gives the possibility to distinguish between dependent and independent variables and improve properties in that it allows flexibility in the structure of lags of the regressors as well as yields robust results for small sample sizes. Moreover, the ARDL technique includes investigating the presence of a long-run relationship using the unrestricted Error-Correction Model (ECM) framework (Bastola and Bastola,2015:10).

Table 2: Augmented Dick &Fulley and Philips-Perron Unit Root Test Results

Augmented Dick and Fulley Test	**At Level** (Null Hypothesis: the variable has a unit root)			
		EX/GDP	HT/TM	RD/GDP
With Constant	t-Statistic	0.8035	-0.9572	0.2273
	Prob.	***0.9915***	***0.7396***	***0.9683***
		n0	n0	n0
With Constant & Trend	t-Statistic	-0.8342	-2.0294	-2.2085
	Prob.	***0.9455***	***0.5399***	***0.4631***
		n0	n0	n0
Without Constant & Trend	t-Statistic	1.6028	0.8201	3.2238
	Prob.	***0.9688***	***0.8783***	***0.9992***
		n0	n0	n0
	At First Difference			
		d(EX/GDP)	d(HT/TM)	d(RD/GDP)
With Constant	t-Statistic	-5.6107	-3.9361	-4.4968
	Prob.	***0.0002***	***0.0113***	***0.0020***
		***	**	***
With Constant & Trend	t-Statistic	-6.5476	-3.7751	-4.5134
	Prob.	***0.0002***	***0.0513***	***0.0086***
		***	*	***
Without Constant & Trend	t-Statistic	-2.3234	-3.6463	-1.4734
	Prob.	***0.0229***	***0.0014***	***0.1279***
		**	***	n0
Philips Perron Unit Root Test	**At Level** (Null Hypothesis: the variable has a unit root)			
		EX/GDP	HT/TM	RD/GDP
With Constant	t-Statistic	-1.6341	-0.9572	0.1761
	Prob.	***0.4499***	***0.7396***	***0.9647***
		n0	n0	n0
With Constant & Trend	t-Statistic	-2.4183	-2.1079	-2.2660
	Prob.	***0.3613***	***0.5009***	***0.4343***
		n0	n0	n0
Without Constant & Trend	t-Statistic	2.1382	0.8201	3.0468
	Prob.	***0.9897***	***0.8783***	***0.9987***
		n0	n0	n0
	At First Difference			
		d(EX/GDP)	d(HT/TM)	d(RD/GDP)
With Constant	t-Statistic	-6.0911	-3.9361	-4.5249
	Prob.	***0.0001***	***0.0113***	***0.0019***
		***	**	***
With Constant & Trend	t-Statistic	-8.8868	-3.7751	-4.5380

	Prob.	***0.0000***	***0.0513***	***0.0082***
		***	*	***
Without Constant & Trend	t-Statistic	-5.6452	-3.6478	-3.2480
	Prob.	***0.0000***	***0.0014***	***0.0024***
		***	***	***

Notes: a: (*)Significant at the 10%. (**)Significant at the 5%. (***) Significant at the 1%. (no) Not Significant , b: Lag Length based on SIC, c: Probability based on MacKinnon (1996) one-sided p-values.

Here, firstly Augmented Dick and Fulley Test and also Philips Perron Test were performed. After, the interaction between R&D expenditures and general export/High Technologiy exports were examined with ARDL bounds test analysis. For EX/GDP data for the years 2000-2023 were used, and for the HT/TM ratio, data, after 2007 were used.

The ratio of RD expenditures to GDP was taken as the independent variable. The dependent variables were the export/GDP ratio in the first analysis and the ratio of HT products exports (HT) to total manufacturing industry exports (TM) in the second analysis. The data for the ratio of R&D expenditures to GDP and export data were obtained from the Turkish Statistical Institute and the World Bank sources. The degree of integration each variables was tested by Augmented Dick&Fulley Test and the Philips and Perron Test. The unit root test results, of the Augmented Dick&Fulley Test and the Philips and Perron Test, are in Table 1.

