DETERMINANTS OF HIGH-TECH EXPORTS: THE CASE OF EU COUNTRIES AND TURKEY

Master's Thesis

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ABSTRACT

DETERMINANTS OF HIGH-TECH EXPORTS: THE CASE OF EU COUNTRIES AND TURKEY

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Export has always been an important concept for national economies. That's why a lot of research has been done on export. In some of these studies, the importance of value-added products in export was emphasized. In this study, based on the literature, the factors affecting the export of high technology products with high value-added and the degree of importance of these factors were attempt to be explained. Annual data of EU member states and Turkey between 2007-2020 were used in the study. In the panel data analysis, resistant Driscoll-Kraay standard errors estimator was used due to the deviations from the assumptions such as heteroskedasticity and cross sectional dependency that impair the efficiency. As a result of the analysis, it has been determined that R&D expenditures are one of the most important driving forces of high technology exports in selected countries. Furthermore, it has been understood that military expenditures are also an essential factor in increasing high technology exports. It has been determined that openness to trade, human capital, and institutional quality also affect high technology positively. In addition, it is understood that GDP, GCF, energy dependence, and bussiness freedom have positive and statistically significant effects on high technology exports. However, these effects are less than those mentioned earlier. Finally, no statistically significant effect of FDI on high technology exports was found in the study.

Keywords: High-tech export, R&D, Trade openness, Human capital, Panel data analysis

ÖZET

YÜKSEK TEKNOLOJİ İHRACATINI ETKİLEYEN FAKTÖRLER: AB ÜYE ÜLKELERİ VE TÜRKİYE ÖRNEĞİ

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Ülke ekonomileri için ihracat her daim önemli bir kavram olagelmiştir. Bu yüzden ihracat üzerine oldukça fazla araştırma yapılmıştır. Bu çalışmaların bir kısmında ihracatta katma değerli ürünlerin önemi üzerinde durulmuştur. Bu çalışmada ise literatürden hareketle katma değeri fazla olan yüksek teknolojili ürün ihracatını etkileyen faktörler ve bu faktörlerin önem dereceleri açıklanmaya çalışılmıştır. Çalışmada AB üye ülkeleri ve Türkiye'nin 2007-2020 yılları arasındaki yıllık verileri kullanılmıştır. Yapılan panel veri analizlerinde heteroskedastisite ve yatay kesit bağımlılığı gibi etkinliği bozan varsayımlardan sapmaların varlığı nedeni ile dirençli Driscoll-Kraay standart hatalar tahmincisi kullanılmıştır. Analizler sonucunda ar-ge harcamalarının seçilmiş ülkelerde yüksek teknoloji ihracatının en önemli itici kuvvetlerinden biri olduğu saptanmıştır. Bununla birlikte askeri harcamaların da yüksek teknoloji ihracatını arttırmada önemli bir faktör olduğu anlaşılmıştır. Ticari açıklık, beşerî sermaye ve kurumsal kalitenin de yüksek teknolojiyi pozitif olarak etkilediği tespit edilmiştir. Ayrıca GDP, GCF, enerji bağımlılığı ve iş özgürlüğü'nün de yüksek teknoloji ihracatına pozitif ve istatistiksel olarak anlamlı etkilerinin olduğu anlaşılmış olsa da bu etkiler daha önce bahsedilen değişkenlere göre daha önemsiz kalmaktadır. Son olarak çalışmada FDI'ın yüksek teknoloji ihracatına istatistiksel olarak anlamlı herhangi bir etkisi bulunamamıştır.

Anahtar Sözcükler: Yüksek teknoloji ihracatı, Ar-Ge, Ticari açıklık, Beşeri sermaye, Panel veri analizi

…/…/2022

STATEMENT OF COMPLIANCE WITH ETHICAL PRINCIPLES AND RULES

I hereby truthfully declare that this thesis is an original work prepared by me; that I have behaved in accordance with the scientific ethical principles and rules throughout the stages of preparation, data collection, analysis and presentation of my work; that I have cited the sources of all the data and information that could be obtained within the scope of this study, and included these sources in the references section; and that this study has been scanned for plagiarism with "scientific plagiarism detection program" used by Anadolu University, and that "it does not have any plagiarism" whatsoever. I also declare that, if a case contrary to my declaration is detected in my work at any time, I hereby express my consent to all the ethical and legal consequences that are involved.

Mehmet Şuayb Yıldırım

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LIST OF SYMBOLS AND ABBREVIATIONS

GDP	: Gross Domestic Product
GCF	: Gross Capital Formation
FDI	: Foreign Direct Investments
OECD	: Organization for Economic Co-operation and Development
EUROSTAT	: The Statistical Office of The European Union
EU	: European Union
U.S.A.	: United States of America
U.K.	: United Kingdom
SITC	: Standard International Trade Classification
ISIC	: International Standard Industrial Classification of All Economic Activities
R&D	: Research and Development
NICs	: Newly Industrialized Countries
BRICS Countries	: Brazil, Russia, India, China, and South Africa
Rev.	: Revision
TFP	: Total Factor Productivity
MIT	: Massachusetts Institute of Technology
ICT	: Information and Communication Technology
High-Tech	: High Technology
OLS	: Ordinary Least Squares
TSI	: Total Sophistitation Index
ECI	: Economic Complexity Index
PSI	: Product Sophistication Index
ESI	: Export Similarty Index

1. INTRODUCTION

Over the years, economists have studied the feasibility of creating a balanced and sustainable growth trend in economies and have come up with theories on growth. These theories, on the other hand, have been examined in the literature in two different groups as “endogenous” and “exogenous” growth theories. As previously stated, the goal of the emergence of the exogenous neo-classical growth theory was also to achieve balanced and sustainable growth in the economy. For this reason, although the Neo-classicals showed technological development as one of the factors affecting growth in the theories they established, they accepted the technology factor as an external factor with population growth and focused more on concepts such as savings and capital efficiency (Özel, 2012, p. 65-66). Endogenous growth models that emerged later emphasized the technology factor by criticizing the Neo-classical approach and said that human capital investments should also increase in order for these technological developments to be fully integrated and used in the economy.

Indeed, the fact that the technological differences of the countries play a very effective role in their growth can be easily understood by the events experienced today. Because it can be seen from developing countries' export data that their exports are primarily made up of low and medium technology goods with low value-added. On the other hand, in developed and industrialized countries, medium-high and high-technology goods with high value-added, account for a large portion of their exports. This situation has negative consequences for developing countries and leads to foreign trade deficits. Foreign trade deficits, on the other hand, make countries more vulnerable to exchange rate fluctuations and also cause them to lag behind in terms of development indices such as per capita income distribution (Göçer, 2013, p. 216).

In this case, closing the technology gap in developing countries like Turkey should be one of the important economic goals. For this, qualified personnel should be trained, and R&D investments should be supported. Thus, by increasing the technological capacity of the country, an increase in the export of high value-added technology products can be achieved.

This study aims to determine the factors affecting high technology exports in EU member countries and Turkey and to measure the impact of these factors with econometric panel data analysis methods. Ten different independent variables were determined for the purpose, and six different models were established with these variables. Determining variables and established models are given in section 5. High technology export data obtained from the World Bank was used as the dependent variable, and the third and fifth sections explain why this variable was used in the study. The analysis and the results of these analyzes are shown in detail in the sixth section.

2. THEORETICAL FRAMEWORK

Adam Smith (1776) wrote in his book to explain why the British economy was in a better condition than other European economies during the industrial revolution developments in England; He emphasized that the reasons behind this economic growth of England were the importance given to trade and the rapid development of the manufacturing industry, and also touched upon the issues of specialization and the use of machinery (Freeman & Soete, 2003, p. 39). After Adam Smith's studies, the foundations of classical economics were laid, and studies in areas such as technological innovation and growth, gained momentum.

John M. Keynes (1936), who wrote "The General Theory of Employment, Interest, and Money" in 1936 on the Great Depression of 1929; brought some dynamic criticisms on the views of classical economics, thus paving the way for the emergence of later neo-classical economic theories (Yülek, 1997, p. 1). Afterwards, Solow (1956) and Swan (1956) initiated the Neo-classical growth theories with their independent articles in the same year.

Technology and population growth were among the factors affecting growth in the Solow-Swan model, but in this model, both were considered exogenous and held constant. In his early theories, Solow (1956, 1957) concentrated more on saving. Although this theory suggests that savings can be used to achieve growth, it also emphasizes the need of technical advancement. However, no statement has been made of how and in what way technological advancements have progressed or will progress (Snowdon & Vane, 2005, p. 579-657; Akçomak, et al., 2016, p. 181-206).

Because technology was regarded as an exogenous factor by the neo-classicals; its impact on growth; working mechanisms, and its development was not explained by technical reasons. This situation has caused other economists and theorists to turn to this field and to focus on the technology factor. Thus, together with the studies of Romer (1986, 1990), endogenous growth models based on the ideas of Schumpeter (1934) and Arrow (1962) emerged (Snowdon & Vane, 2005, p. 579-657; Akçomak, et al., 2016, p.

211; Şeker & Özcan, 2019, p. 868). With the subsequent studies of Grossman & Helpman (1987, 1991) and Aghion & Howitt (1992), endogenous growth theories have been expanded and attention has been drawn to the impact of elements such as R&D and innovation as an important factor of growth. (Snowdon & Vane, 2005, p. 579-657; Yıldırım & Kesikoğlu, 2012, p. 166).