These results are related to the unit root test (ADF test) and are used to evaluate whether the variables are stationary. According to the Augmented Dick and Fulley Test results, at level Export/GDP, HT/GDP, and R&D/GDP values, the series contain unit roots at the level values and are not stationary. When it is analyzed, at First Difference, d(EX/GDP), d(HT/TM), d(RD/GDP), With Constant, With Constant and Trend, Without Constant and rend there is no unit root and they are stationary. According to the Phillips-Perron (PP) unit root test's results, at level, With Constant, With Constant and Trend, Without Constant and Trend, Export/GDP, HT/TM, and RD/GDP values have a unit root and they are not stationary. When it is analyzed at First Difference, with Constant, With Constant and Trend, Without Constant and Trend, d(EX/GDP), d(HTP/TM), d(R&D/GDP) values have no unit root and they are stable. These data show that the variables aren't stationary at I(0) (level in ADF and PP tests. But when it is taken at first level (I(1) becomes stationary (at first difference). According to the root test analysis, it can say that EX/GDP (Export/GDP) is not stationary in both tests in at level. But variables become stationary in the first difference (I(1)). HT (High Technology Exports/TM) is not stationary at level but it found to be stationary in the first difference (I(1)) according to ADF and PP tests. RD/GDP (R&D Expenditures/GDP) shows that it is stationary in the first difference (I(1)) according to both ADF and PP test results (At level it isn't stationary).These results determine the model.

3.2.ARDL Bounds Test Findings for Interaction of Research&Development Expenditures and General Export

Here, according to Conditional Error Correction Regression, while the coefficient of the C Constant Term is 4.173040, the t-statistic is 1.102422 and the p-value is 0.2877. With this result, it should be said that the constant term is not significant in the model ($p > 0.05$). When EX/GDP(-1) is examined, the coefficient of the lagged EX/GDP variable is -0.409045, the t-statistic is -2.099268 and the p-value is 0.0531. This coefficient value is at the limit of significance.

Here, it can be said that the lagged value of EX/GDP indicates at limit a significant, negative, and borderline effect on the dependent variable. When RD/GDP(-1) is examined, it is seen that the coefficient for the lagged RD/GDP variable is 8.745337, the t-statistic is 3.860419 and the p-value is 0.0015. This result indicates that the lagged value of RD/GDP has a statistically significant and positive effect on EX/GDP. In D(EX/GDP(-1)), the coefficient for the lagged value of the first difference of EX/GDP is -0.247920, the t-statistic is -1.022383 and the p-value is 0.3228. This coefficient indicates that the lagged value of the first difference of EX/GDP is not significant ($p > 0.05$). In D(EX/GDP(-2)), the coefficient for the lagged value of the second difference of EX/GDP is -0.495382, the t-statistic is -2.652480 and the p-value is 0.0181. This coefficient shows that the lagged second difference has a negative and significant effect. In the calculation of D(RD/GDP), the coefficient for the first difference of RD/GDP is -13.23660, the t-statistic is -1.783667 and the p-value is 0.0947. This result indicates that the first difference of RD/GDP is not significant but borderline.

Levels Equation shows that the RD/GDP coefficient is 21.37987, the t-statistic is 2.905885 and the p-value is 0.0109. This result indicates that RD/GDP has a significant positive impact on EX_GDP in the long period. The C Constant Term coefficient is 10.20190, the t-statistic is 1.998070 and the p-value is 0.0642. The C constant term ($p < 0.10$) indicates that the relationship is borderline significant in the long period. In the F-Bounds test, the F-statistic is 7.259043. This calculated value is above the critical values of I(0) and I(1). Therefore, when compared with the values of 3.62 for I(0) and 4.16 for I(1) at the 5% significance level, it is seen that the F-statistic exceeds these values.

Table 3: R&D/GDP-EX/GDP Interaction with ARDL Bounds Test Results

ARDL Long Run Form and Bounds Test
Dependent Variable: D(EX/GDP)
Selected Model: ARDL(3, 1)
Case 2: Restricted Constant and No Trend
Date: 08/15/24 Time: 20:57
Sample: 2000 2023
Included observations: 21

Conditional Error Correction Regression (CECR)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.173040	3.785339	1.102422	0.2877
EX/GDP(-1)*	-0.409045	0.194852	-2.099268	0.0531
RD/GDP(-1)	8.745337	2.265386	3.860419	0.0015
D(EX/GDP(-1))	-0.247920	0.242492	-1.022383	0.3228
D(EX/GDP(-2))	-0.495382	0.186762	-2.652480	0.0181
D(RD/GDP)	-13.23660	7.421007	-1.783667	0.0947

* p-value incompatible with t-Bounds distribution.

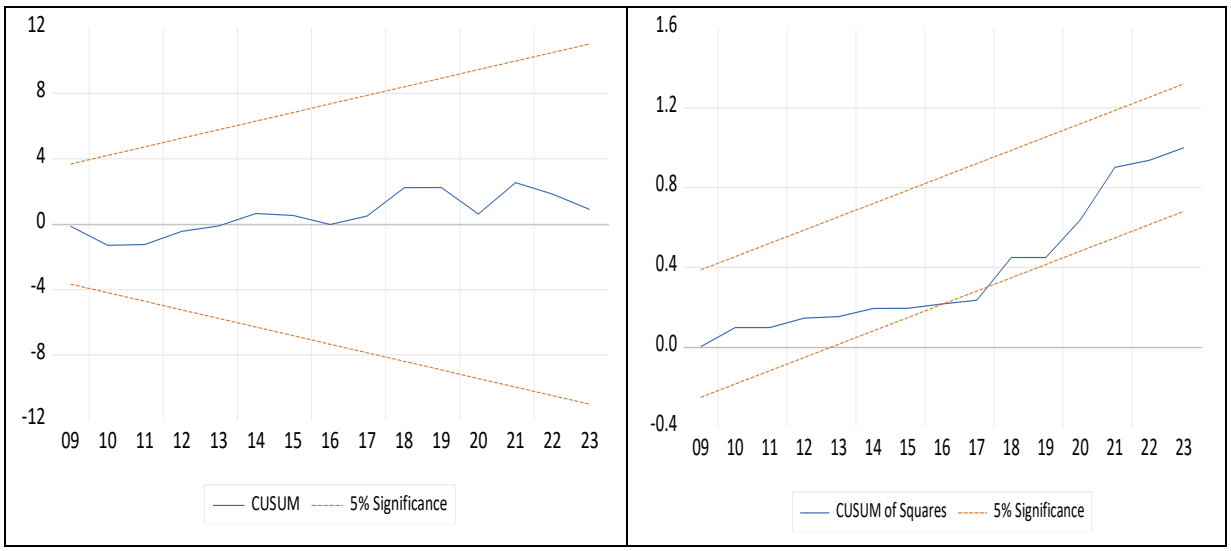
Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RD/GDP	21.37987	7.357438	2.905885	0.0109
C	10.20190	5.105876	1.998070	0.0642

EC = EX/GDP - (21.3799*RD/GDP + 10.2019)

F-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	7.259043	10%	3.02	3.51
k	1	5%	3.62	4.16
		2.5%	4.18	4.79
		1%	4.94	5.58



Graphic 1: CUSUM ve CUSUMSQ for EX

It should be said that these data show us that there is a long period interaction between the dependent and independent variables. In the analysis, when the long period interaction is examined, the F-Bounds test results strongly support the a long period interaction in the model. The effect of RD/GDP is positive and significant on EX/GDP both in the short period and in the long period. However, it should be noted here that the first difference of RD/GDP is not significant in the short period. The lagged values of EX/GDP have both a negative effect and an effect significance at the limit. These results show that research and development expenditures have a positive effect on exports in the long period. These results indicate that there is a balanced interaction in the model in the long period. And CUSUM and CUSUMSQ show that the model is stable.