According to the endogenous growth theories, companies will aim to maximize profits by improving their competitiveness in trade by differentiating their products and services, and for accomplish so, they will do more R&D investments. Furthermore, the presence of protective structures in the economy (for example, strong institutions and regulations for the protection of patents and copyrights[1]) will encourage companies to invest more and technological advancements will accelerate (Snowdon & Vane, 2005, p. 579-657; Akçomak, et al., 2016, p. 229-230). Additionally, allocating resources in the economy to research for the creation of R&D and innovation will be advantageous in catching a long-term increase trend in economic growth rates through technological developments. Because, according to Romer's (1986) theories, new technologies and ideas that arise because of these studies will not have a competitive environment (Göçer, 2013, p. 218).

In this context, companies with sufficient resource power will invest in R&D and innovation activities utilizing their skilled and trained staff, and therefore attempt to develop a new product in an economy where their rights are well protected. This developed product or innovation will be employed in the production process to improve efficiency or offered as a finished product with value-added. (Yaşar, 2020, p. 559; Göçer, 2013, p. 218-219; Akçomak, et al., 2016, p. 211-230). According to Vernon's (1966) "product life cycle" theory, the company that launches a new product will have a monopoly position in the market and will profit unrivaledly for a period because there will be no competitive environment. The company will be able to fund future R&D studies and strengthen its position in foreign trade in comparison to competitors with the profits made (Vernon, 1966, p. 190-207).

On a micro scale, these high value-added products produced with innovative technologies return to the company as profit; on a macro scale, such efforts by companies that remain in the economy will provide an advantage in foreign trade

[1]See. O. Ivus (2010). Do Stronger Patent Rights Raise High-tech Exports to the Developing World? *Journal of International Economics, 81,* 38–47.

through the export of high-tech products to the country's economy and will be a factor supporting economic growth (Şeker & Özcan, 2019, p. 865-879; Özçelik & Taymaz, 2004, p. 409-422). It is obvious that encouraging the export of advanced technology in order to attain growth stability can provide great benefits to the economy. For this, the well-educated and qualified human factor is of great importance, because it is human capital that generates the ideas that form the foundation of innovation. After all, the qualified human factor plays a major role in the transformation of these ideas into a product through R&D and innovation, and ultimately, it is the human factor that will transform technological developments into more advanced innovations and technologies with new ideas (Gökmen & Turen, 2013; Tebaldi, 2011; Vogiatzoglou, 2009).

On the other hand, it is critical for businesses to learn and internalize technologies that they do not currently possess. This situation is linked to the magnitude of the economy's trade volume and international corporations' direct investments. Such that, the absence of trade restrictions and customs tariffs, or the fact that they have little impact on commerce, will encourage enterprises to trade in the global market. This environment will force enterprises that are exposed to the compelling effects of international competition to produce new products and productivity-enhancing technologies, or to acquire these technologies from outside, as in the creative destruction theory of Schumpeter (Schumpeter, 1943, p. 75-78; Brahm, 1995, p. 71-72; Özer & Çiftçi, 2009, p. 40; Göçer, 2013, p. 218-219). Brahm (1995), on the other hand, defined this destructive competition in the international market in high technology sectors as "excessive competition".

Technology acquisition for economies and enterprises engaged in international trade can be made possible by technological diffusions and technology transfers, as well as investments by international companies, which can introduce new technologies to the economy and effect high technology exports (Almeida & Fernandes, 2008, p. 722-723; Seyoum, 2005, p. 76; Srholec, 2007, p. 247-250; Xing, 2012, p. 357). Furthermore, because factors like trade volume and openness can directly promote growth, this situation will also improve the resource opportunities that corporations can allocate to R&D and innovation research (Awokuse, 2008, p. 172; Baldwin, 2004, p. 518; Almeida & Fernandes, 2008, p. 722-723; Karam & Zaki, 2015, p. 31).

So that; When the economic indicators in Table 2.1 of former NICs (Newly Industrializing Countries) countries such as South Korea, Hong Kong, and Singapore are examined, it can be seen that there has been a noticeable increase in the exports of these countries, which have shown an explosive growth performance since the 1960s and entered rapidly the category of developed countries. This rapid increase in exports also contributes significantly to the economy's productivity performance and is thought to have a growth-enhancing effect. (Bernard & Jensen 2004; Cooke & Watson, 2011; Madsen, 2009).

Table 2.1. *GDP, GDP per capita and export values of former NICs countries (World Bank, n.d.)*

Countries	Years	GDP (Current US$)	GDP Per Capita (Current US$)	Exports of Goods and Services (Current US$)
South Korea	1960	3.958.190.759	158	103.762.705
	1980	65.398.646.758	1.715	18.598.850.896
	2000	576.178.114.168	12.256	195.550.063.662
	2020	1.637.895.802.792	31.597	596.945.196.581
Hong Kong	1960	1.320.796.652	429	NA
	1980	28.861.759.209	5.700	25.613.432.206
	2000	171.668.164.082	25.756	216.355.888.694
	2020	346.585.881.503	46.323	612.566.518.847
Singapore	1960	704.756.304	428	1.147.523.846
	1980	11.896.256.782	4.928	24.031.178.147
	2000	96.074.477.958	23.852	180.957.134.570
	2020	339.998.477.929	59.797	599.216.278.901

Note: The data used to create the table are taken from World Bank, World Development Indicators data.

South Korean records show that while the country had a GDP of around $4 billion in the 1960s but only $103 million in exports, these numbers increased dramatically in the 1980s. South Korea's GDP climbed to $576 billion in the 2000s, exports to $195 billion, and per capita income as an indicator of development increased to around $32 thousand. This is also the case for Hong Kong and Singapore. For example, in 1960, Singapore's GDP was $704 million, and exports were $1.1 billion; by 2020, these values had risen to $339 billion and $597 billion, respectively. Furthermore, it can be seen that Singapore's per capita income has nearly reached $60 thousand. As a result, these former NICs countries are included in the category of developed and high-income countries (World Bank, 2022a; World Bank, 2022b).

While a country's export capacity and capability are essential factors in its international competitiveness (Ruzekova, Kittova, & Steinhauser, 2020; Williams, 2007; Efrat, Hughes, Nemkova, Souchon, & Sy-Changco, 2018; Kaleka, 2002), what is exported is also important (Hausman, Hwang & Rodric, 2007).

3. HIGH TECHNOLOGY EXPORT

Although it is well known that exports are an essential element for economies, what is exported is also a crucial factor. The significance of variables such as technology, high-tech exports, innovation, R&D-intensive products, and export development is appreciated from this perspective.

3.1. Definition

Companies' investments in technology and innovation studies in national economies have enhanced productivity, international competitiveness, and the shares of these companies in exports from global markets. This situation has significantly increased the importance given by national governments on concepts such as technology and innovation and giving these variables strategic relevance. The fact that technology provides economies with a major advantage in international competition has increased the numbers of technological discussions and studies (Pavitt, 1984, 1990; Berry & Taggart, 1994).

Galbraith (1967) defined technology simply as "the systematic application of scientific or other organized knowledge to practical tasks". However, Monck et al. (1988) define technology as all the knowledge and equipment used for practical solutions to the problems encountered. Afterwards, Freeman (1982) separated the concepts of "technology" and "technological innovation" and defined technological innovation as the creation of newer and more advanced products and production methods (Berry & Taggart, 1994).

High-tech products, on the other hand, are defined by the OECD as technological products that utilize components with a high R&D intensity in their manufacture and have emerged as a result of R&D expenditures (Hatzichronoglou, 1997; OECD, 2011).

Following that, research on the concepts of technology and innovation continued, and discussions on the classification of high technology began (Roberts, 1987; Porter, 1983; Rothwell & Zegveld, 1985; Pavitt, 1984, 1990; Davis, 1982, 1988; Hatzichronoglou, 1997).

3.2. Classification and Measurement Methods of High-Tech Exports

With the increase of research on high-tech exports, R&D, and innovation in the 1980s, new approaches and perspectives on the classification of high-tech products and industries emerged.

Pavitt (1984) developed a high-tech classification for eleven 2-digit sectors and 26 3- and 4-digit sub-sectors and attempted to quantify it based on the number of innovations occurring in the sectors. In addition, he divided the industrial sectors into 4 categories as supplier dominated, scale intensive, science based and specialized suppliers and stated that engineering sectors such as mechanical engineering, electrical and electronic engineering are more innovative and more technology intensive.

Davis (1982) used direct or indirect R&D expenditures in the production of products to classify high-tech sectors. According to Davis (1982, 1988), products with high technology intensity can naturally be produced in sectors where R&D studies are intense, as they emerge as a result of R&D efforts. Although Abbott III (1991) criticized Davis's (1982) method of classifying high-tech exports, saying that it was simple and superficial in classifying high-tech exports, Davis's method was accepted in the literature and continued to be developed and used. According to Abbott III, it is not correct to accept that all sub-goods produced in the industry have the same R&D intensity in Davis' method, and that sub-goods produced within the same industry may have various R&D intensities. Additionally, he argued that R&D data may lead to deceptive results in companies with multiple business and product lines, since companies in high-tech sectors report their R&D investments in total.

Likewise, Grupp (1995) attempted to determine high technology based on R&D intensity. However, unlike Davis (1982), he divided the high-tech classification into two groups. He defined the first group with an extremely high R&D intensity as “leading-edge technology” and the second group as “above-average R&D intensive” or “high-level technology.” He created the high-tech classification using the "standard international trade classification" (SITC) Rev.3 and classified the 16 "leading-edge" and 57 "high-level technology" products and sectors shown in Table 3.2.1 as high technology.