3.3.ARDL Bounds Test and Findings for Interaction of Research&Development Expenditures and High Technology Export

When the Conditional Error Correction Regression is examined in the ARDL Bounds Test of the R&D Expenditures (RD/GDP) - High Technology Exports (HT/TM) relationship, it is seen that the C (Constant Term) coefficient is -1.276366, the t-statistic is -1.466311 and the p-value is 0.2802. These results indicate that the C constant term coefficient is not statistically significant in the model ($p > 0.05$). In HT(-1), the coefficient for the lagged value of High Technology Exports (HT) is 1.724083, the t-statistic is 2.185075 and the p-value is 0.1605. This result indicates that although the lagged value of High Technology Exports (HT) shows a positive relationship, it does not indicate a significant situation. For lagged value of R&D Expenditures in RD/GDP(-1), the coefficient is -1.412314, t-statistic is -1.479951 and p-value is 0.2770.

Variable for D(RD/GDP(-1), coefficient value is -6.897122, std. error value 4.303039, t-statistic value -1.602849, prob. value is 0.2501. For variable D(RD/GDP(-2)) coefficient -11.54112, std. error 2.451323, t-statistic -4.708120, prob. value is 0.0423. Here, while varibles's coefficients (in order of) -6.897122, -11.54112 and -8.813247, prob. values are 0.2521, 0.0423, 0.0578. These results show that these impacts are in limit and significant. Levels Equation shows that RD/GDP coefficient is 0.819168, the t-statistic is 3.099975 and the p-value is 0.0902. This result shows that RD/GDP has a borderline significant and positive effect on HT in the long run. And C (Constant Term) coefficient is 0.740316, the t-statistic is 3.255168 and the p-value is 0.0828, this constant term value shows that the relationship is borderline significant in the long run. According to F-Bounds Test F-statistic is 12.84594. This value is well above the critical values of I(0) and I(1). When this value is compared with the digits of 3.62 for I(0) and 4.16 for I(1) at the 5% significance level, the F-statistic value exceeds these values, indicating that there is a long-term interaction between RD/GDP and HT/TM in the model.

These findings (especially based on the F-Bounds test results) says that there is a long period interaction between RD/GDP and HT. According to CUSUM and CUSUMSQ, it can be said that the model is partially stationary. The conditional error correction model (ECM) reveals that this long-term balance is slowly

corrected over time. However, it should be noted here that the effect of RD/GDP on HT is negative in the short term, and this negative effect turns positive in the long term, albeit at a low level, and shows a borderline significant interaction. Although the lagged values of HT have a negative impact on HT in the short period, it should be noted that most of these effects are not statistically significant.

Table 4: R&D/GDP-HT/TM Interaction with ARDL Bounds Test Results

ARDL Long Run Form and Bounds Test
Dependent Variable: D(HT/TM)
Selected Model: ARDL(4, 4)
Case 2: Restricted Constant and No Trend
Date: 08/15/24 Time: 21:04
Sample: 2000-2023
Included observations: 12

Conditional Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.276366	0.870460	-1.466311	0.2802
HT/TM(-1)*	1.724083	0.789027	2.185075	0.1605
RD/GDP(-1)	-1.412314	0.954298	-1.479951	0.2770
D(HT/TM(-1))	-2.371260	0.862489	-2.749321	0.1107
D(HT/TM(-2))	-1.884132	0.643431	-2.928260	0.0995
D(HT/TM(-3))	-1.394093	0.396748	-3.513802	0.0723
D(RD/GDP)	-2.415227	1.675110	-1.441832	0.2861
D(RD/GDP(-1))	-6.897122	4.303039	-1.602849	0.2501
D(RD/GDP(-2))	-11.54112	2.451323	-4.708120	0.0423
D(RD/GDP(-3))	-8.813247	2.215979	-3.977135	0.0578

* p-value incompatible with t-Bounds distribution.

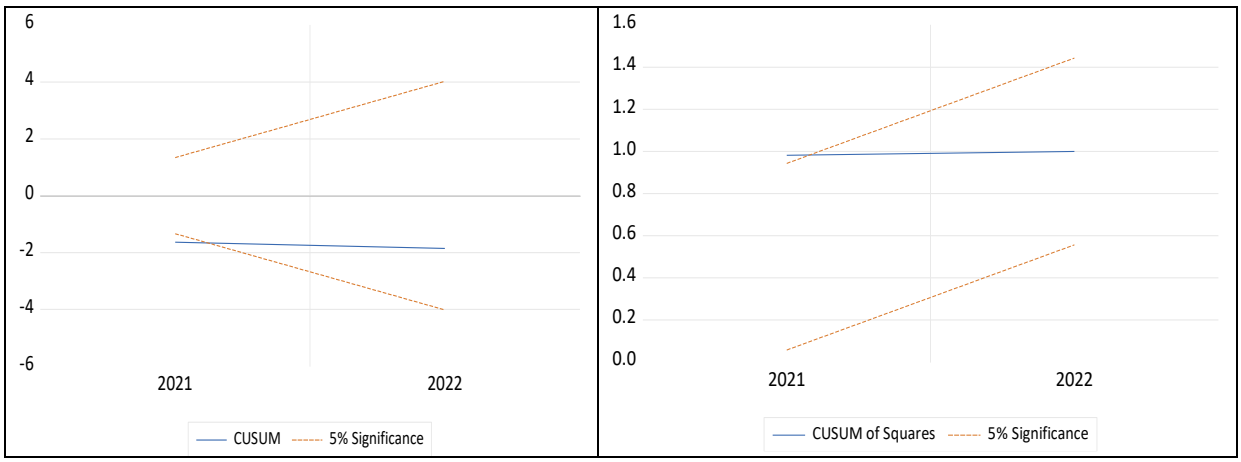
Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RD/GDP	0.819168	0.264250	3.099975	0.0902
C	0.740316	0.227428	3.255168	0.0828

EC = HT/TM- (0.8192*RD/GDP + 0.7403)

F-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	12.84594	10%	3.02	3.51
K	1	5%	3.62	4.16
		2.5%	4.18	4.79
		1%	4.94	5.58



Graphic 2: CUSUM ve CUSUMSQ for HT

The main problem here is this: In principle, the the error correction term's coefficient (HT(-1)) in the model (within the error correction model (ECM)) would be expected to be negative at a value between 1 and 0. This value, which is expected to be negative, indicates that the model will return to long-term balance and the deviation will be corrected over time. However, in the ARDL bounds test results, this coefficient was positive with a value of 1.724083. This positive value obtained indicates that there is a problem in the model specification in the long-term relationship in the model. And it creates question marks in the ,interaction between long period R&D expenditures and HT product exports.

At this point, this positive result in the error correction term in the ECM indicates that the balance cannot be fully formed in a stable manner in the long-term relationship or that there may be data-related problems. For this reason, the lag lengths (4,4) in the model specification may need to be reviewed again, or there may be a problem of fit between the variables or insufficiency of the data. Here, the insufficient data set may consider to be the primary factor.

In the ARDL analysis, the relationships between R&D/GDP and EX/GDP and HT/TM were examined in terms of long-term and short-term dynamics. The findings of the research show that there is a clear long-term relationship between R&D expenditures and exports in Turkey. But, although the relationship between R&D expenditures and high technology exports exists, these relation is weak. The reasons for this can be counted as a factor as a factor the shortness of the data period. And also, it must say that R&D expenditures in Türkiye are generally low compared to world examples. And in current R&D expenditures, instead of focusing on new product development and new face and form development for old products, there is a tendency towards cost-cutting R&D activities. It can say that all these factors are also reverberated to short-term results.