Table 3.2.1. *Grupp's classification of high-tech sectors and R&D intensive products (Grupp, 1995).*

Technology Group	SITC Rev.3 Codes	Product Group
	516	Advanced organic chemicals
	525	Radioactive Materials
	541	Pharmaceutical product
	575	Advanced plastics
	591	Agricultural chemicals
	714	Turbines and reaction engines
	718	Nuclear, water, wind power generators
"Leading-edge	752	Automatic data processing machines
Technology"	764	Telecommunications equipment
	774	Medical electronics
	776	Semi-conductor devices
	778	Advanced electrical machinery
	792	Aircraft and spacecraft
	871	Advanced optical instruments
	874	Advanced measuring instruments
	891	Arms and ammunition
	266	Synthetic fibres
	277	Advanced industrial abrasives
	515	Heterocyclic chemistry
	522	Rare inorganic chemicals
	524	Other precious chemicals
	531	Synthetic colouring matter
	533	Pigments, paints, varnishes
	542	Medicaments
	551	Essential oils, perfume, flavour
	574	Polyethers and resins
"High-level	598	Advanced chemical products
Technology"	663	Mineral manufacturers, fine ceramics
	689	Precious non-ferrous base metals
	724	Textile and leather machinery
	725	Paper and pulp machinery
	726	Printing and bookbinding machinery
	727	Industrial food-processing machines
	728	Advanced machine-tools
	731	Machine tools working by removing
	733	Machine tools without removing
	735	Parts for machine-tools
	737	Advanced metalworking equipment

Table 3.2.2. *(cont.) Grupp's classification of high-tech sectors and R&D intensive products (Grupp, 1995).*

"High-level Technology"	741	Industrial heating and cooling goods
	744	Mechanical handling equipment
	745	Other non-electrical machinery
	746	Ball and roller bearings
	751	Office machines, word-processing
	759	Advanced parts for computers
	761	Television and video equipment
	762	Radiobroadcast, radiotelephony goods
	763	Sound and video recorders
	772	Traditional electronics
	773	Optical fiber and other cables
	781	Motor vehicles for persons
	782	Motor vehicles for goods transport
	791	Railway vehicles
	872	Medical instruments and appliances
	873	Traditional measuring equipment
	881	Photographic apparatus and equipment
	882	Photo- and cinematographic supplies
	884	Optical fibers, contact, other lenses

Later, the OECD developed its own classification by employing R&D intensity to determine high-tech sectors and product lines, similar to Davis (1982)'s method (Hatzichronoglou, 1997). While creating the classification, the points criticized by Abbott III (1991) were tried to be eliminated in this method. So that; Abbott III emphasized that only two groups separated as "high technology" and "low technology" in Davis (1982)'s method were insufficient. In the OECD classification, Hatzichronoglou (1997) increased the number of groups to three as "high technology", "medium technology" and "low technology". It also divided the "medium technology" group into two separate groups as "medium-high" and "medium-low." Hatzichronoglou identified four distinct technological sectors utilizing the ISIC Rev.2 sectoral classification over 22 sectors using data from 10 OECD countries[2] , as shown in Table 3.2.2.

[2]United States, Japan, Germany, France, United Kingdom, Italy, Canada, Australia, Netherlands, and Denmark.

Table 3.2.3. *Hatzichronoglou's ISIC Rev.2 sectoral technology classification (Hatzichronoglou, 1997)*

Technology Group	Sectors	ISIC Rev.2 Codes
High Technology	Aerospace	3845
	Computers, office machinery	3825
	Electronics-communications	3832
	Pharmaceuticals	3522
Medium-high Technology	Scientific instruments	385
	Motor vehicles	3843
	Electrical machinery	383-3832
	Chemicals	351+352+3522
	Other transport equipment	3842+3844+3849
	Non-electrical machinery	382-3825
Medium-low Technology	Rubber and plastic products	355+356
	Shipbuilding	3841
	Other manufacturing	39
	Non-ferrous metals	372
	Non-metallic mineral products	36
	Fabricated metal products	381
	Petroleum refining	351+354
	Ferrous metals	371
Low Technology	Paper printing	34
	Textilee and clothing	32
	Food, beverages, and tabacco	31
	Wood and furniture	33

Later, he expanded this classification by using the SITC Rev.3 product classification and determined 9 high-tech product groups and the sub-products that make up these groups, the calculation methods of which are also given in Table 3.2.3. A more detailed table of these identified products can be seen in Appendix-1 in the Appendices.

Table 4.2.3. *Hatzichronoglou's SITC Rev.3 high-tech product groups and products (Hatzichronoglou, 1997)*

Product Group	Definition (Codes of Sub-products)
1- Aerospace	7921+7922+7923+7924+7925+79293+(714-71489-71499)+8741
2- Computers, Office machines	75113+75131+75132+75134+(752-7529)+75997
3- Electronics, Telecommunications	76381+76383+(764-76493-76499) +7722+77261+77318+77625+7763+7764+7768+89879
4- Pharmacy	5413+5415+5416+5421+5422
5- Scientific instruments	774+8711+8713+8714+8719+87211+(874-87411-8742)+88111+88121 +88411+88419+89961+89963++89967
6 -Electrical machinery	77862+77863+77864+77865+7787+77844
7- Chemistry	52222+52223+52229+52269+525+57433+591
8- Non-electrical machinery	71489+71499+71871+71877+72847+7311+73131+73135 +73144+73151+73153+73161+73165+73312+73314+73316 +73733+73735
9- Armament	891

In 2006, the Economic and Social Relations Office of the United Nations revised the SITC Rev.3 product classification and created the new SITC Rev.4 classification (UN Secretariat, 2006). EUROSTAT, on the other hand, gave its final form to the classification of high technology products with minor revisions, as shown in Table 3.2.3 (EUROSTAT, n.d.).

Table 3.2.5. *SITC Rev.4 product classification, high-tech products, and product groups (EUROSTAT, n.d.)*

Product Group	SITC Rev.4 Codes	Definition
Aerospace	(714-714.89-714.99)+	Aeroplane motors
	792.1+	Helicopters
	792.2+792.3+792.4+	Aeroplanes and other aircraft, mechanically propelled
	792.5+	Spacecraft (including satellites) and spacecraft launch vehicles
	792.91+	Propellers and rotors and parts thereof
	792.93+	Undercarriages and parts thereof
	874.11	Direction finding compasses; other navigational instruments and appliances
Computers, Office machines	751.94+	Multifunction office machines, capable of connecting to a computer or a network
	751.95+	Other office machines, capable of connecting to computer or a network
	752+	Computers
	759.97	Parts and accessories of group 752
Electronics, Telecommunications	763.31+	Sound recording or reproducing apparatus operated by coins, bank cards, etc
	763.8+	Video apparatus
	(764-764.93-764.99)+	Telecommunications equipment
	772.2+	Printed circuits
	772.61+	Electrical boards and consoles < 1000V
	773.18+	Optical fibre cables
	776.25+	Microwave tubes
	776.27+	Other valves and tubes
	776.3+	Semiconductor devices
	776.4+	Electronic integrated circuits
	776.8+	Piezoelectric crystals
	898.44+	Optical media
	898.46	Semiconductor media

Table 3.2.6. (cont.) *SITC Rev.4 product classification, high-tech products, and product groups (EUROSTAT, n.d.)*

Pharmacy	541.3+	Antibiotics
	541.5+	Hormones and their derivatives
	541.6+	Glycosides, glands, antisera, vaccines
	542.1+	Medicaments containing antibiotics or derivatives thereof
	542.2	Medicaments containing hormones or other products of subgroup 541.5
Scientific instruments	774+	Electrodiagnostic apparatus for medicine or surgery and radiological apparatus
	871+	Optical instruments and apparatus
	872.11+	Dental drill engines
	(874-874.11-874.2)+	Measuring instruments and apparatus
	881.11+	Photographic cameras
	881.21+	Cinematographic cameras
	884.11+	Contact lenses
	884.19+	Optical fibres other than those of heading 773.1
	(899.6-899.65-899.69)	Orthopaedic appliances
Electrical machinery	(778.6-778.61-778.66-778.69)+	Electrical capacitors, fixed, variable or adjustable
	778.7+	Electrical machines, having individual functions
	778.84	Electric sound or visual signalling apparatus
Chemistry	522.22+	Selenium, tellurium, phosphorus, arsenic and boron
	522.23+	Silicon
	522.29+	Calcium, strontium and barium
	522.69+	Other inorganic bases
	525+	Radioactive materials
	531+	Synthetic organic colouring matter and colour lakes
	574.33+	Polyethylene terephthalate
	591	Insecticides, disinfectants
Non-electrical machinery	714.89+	Other gas turbines
	714.99+	Part of gas turbines
	718.7+	Nuclear reactors and parts thereof, fuel elements, etc
	728.47+	Machinery and apparatus for isotopic separation
	731.1+	Machine-tools working by laser or other light or photon beam, etc
	731.31+	Horizontal lathes, numerically controlled
	731.35+	Other lathes, numerically controlled

Table 3.2.7. (cont.) *SITC Rev.4 product classification, high-tech products, and product groups (EUROSTAT, n.d.)*

Non-electrical machinery	731.42+	Other drilling machines, numerically controlled
	731.44+	Other boring-milling machines, numerically controlled
	731.51+	Milling machines, knee-type, numerically controlled
	731.53+	Other milling machines, numerically controlled
	731.61+	Flat-surface grinding machines, numerically controlled
	731.63+	Other grinding machines, numerically controlled
	731.65+	Sharpening machines, numerically controlled
	733.12+	Bending, folding, straightening, or flattening machines, numerically controlled
	733.14+	Shearing machines, numerically controlled
	733.16+	Punching machines, numerically controlled
	735.9+	Parts and accessories of 731 and 733
	737.33+	Machines and apparatus for resistance welding of metal, fully or partly automatic
	737.35	Machines and apparatus for arc welding of metal, fully or partly automatic
Armament	891	Arms and ammunition

As previously noted, studies on the classification of high technology sectors and products have resulted in the OECD classification being much more accepted and used in the literature. However, factors other than R&D intensity have been used in measuring the level of technology.