4. CONCLUSION AND DISCUSSION

This study investigated whether R&D expenditures have an effect on exports in Turkey in the period 2000-2023. As a result of the research, the ARDL Bounds Test results showed that there is a long-term and statistically significant interaction between R&D expenditures and exports in Turkey in the period 2000-2023. Although some coefficients of lagged dependent variables in short-term effects are not statistically significant, the ARDL(3, 1) model selected based on the Akaike Information Criterion (AIC) clearly revealed the interaction between R&D expenditures and exports in Turkey.

But, although the relationship between R&D expenditures and general exports can be clearly demonstrated, it is seen that the positive interaction between R&D expenditures and high-technology product exports is not strong. There is a weak relationship between R&D and high-technology exports. In particular, the coefficients of lagged variables emphasize that the significance of the relationship is weak. On the other side, it is also a fact that the ARDL model used to examine the R&D/GDP, HT relationship also indicates a long-term balance relationship, albeit weak, in the R&D/GDP, HT relationship. However, there is no clarity in the R&D/GDP, HT relationship in the short term.

These results obtained from the research show that the increase in R&D expenditures is effective in increasing general export success and that there is a clear mechanism of influence between the two elements. When it look, especially to relationship of R&D-HT product export, (although there is a connection between HT

product exports and R&D), the fact that this is a weak relationship is due to many reasons. Firstly, it must think that the fact that high-technology product export data cannot be spread over a long period may be effective here. And, also, it should be considered here that the current R&D investment levels will not be sufficient to support the production of high-technology products in their current form. On the other hand, the current R&D investments in the country may be related more to production techniques and systems rather than product innovation. This condition will effect to composition of product export. In result, even product technics changes, export composition of products may not change. In this case, the current R&D expenditure level may not have an effect on high-tech exports.

These results are also consistent with most research results obtained from studies in the literature. The positive relationship between R&D and exports, which is valid for most countries, was also determined for Turkey in the period examined. When viewed from this perspective, the basic hypothesis stated at the beginning was confirmed by the research results. However, the positive relationship between R&D and high technology exports, which is valid for some countries, was seen to be relatively weak in the case of Turkey. Here, it should be considered that the R&D orientation in Türkiye, which prioritizes price competition and stays away from new product development, may be a factor in the weak relationship between high-tech exports and R&D expenditures. Because, as in most developing countries, also in Turkiye, this is what most companies do. Therefore, it is not surprising that the relationship between R&D expenditures and high-tech exports is weak in an environment of intense price-based competition. According to anayse results, the relationship is weak according to these research period but at the other side, in this area, as the years go by and the examination interval increases, the R&D-high tech export relationship may become more apparent. In this surround, it must consider that new researches on this subject may also show more positive results.

When it look in Turkey specifically, it is seen that R&D expenditures are low in Turkey and that, rather than new product development and develope of new face and form with R&D activities for old products, more cost-cutting technology-R&D investments are included. This is actually understandable. Because, in comparison to the world's large-scale companies in terms of new product development, companies in Turkey are more focused on R&D activities aimed at cost minimization rather than allocating too much resources for this. Here, it can be said that the perspective and preferences of companies towards R&D are (relatively) in the form of achieving competition in the markets with price.

With the this compostion, the weak effect of R&D expenditures on high-tech exports suggests that governments should support the increase of R&D investments in the country. However, it should be considered that public policies to support R&D activities should include not only general support but also enrichment in policy details (product innovations, production developments, etc.). Because such a policy enrichment, compared to a general support policy, will be able more to increase the country's export capacity and thus production, and these developments will positively affect economic growth. The increase in the production and export of high-tech products that may emerge with the increase in R&D support will ultimately affect not only foreign trade and economic growth, but also social welfare may be impact positively by increasing social consumption opportunities and income.

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