Because the data utilized in the R&D method is generally only available for developed and certain developing countries, measuring the level of technology in low-income and underdeveloped countries has become an issue. Therefore, it has been suggested to use patent counts to measure the level of technology in products and sectors. Thus, a benchmark can be established for low-income countries by using patent data that began to be recorded a long time ago. However, as in the R&D method, this method has some shortcomings and weaknesses. Such that; some few patents alone represent a large part of the total value created by distinguishing itself from other patents. Furthermore, it should be noted that patents for new products or inventions are obtained at the initiative of the owner of the product or innovation covered by the patent. This method has flaws, such as the fact that most existing products and innovations do not have patent protection, and that some patents are more valuable than others (Keller, 2004, s. 757-758).

Unlike R&D and patent methods, another method used in technology measurement is the use of total factor productivity (TFP). The influence of technology is attempted to be determined in this method, which derives from the Cobb-Douglas basic production function [Q=f (K, L)], by subtracting the effect of capital and labor from the output level of the economy. However, this strategy, like others, has limitations due to data suitability and accessibility. Moreover, in this method, both input and output data are required separately, and because the influence of labor and capital must be estimated, errors in the calculations may occur during the measurement (Abramovitz 1956, 1986; Keller, 2004, p. 758).

Although their purpose is not to directly evaluate high technology, sophistication indexes mentioned in the literature have been used to measure the quality of an economy's export structure, and it is assumed that this quality can represent high technology as a criterion (Finger & Kreinin, 1979; Kwan, 2002; Hausman, Hwang & Rodric, 2007; Koopman, Wang, & Wei, 2008; Hidalgo & Hausman, 2009; Hausman et al., 2014; Yu & Hu, 2015).

According to these indexes based on Ricardo’s (1821) theories of comparative advantage between economies, the fact that the majority of exported products are such sophisticated products is accepted as an indicator of export quality in that economy (Kwan, 2002). Thus, by evaluating the structure of exports in economies, different calculation methods, indexes, and studies that attempt to determine the level of sophistication of that economy have emerged.

Due to the inconvenience of the data, Finger & Kreinin (1979) proposed the "export similarity index" (ESI), one of the first export sophistication index based on more accessible international trade data, with the aim of determining the similarities and differences in the economies' exports.

Kwan (2002), on the other hand, developed the "product sophistication index" (PSI), that for the first time took the income effect into consideration when evaluating the development of exports in economies.

The EXPY index, which is another index that also considers the income effect, was developed by Hausman, Hwang & Rodric (2007). The weighted average of GDP per capita is utilized in its calculation to show each country's comparative advantage in a specific product. First, the income/productivity ratio for each "product" is estimated, and then this ratio is calculated for a specific "product basket." The EXPY index has gained widespread acceptance in the literature and has become one of the most used sophistication indexes.

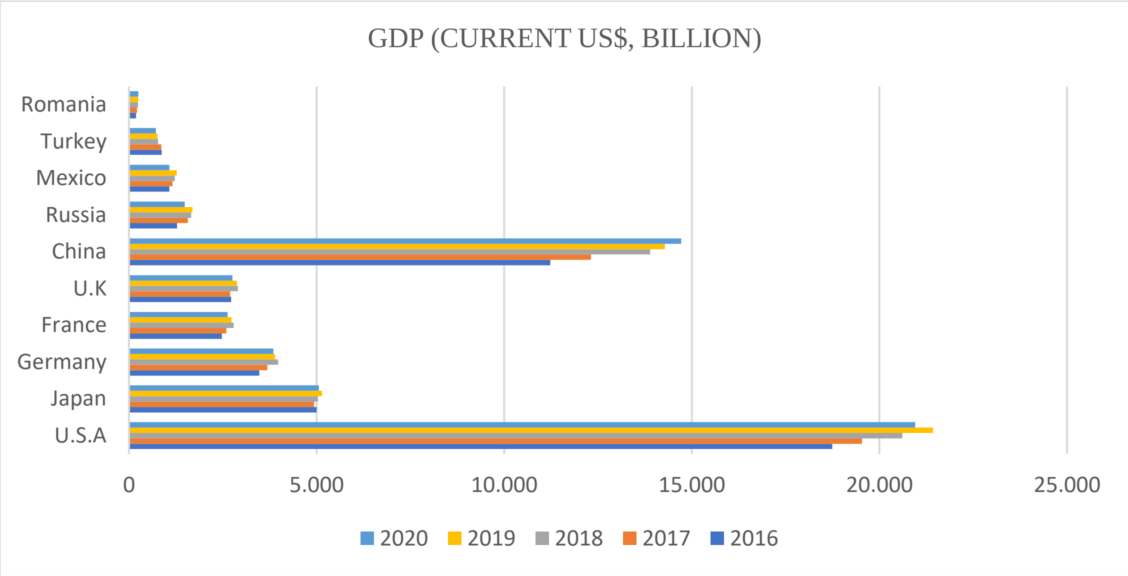
The ECI index, on the other hand, is an index developed by Hidalgo and Hausman (2009) and later updated by Hausman et al. (2014), calculated by MIT (Massachusetts Institute of Technology) and Harvard University the Atlas of Economic Complexity. This index also considers the variety of exporting products.

Yu & Hu (2015) suggested the TSI index, which is based on the EXPY index developed by Hausman, Hwang, & Rodric (2007), but which, unlike EXPY, takes into account the countries' vertical specialization processes when estimating export development.

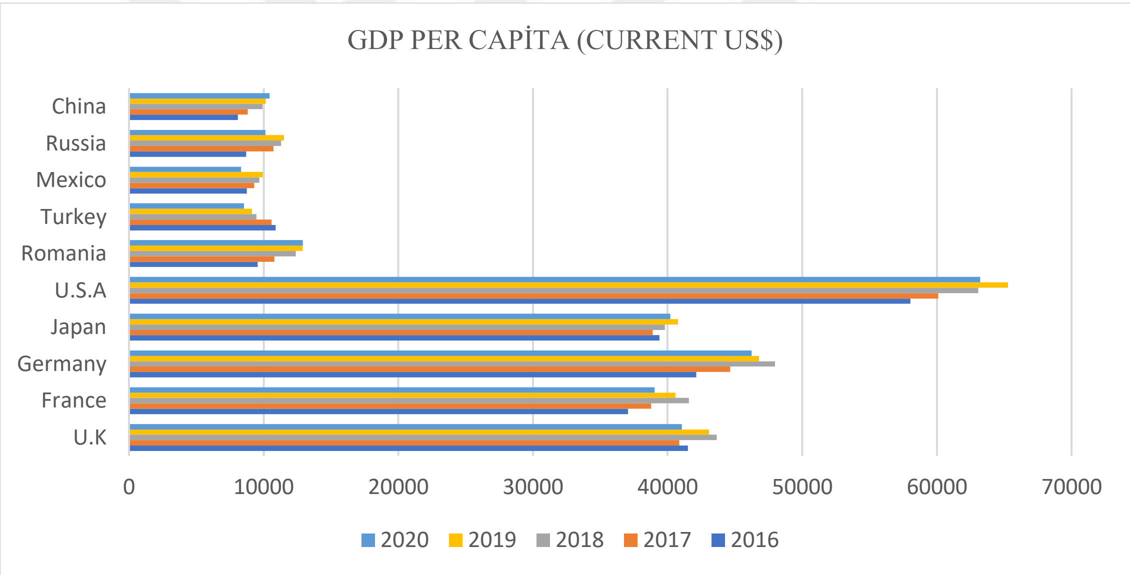
High technology export data created using SITC Rev.4 product classification will be used in this study. These are the most recent versions of Hatzichronoglou's (1997) high-tech product categorization, which incorporates the SITC Rev.3 product classification.

3.4. State of High-Tech Exports in Developed and Developing Countries

It has been criticized many times by the neo-classical view that the per capita income differences between economies will disappear in the long run (Yülek, 1997) because it does not match the economic realities. One of the primary causes of this predicament is the growing disparity in growth and welfare between developed and developing countries. This situation can be grasped more easily by examining Graph 3.4.1 and Graph 3.4.2.



Graph 3.4.1. *GDP values of selected developed and developing countries (World Bank, n.d.)*[3]



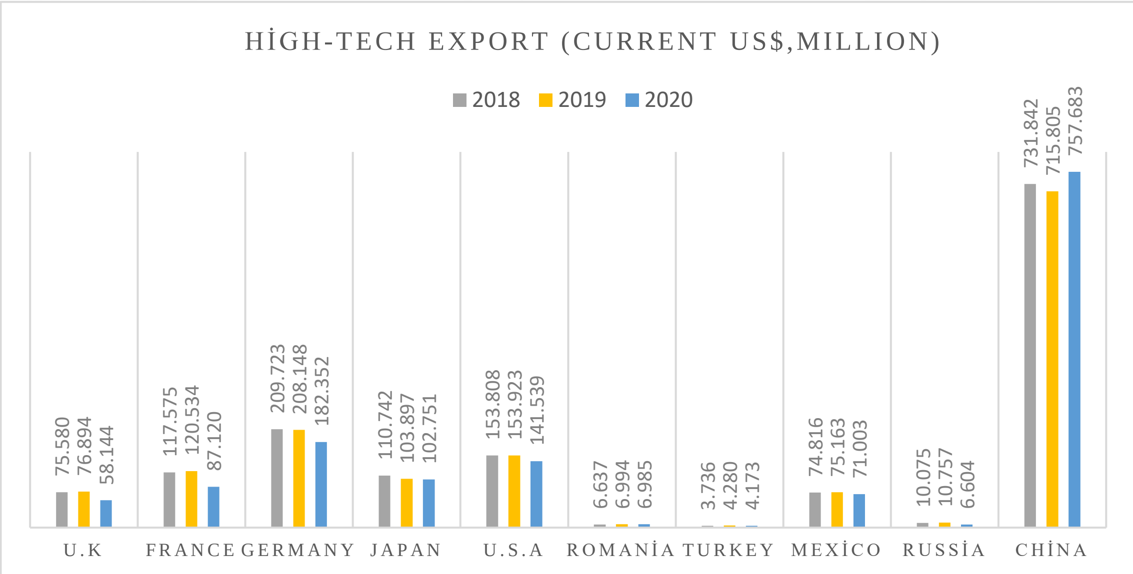
Graph 3.4.2. *GDP per capita values of selected developed and developing countries (World Bank, n.d.)*

As can be seen from the graphs, the GDP figures in developed[4] countries are higher than those in developing countries[5], but more importantly, when the graph of GDP per capita, which is an indicator of welfare, is taken into account, the situation is much clearer. While the GDP per capita in developing countries ranges between $8,000 and $13,000, it ranges from $39,000 to $63,000 in developed economies (World Bank,

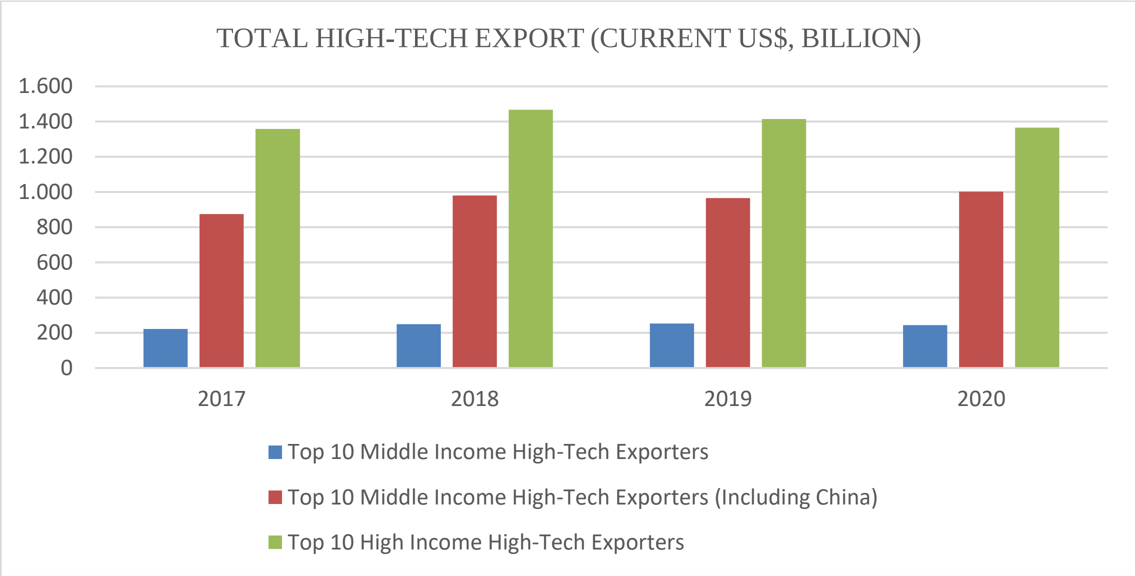
[3]Note: All data used to create Graph 3.4.1, Graph 3.4.2, Graph 3.4.3, Graph 3.4.4, Graph 3.4.5, and Graph 3.4.6 were obtained from the World Bank and World Development Indicators.
[4]Germany, France, United Kingdom, U.S.A., and Japan
[5]Turkey, Russia, China, Mexico, and Romania

n.d.). For this reason, it is not surprising that studies on concepts such as R&D, innovation, export, and advanced technology have increased in developing countries in recent years.

In addition to these, the reason for this growth and welfare disparity, which continues against developing economies, can be shown as lagging behind developed countries in the technological development race and trained personnel gaps. With simple reasoning, these countries that are falling behind in the technological race and have a lack of skilled employees are also falling behind in the production and export of high value-added products. For example, when Graphs 3.4.3 and 3.4.4 are examined, the disparities in the export figures of high-tech products may be seen.



Graph 3.4.3. *High-tech export values of selected developed and developing countries (World Bank, n.d.)*



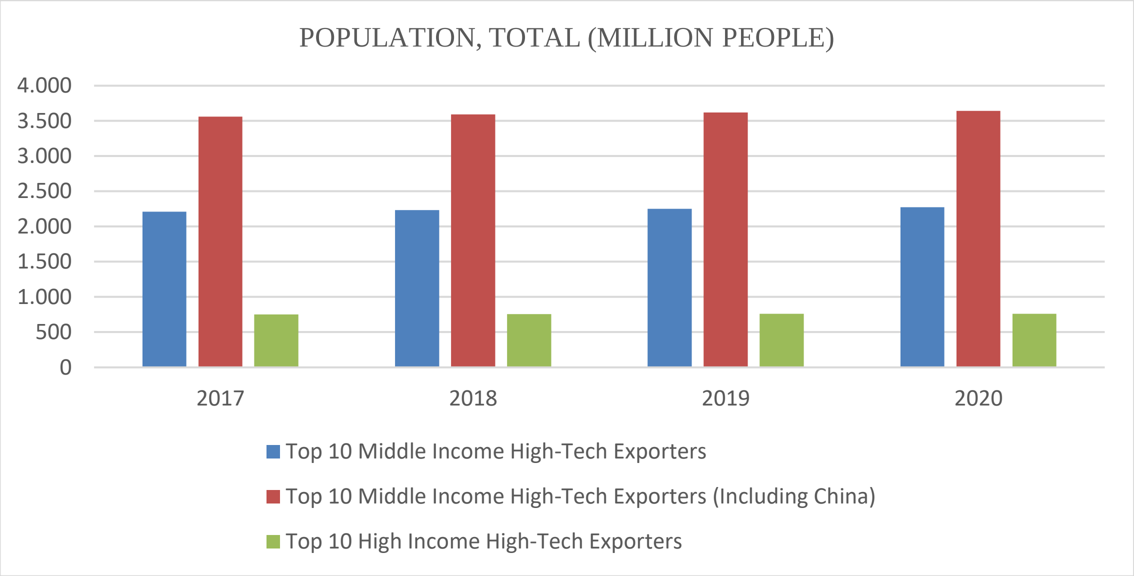
Graph 3.4.4. *High-tech export values of selected middle and high-income country groups (World Bank, n.d.)*

As shown in the graphs above, developed countries dominate the market by a very large margin compared to developing countries in the export of products containing advanced technology. Except for a few countries such as China and Mexico, which stand out from similar emerging economies, this situation creates a very unfavorable situation for developing countries in general. For example, when Graph 3.4.4 is examined more closely, it can be observed that the total high-technology export values of 10 high-income and developed countries[6] and 10 middle-income and developing countries[7] with the highest high-tech exports are presented. According to 2020 statistics, while middle-income countries export roughly $200 billion in high-tech products, developed high-income countries export around $1.3 trillion. In the chart, a different group of middle-income countries has been formed to demonstrate the effect of China separately. Because it is vital to note in the case of China that China is different from other developing and even developed economies. This is due to China's enormous population and the fact that it is the world's factory, as well as the fact that these spectacular results in high-tech exports can be an illusion (Xing, 2012; Srholec 2007). Such that; Mani (2000) investigated which factors affect high technology exports in some newly industrializing Asian economies and attributed the increase in high technology exports in such countries to the sharing of production stages and the

[6]Hong Kong, Germany, South Korea, Singapore, U.S.A, Japan, Netherland, France, United Kingdom, Ireland
[7]Malaysia, Mexico, Philippines, India, Romania, Russia, Indonesia, Turkey, South Africa, Ukraine

existence of a form of assembly industry. Srholec (2007), on the other hand, defined this situation as “statistical illusion” and stated that the increase in high technology exports in developing countries is usually the export of imported sub-parts after they have been assembled and made into a finished product. However, despite the addition of China's export values, it is clear that developing countries still far behind developed countries by a large margin.

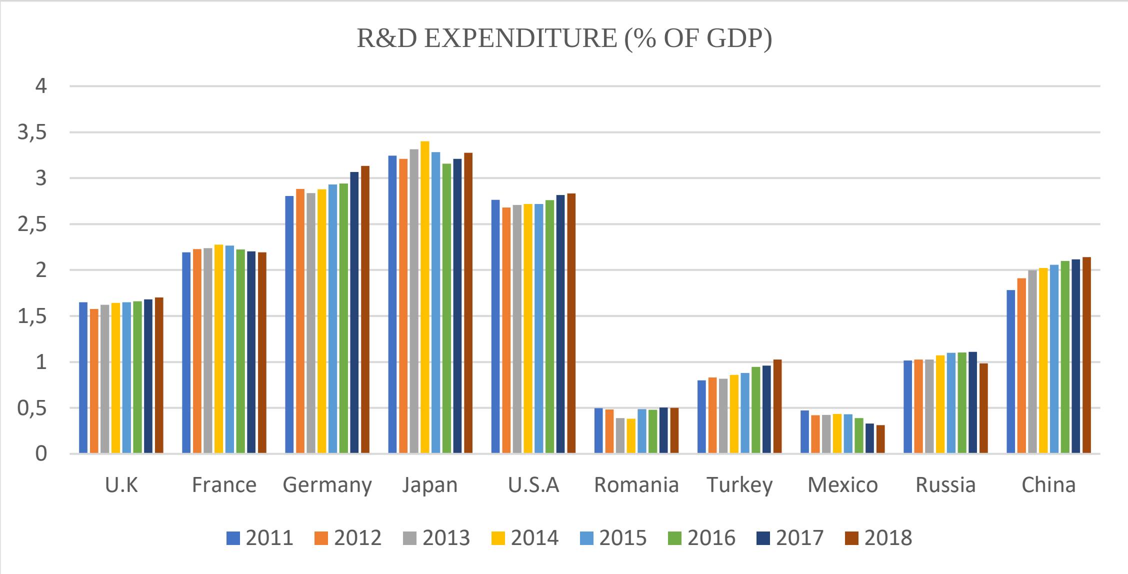
Another related issue is the population numbers in these developed and developing countries. When the population statistics from Graph 3.4.5 are included into the equation, the enormity of the situation becomes clearer.



Graph 3.4.5. *Population numbers of selected middle and high-income country groups (World Bank, n.d.)*

The total population of the 10 developed countries, which exported approximately $1.3 trillion high technology in 2020, is 762 million. In developing countries, about $200 billion of high-tech products, corresponding to a population of 2.27 billion, were exported. For the group of developing countries, including China, an export value of $975 billion is seen, corresponding to a population of 3.64 billion people. Considering that the world population is 7.76 billion people in 2020, the population of the developing country group corresponds to approximately 9.81% of the world's population, while this rate is 46.91% in the group of developing countries including China (World Bank, n.d.).

For these reasons, the efforts, and desires of developing countries to close these differences have driven them to invest in factors such as R&D, human capital, and high-tech products. However, when the ratios of these investments are examined, it can be understood with the help of Graph 3.4.6 below that, developed countries invest more in factors such as R&D, and that despite everything, these factors are not given sufficient importance and investments are insufficient in developing countries.



Graph 3.4.6. *R&D expenditures of selected developed and developing countries (World Bank, n.d.)*

As a result of the basic comparisons presented above, the effects of factors such as R&D and high technology exports can be clearly seen in the economies of developing countries like Turkey. The existence of these factors and other factors and variables that have a direct or indirect effect on the economy should not be disregarded. For example, human capital might indirectly affect economic growth by affecting the R&D factor. It should also be noted that variables like as the number of patents, foreign investments, and openness to trade may also have indirect or direct effects.

Thus, it should not be forgotten that, in developing economies that lack competitiveness in international trade, innovation and R&D studies may have a leveraging effect on growth and export, rather than policies that have no practical effect, such as export subsidies or devaluation. However, since it is known that R&D and innovation studies play a significant role in increasing the international competitiveness of Turkish manufacturing industry companies (Özçelik & Taymaz, 2004, p. 409-410) it is vital to prioritize R&D investments. It is thought that giving priority to such studies in developing countries, as well as supporting and increasing them, is expected to benefit the economy greatly.

4. LITERATURE REVIEW

The studies on how to achieve desirable economic growth, which began with Adam Smith (1776), eventually became the widely discussed topic. The neo-classical growth theories and the later emergence of endogenous growth models have substantially improved the literature on the subject. Variables such as savings and capital were emphasized as determinants of economic growth in neo-classicals, and although the concept of technological development was mentioned, it was assumed constant in models developed by assuming it to be an external component. On the other hand, in the endogenous growth theories, it has been argued that technology is quite effective on growth and studies on growth have focused on the effects of the technology factor. As a result, it has become widely accepted that technology has an obvious impact on growth, and this circumstance has prompted research into the concepts of R&D and innovation in order to accelerate technological advancements and so ensure growth.

When it comes to concepts such as R&D, advanced technology, and export, of course, export performance of manufacturing industry products of companies operating in the economy (Özçelik & Taymaz, 2004), innovation studies (Bujari & Martinez, 2016; Guarascio, Pianta, & Bogliacino, 2016), factors such as regional collaborations and R&D expansions (Funke & Niebuhr, 2005) also be involved in and affect the growth performance of the economy. Özçelik & Taymaz (2004), who investigated the factors affecting the export performance of companies in the Turkish manufacturing industry, emphasized the importance of R&D and Innovation studies on the Turkish manufacturing industry for this purpose. According to the study, such efforts will improve the international competitiveness of the companies operating in the economy, raising their export performance, and achieving a growth trend in the economy. A similar study was conducted by Bojnec & Fertő (2011). According to the article, exports of manufacturing industry products have a positive relationship with economic growth in export or import-intensive countries, and R&D expenditures in exporting countries promote exports of manufacturing industry products. However, the existence of a positive relationship between manufacturing industry product exports and R&D expenditures in importing countries could not be confirmed.

Since the development of R&D is thought to be affected by human capital, that is, trained and qualified workforce, human capital has gained value, so human capital investments have expanded with R&D investments. Foreign investments, on the other hand, have gained importance due to their direct effects on growth as well as the fact that foreign companies bring their technological know-how to the economies to which they direct their investments.

For example, in his study on the effects of foreign investments in Turkey, Örnek (2008) stated that foreign direct investments have positive effects on the growth of the economy (Örnek, 2008). Topallı (2016), on the other hand, in his study on the BRICS countries and Turkey, in addition to the findings of Örnek (2008), also revealed the existence of a positive bidirectional relationship between trade openness and growth (Topallı, 2016). Berthélemy & Démurger (2000), researched on China and found that foreign investments led to economic growth by triggering technological transfers in 24 Chinese regions between 1985 and 1996.

According to Telatar, Değer, & Doğanay (2016)'s study on the export of technology-intensive products, it has been shown that the export of technology-intensive products has a favorable effect on Turkey's economy. In the study of Alper (2017), which has findings supporting the studies of Telatar, Değer & Doğanay (2016), the effects of high technology exports, number of patents and R&D expenditures on the growth of the Turkish economy are clearly shown.

As previously mentioned, technological advancements as a consequence of innovative studies and incoming foreign investments are also important as they promote companies and economies through trade. Related to this, studies of Almeida & Fernandes (2008) emphasized that trade openness accelerates technology transfers and foreign direct investments are also effective in this. Mentioning the existence of an effect between trade and technological developments, the authors also stated that technological innovations are an important factor in emerging countries. Furthermore, Kaya & Şahin (2015), who investigated the impact of trade volume on growth, concluded that increased trade volume had favorable effects on economic growth. Using BRICS countries' growth and trade statistics from 1995 to 2013, researchers discovered that a 1% increase in trade volume produces a 0.81% increase in growth. Karam & Zaki (2015) reached similar conclusions and emphasized the existence of a positive relationship between trade volume and growth in their studies, which included data from MENA (Middle East and North Africa) countries between 1960 and 2011. For these reasons, the inclusion of factors such as the trade volume and foreign investments in these studies, is also considered important as they can accelerate trade, technology transfers and innovation studies.

The technology gap between developing and developed countries, as well as the aim to close welfare gaps, which is regarded to be one of the consequences of the technology gap, has intensified such studies, particularly in developing countries. Because studies have shown that factors such as R&D, innovation, technology, and export can significantly improve a country's welfare levels with the right decisions and practices. When the studies in the related literature are examined, Gani (2009), who studies how high technology exports affect national income per capita, set out from the 1996-2004 data of 45 countries. He concluded that high technology exports have significantly positive effects on GDP per capita in technologically advanced countries while emphasizing that even if the effect is positive, in other countries this situation is rather insignificant. In their study, comparing South Korea and Turkey, Ustabaş & Ersin (2016), similarly investigated how high technology exports affects GDP per capita in the economy. According to the study, whereas high technology exports have a significant and positive effect on GDP per capita in both the long and short term in South Korea, they revealed that this situation is unfortunately only short-term and insignificant for Turkey. This situation yields comparable results to Gani (2009)'s research. These studies also show the difference in impact between developed and developing countries' technological efforts.

In addition to these, Yoo (2008), who examined data from 91 countries between 1988 and 2000, concluded in his study that high technology exports greatly increased the economy's output level. This situation once again demonstrated the significance of high-technology exports.

There are also other studies that are worth mentioning here. Working on the effect of patent rights protection on high technology exports, Ivus (2010) discovered that patent rights protection promotes exports in economies. Smith (1999), on the other side, stated in her study on patent rights, using data from the United States, that inadequate patent rights have a negative impact on various sectors in the United States, and so patent rights should be protected more strictly.

Gkypali, Arvanitis, & Tsekouras (2018) reported that the technology absorption capacity of 300 Greek manufacturing industry companies engaged in R&D studies had a significant impact on their innovation performance. According to the researchers, R&D collaborations between enterprises will improve this absorption capacity, which will stimulate innovation studies, resulting in new collaborations through trade networks, creating a cycle in and of itself.

Although the effects and importance of R&D expenditures on the economy have been highlighted above, it would be helpful to analyze these effects further because the R&D factor is also a critical concept for high technology exports. For example, Çetin (2016) found that a 1% increase in R&D expenditures improved high technology exports by 0.25 percent in his research of seven newly industrializing economies. This factor, however, impacts developed countries as well as developing countries. In fact, Fagerberg (1995) wrote in his study that large countries achieve more competitive results in investments made in R&D-intensive high-tech industries. Similarly, Hüseyni & Çakmak (2019) employed the EXPY index as a dependent variable and stated that R&D expenditures are more effective in developed countries than in developing countries. So that; Braunerhjelm & Thulin (2008) shown in their analysis using data from 19 OECD countries, including developed countries, that a 1% increase in R&D expenditures will cause an approximately 3% growth in high technology exports. Likewise, Özkan & Yılmaz (2017), in their study on 12 European Union member countries, including developed countries, and Turkey, showed that R&D expenditures increased advanced technology exports by 3.5%. These findings are significantly higher than those obtained by Çetin (2016) in his research of newly industrialized countries. Furthermore, Fagerberg (1995, p. 24) also revealed that the R&D factor has more positive effects on the export of products and goods with higher technology intensity compared to low and medium technology goods. As shown in some other studies on the subject;

- R&D intensity increases the share of innovative enterprises working towards the production of advanced technology products in the economy, thus playing a triggering role in high technology exports (Sandu & Ciaconel, 2014),
- Exports of high-tech products supported by R&D expenditures can create positive effects on foreign trade balance and economic growth (Göçer, 2013),
- In addition, foreign investments of multinational companies may affect high technology exports in some developing economies (Seyoum, 2005; Xing, 2012),

- R&D and Innovation activities can have positive effects on economies by increasing the international competitiveness of companies (Özçelik & Taymaz, 2004).

The conclusion that Fagerberg (1995) puts forward in his study, that the R&D factor has more positive effects on the export of products and goods with higher technology intensity, is also supported by subsequent studies focusing on R&D expenditures and high technology exports (See. Braunerhjelm & Thulin, 2008; Güravşar Gökçe, Karatepe & Karagöz, 2009; Özçelik, Aslan & Özbek, 2018). However, the depth of the relationship between R&D expenditures and high-tech product exports can be easily understood when the study of Şahbaz, Yanar, & Adıgüzel (2014) who emphasizes the existence of a bidirectional relationship between these variables. Furthermore, this finding is also aligned with the research of Kılıç, Bayar & Özekicioğlu (2014). However, unlike the study by Şahbaz et al., Kılıç et al., indicated that R&D expenditures also in a bidirectional relationship with the real effective exchange rate. In this case, it can be thought that the exchange rate increases in Turkeys in recent years may complicate R&D expenditures and high technology exports may be affected by this. On the other hand, it is a fact that the export of advanced technology can provide foreign exchange inflow to the country. In such a case, high-tech exports may have a positive effect on the exchange rate problem.

Additionally, it was revealed in the study of Sandu & Ciocanel (2014) that the effects of private and public sector R&D investments on high technology exports are positive but at different rates. In the study, researchers found that 2 years delayed R&D expenditures increased high technology exports by 9.17%. They also stated that the R&D expenditures of the public sector at the same lag value increase the high technology exports by 8.23%. In the further stages of the study, it is shown that public sector R&D expenditures increased high technology exports by 14.42% with a 5-year lag and by 16.07% with a 7-year lag. In this regard, it can be stated that emerging economies can increase the positive effects of R&D research through both public-sector investments and incentives provided to the private sector. Similarly, in their study, Kızılkaya, Ay, & Sofuoğlu (2016) investigated the factors influencing BRICS countries' technology exports and discovered a long-term association between R&D expenditures and high technology exports in these countries. In this regard, the study is comparable to Sandu & Ciaconel's (2014). However, in some studies, it has been revealed that the main driver of high technology exports in some developing countries is the presence of multinational companies in the economy rather than R&D expenditures. It has also been stated that, majority of these high-tech products exported from developing countries are manufactured by combining imported sub-parts (Seyoum, 2005, p. 76; Srholec, 2007, p. 247-250; Xing, 2012, p. 10).

Nugent & Demiral (2017) investigated the association between R&D expenditures and information technology exports, which is one of the high-tech product groups according to the SITC Rev.3 categorization, using data from six emerging industrial economies. According to their short-term Panel System GMM analysis, a 1% increase in R&D expenditures would increase information and communication technologies exports by 0.41%. In addition, they also discovered that the real effective exchange rate has a negative effect on the export of information and communication technologies (ICT). In this regard, the study yielded similar results to the research conducted by Göçer (2013) analyzing data from 11 Asian countries. In his study, Göçer (2013) discovered that a 1% increase in R&D expenditures resulted in a 0.6% growth in ICT exports, while high technology exports improved by 6.5%. Studies by Nugent & Demiral (2017) and Kılıç, Bayar & Özekicioğlu (2014) have shown that exchange rate increases have negative effects both on R&D expenditures and high technology exports. Considering these findings, it is believed that exchange rate volatility may have a negative impact on such investments by companies in emerging economies, as well as on long-term growth through the export of value-added products.

Yu & Hu (2015), on the other hand, proposed new export sophistication indexes (TSI, TSID, TSIF) to measure the technological intensity in exports, based on the studies of Hausman et al., (2007) and Rodrik (2006). With these indexes, they created a sample of 29 countries, including China, and investigated the determinants of technology-intensive exports in China. As a result, they have demonstrated that R&D investments and the presence of an effective financial sector will improve export sophistication.

It is obvious that R&D expenditures have an impact on economic growth not only directly but also indirectly through other variables such as high technology exports. At the same time, it is not unreasonable to think that this effect occurs in both directions. In fact, it is quite possible that the share of R&D expenditures will gradually increase in an economy that grows with the effect of R&D expenditures. Korkmaz (2010)'s study also clarifies this situation, and while it is observed that R&D expenditures affect growth in the short run, it is mentioned that there is a bidirectional relationship between these two variables in the long run. Göçer (2013), who determined that a 1% increase in R&D expenditures would increase economic growth by 0.43%, and Özkan & Yılmaz (2017), who studied the effect of R&D expenditures on high technology exports and economic growth, reached similar results. In this respect, they confirmed previous studies.

Apart from the studies in the world literature, other studies conducted specifically in Turkey have shown that R&D expenditures have positive effects on growth (Duman & Aydın, 2018). Furthermore, Taban & Şengür (2014) found that the number of full-time employees in the R&D industry also had a positive effect on growth. On this subject, Altın & Kaya (2009), on the other hand, did not find the effect of R&D expenditures on growth in the short term in their study, but they concluded that there is a positive effect of R&D on growth in the long run. However, there are also negative opinions about this subject in the literature.

Sylwester (2001), for example, attempted to examine the effects of R&D expenditures on growth using data from 20 OECD countries. While the researcher could not find a relationship between R&D and growth in the first 20 OECD countries, he discovered a positive relationship between the two variables in the second group of G-7 countries. He stated that the possible reason for this may be that R&D is a more important and effective variable in explaining growth in countries with high technological development.

Apart from R&D expenditures, another important factor affecting high technology exports is human capital (Gökmen & Turen, 2013, p. 227), and besides human capital, openness to international trade and foreign investments affects high technology exports (Tebaldi, 2011, p. 343) is indicated by literature studies. Considering the research of Vogiatzoglou (2009), who examines the effect of R&D expenditures and human capital on the export of ICT goods and emphasizes that the effect of R&D expenditures is more effective than human capital; With a simple logic, it can also be expected that the effect of R&D expenditures on high technology exports will be slightly higher than on human capital. The reason for this may be that the investments made to train qualified personnel begin to show their effects in the long term. Nonetheless, the impact of human capital should not be underestimated, and human capital investments should also be increased along with R&D investments. Because the need for qualified personnel to carry out R&D activities is essential for the impact and results of R&D investments (Özer & Çiftçi, 2009, p. 9-10). This situation can be understood more easily by examining the studies of Özer & Çiftçi (2009).

Likewise, Montobbio & Rampa (2005) indicated in their studies that policies focused at improving normal and technical education increase technological capacity and production efficiency, which will allow the economy to make significant gains in exports. Such that; Cimoli, Fleitas & Porcile (2013) showed that human capital has positive effects on the export of high and medium technology products as a result of the empirical analyzes they made with the 1962-2008 data of 111 countries.

However, Hausman, Hwang & Rodrik (2007), who developed the EXPY export sophistication index to measure the development of exports and showed the usability of the index with their simulations, stated that they could not detect any statistical effect of human capital on export performance. In the research, a cross-sectional study was conducted using the 2001 data from more than 100 countries. A similar result was also found in the study of Kocenda & Poghosyan (2018), which covered 101 countries from 2001 to 2015. Researchers have stated that the human capital index has no statistical effect on the EXPY index. On the other hand, Xu & Lu (2009) worked on the PRODY index, which is also an export sophistication index, and used the average real wage statistics in industries to measure the effect of human capital. As a result of the study, the authors stated that the average wages paid to human capital had no statistically significant effect on export performance.

Cabral & Veiga (2010), who also used the EXPY index, found that, contrary to Hausman, Hwang, & Rodrik (2007) and Kocenda & Poghosyan (2018), human capital positively affects both export performance and export diversity in Sub-Saharan African countries. Using data from 48 Sub-Saharan countries from 1960 to 2005, the authors investigated the effect of labor force education quality on the EXPY index and discovered that higher education was more effective on export performance and primary education on export diversity. A similar result was also revealed in the study of Weldemicael (2012). In the study, the researcher, who calculated the EXPY indexes of 120 countries using the data of 1980 to 2000, stated that human capital had positive effects on export performance. On the other hand, Hüseyni & Çakmak (2019) examined the impact of education expenditures on the EXPY index separately as developing and developed countries. Using the data of 5 developing and 5 developed countries in their studies between 1996 and 2013, the researchers mentioned the existence of a significant and positive effect of education expenditures on export performance. Similarly, the view that human capital is an important and positive factor for export performance has also been demonstrated in the studies of Teng & Lo (2019), Gan & Cheng (2019), and Zhang & Chen (2020).

Although there are studies in the literature that cannot empirically find the effect of human capital on high technology exports and export performance, the prevailing view in the literature is that the well-educated human factor is an important element that positively affects the value-added product export.

Along with these researches, the significance of human capital can be grasped by examining studies that demonstrate its direct influence on growth. As an example, Bassanini & Scarpetta (2001) investigated the relationship between human capital and growth and concluded that human capital has also a favorable impact on growth. Furthermore, Şimşek & Kadılar (2010) studied human capital, exports and growth in Turkey and discovered a long-term bidirectional relationship between human capital and growth.

Trade openness is another factor commonly highlighted in the literature on high-tech product export. The increase in trade openness enables companies exporting in economies to compete in the international market. Thus, in the face of fierce competition, companies strive to maintain their competitiveness at the highest level in global markets by investing in innovative products and manufacturing technologies. Furthermore, trade openness gives companies the opportunity to observe and absorb the innovations developed by other worldwide companies (Schumpeter, 1943; Vernon, 1966; Romer, 1986; Özer & Çiftçi, 2009; Göçer, 2013; Akçomak et al., 2016). Such that; Liu & Lin (2005) stated that trade openness has favorable and significant impacts on the export of semiconductors, information technology and communication equipment from high-tech industries in Taiwan. Performing a similar study over India, Fayaz & Kaur (2019) showed that trade openness affects high technology exports in the long run. In the causality analyzes they conducted in the later stages of their studies, they also mentioned the existence of a bidirectional causality relationship between trade openness and technological activities in economies. This result is somewhat consistent with Schumpeter's (1943) theory of creative destruction and Vernon (1966) and Romer's (1986) theories. Likewise, as mentioned above, the competitive conditions of the international market will drive companies operating in economies to engage in technological activities.

On the other hand, in his panel data analysis using the high technology export data from 1980 to 2008 for 99 countries, Tebaldi (2011) obtained results similar to those of Liu & Lin (2005) and Fayaz & Kaur (2019). In the analysis, he stated that trade openness, together with human capital and foreign investments, is one of the most important elements positively affecting high technology exports. Kızılkaya, Ay & Sofuoğlu (2016) investigated the long-term impacts of trade openness on high-tech exports. Based on data from the BRICS countries from 2001 to 2011, they concluded that trade openness has a long-term positive influence on high-tech exports.

In addition to the studies on trade openness mentioned above, similar results were obtained in studies on advanced technology and indexes used to measure the quality of exports. Teng & Lo (2019), for example, in their study using the EXPY index developed by Hausman, Hwang & Rodrik (2007) to measure the development of exports, said that trade openness is an important factor in increasing export' sophistication. In a similar study, utilized the ECI index used to measure export complexity, Saadi (2020) stated that trade openness had significant and positive effects on export complexity in economies, using the 2002-2014 data of 81 developing countries.

Based on these findings, it is possible to conclude that trade openness and the size of trade in economies have technological returns and act as a driving factor in advanced technology exports by improving countries export quality.

Foreign direct investment (FDI) is another aspect that is regarded to have an impact on high technology. According to the theory, when foreign investments come to the country, they will improve production quality and performance by bringing new technologies and production methods with them, generating a driving force for exports (Seyoum, 2004, 2005; Srholec, 2007). Seyoum (2004), for example, investigated the determinants influencing the export of sophisticated technology using data from 60 countries from 1996 to 1998. As a result of his empirical research, he emphasized the importance of economies attracting foreign investment in export-oriented sectors for the export of sophisticated technology. Again, Seoum (2005) conducted a cross-section study for 55 countries using data from the year 2000 and showed that FDI had positive and statistically significant effects on high technology exports. Similarly to Seyoum

(2004, 2005), Montobbio & Rampa (2005) studied the high technology export statistics of 9 developing countries for the years 1988-1998 and emphasized the importance of FDI.

Zhang (2007) analyzed data from 87 countries from 1985 to 1998 and found that FDI per capita had a significant and increasing effect on high technology exports. However, in the same study, Zhang (2007) stated that although per capita FDI had a positive effect on high technology exports, total FDI on the other hand, had no significant impacts on high technology exports. Furthermore, Weldemicael (2012), who studied the EXPY index data of 120 countries from 1980 to 2000, emphasized the positive effects of FDI per capita on export' sophistication. Afterwards, similarly, Gökmen & Türen (2013) examined the effect of FDI per capita on high technology exports by using data from 1995 to 2010 for 15 EU countries and showed that the results were statistically significant and positive. These findings are similar to the result obtained by Zhang (2007) with the FDI per capita.

Hüseyni (2017) measured the export of high technology products with the EXPY index, which is used to determine the export' sophistication, and stated that FDI has a positive and significant effect on the development of exports in the long run. In his study, the researcher used data from the BRICS countries and Turkey through 1996 to 2012. However, Li (2019), similarly using EXPY index data of the BRICS countries, got the opposite of the result obtained in the study of Hüseyni (2017). Li (2019) used the data of the BRICS countries between 1990 and 2010 in his study and could not find any significant result that FDI affects export' sophistication. However, in the analysis, he observed that export' sophistication increased by 0.1% if foreign investments outgoing from BRICS countries grow by 1%.

In the study of Zu & Fu (2013), researchers examined the effect of FDI on the EXPY index and showed the existence of a statistically significant and positive effect as a result of the analysis. However, they stated that in some developing economies, foreign companies importing technology-intensive intermediate goods and exporting them after processing and simple assembly activities had a significant impact on the growth of exports. They argued that this situation did not create a sustainable growth but had only a short-term and temporary effects.

Yu & Hu (2015), on the other hand, focused on the effects of FDI on export' sophistication with China's data for 1995 to 2010 and as a result of his analyzes showed that FDI does not have any important role in increasing export' sophistication. In addition, Teng & Lo (2019) studied the EXPY index data of 62 developing countries covering the years 1995-2014 and examined the effects of FDI on export' complexity. According to their empirical research, they found no substantial influence of FDI on export' complexity. Gan & Cheng (2019), also researching on China, studied with the EXPY index data from 2000 to 2010 for 26 Chinese industry sectors. In the study, the researchers found that FDI had a negative effect for the specified sectors. In the later stages of the study, it has been shown that FDI is more effective on medium technology products.

As it can be understood from the studies mentioned above, although there are studies suggest that the effect of foreign direct investments (FDI) on the development of high technology and exports is meaningless or negative, the dominant view in the literature is that FDI has a positive effect on high technology exports.

Another aspect investigated in the literature in high technology studies is the presence of institutional quality. In various research, different variables were utilized to assess institutional quality.

For example, Zhu, Fu, Lai & Xuan (2009) employed rule of law index values as a measure of institutional quality in their analyses. Researchers using the EXPY index data of 65 countries in the study for the years 1992-2006 examined the effects of institutional quality on export' sophistication. Although the authors could not find a significant effect of institutional quality on export' sophistication as a result of empirical findings; In the later stages of the study, they stated that in economies with institutional quality, other factors that positively affect high-tech exports are more effective than economies with lower institutional quality. Cabral & Veiga (2010), on the other hand, obtained significant results in their analysis using EXPY index data for 48 Sub-Saharan African countries from 1960 to 2005, in contrast to Zhu, Fu, Lai, & Xuan (2009). Researchers measured the existence of institutional quality using indices such as rule of law, government effectiveness, government accountability, political stability, and control of corruption. As a result of the study, they showed that institutional quality has very important and positive effects on both export' sophistication and export' diversity. Vu (2021), on the other hand, used the voice and accountability index as well as other indexes used in the literature to measure institutional quality. Using the ECI index of 115 countries in his study, the researcher worked with data covering the years 2000-

2010. According to his empirical analyses, he stated that institutional quality is a very important factor for export' sophistication. However, he stated that for many developing countries where institutional quality is lower than developed countries, this situation will complicate their efforts to develop themselves technologically. Zu & Fu (2013) and Kočenda & Poghosyan (2018) similarly showed that institutional quality has significant and positive effects on export’ sophistication.

From this point of view, it is understood that the development of institutional quality has positive effects on the export of advanced technology and exports of high value-added products and export’ sophistication in economies.

Although the literature examining the effects of capital formation on high-tech exports is limited, it is examined because it is thought that capital formation can be effective in investments to produce high-tech products.

For this, Tebaldi (2011) examined the effects of gross capital formation on high technology exports and could not obtain a statistically significant result. Tebaldi (2011) used high technology export data of 99 countries covering the years 1980-2008 in his study. On the other hand, Kabaklarlı, Duran, Telli Üçler (2017) examined the effects of gross capital formation on high technology exports for 14 OECD countries. Using data from 1989 to 2015, the researchers determined that gross capital formation had a significant but negative effect for the 14 selected countries. Examining the effects of gross capital formation in Turkey on the ECI index, Şeker (2019) has shown that, unlike other studies, a 1% increase in gross capital formation in the long run will create an increase of 0.23% on Turkey's export development. In the literature, different results have been obtained on gross capital formation.

In this study, high technology export data of EU countries and Turkey covering the years 2007-2020, calculated from the newly created STIC Rev.4 product classification, will be used. The reason for using this variable in measuring high technology in the study is that it takes a direct approach to measuring high technology. Moreover, it has been widely used in the literature, and it has become more up to date than when it was first developed, with the deficiencies it contains gradually diminishing. Furthermore, it will be attempted to determine the factors influencing high technology exports by using variables mentioned in the literature or that have not yet been studied.

5. DATA AND MODEL

The neo-classical growth models that emerged in 1956, and then the endogenous growth models that started in 1986, stated that the technology factor is an important factor for the economy in order for growth to occur. Particular attention was drawn to this situation in R&D-based endogenous growth models, and they argued that growth could be increased by increasing technology through R&D and innovation studies.

Innovations resulting from R&D and innovation studies will add value to the economy through increased productivity in production and advanced technology exports. For this, it is inevitable that a competent human capital is needed. Of course, trade openness, which is an important factor in foreign trade, can be effective on high technology exports as well. In addition to these, the effects of other variables should be considered.

For this, 6 different models were established in this study. The established models used 10 different variables thought to affect high technology exports, with the aim of determining the degree of influence of these variables. The data used were obtained from OECD, World Bank and EUROSTAT databases. The established models will be mentioned in the study's subsequent sections.

5.1. Variables

The effects of different variables are discussed in studies on high technology exports. In this study, in addition to the variables frequently mentioned in the literature, the variables that have not yet been mentioned will be examined collectively with the established models and how and to what extent they affect high technology exports will be attempted to be explained using econometric panel data analysis.

5.1.1. High-tech exports

The World Bank's high technology export data will be used in this study. These statistics are based on the most recent high-tech products and product groups developed using the SITC Rev.4 product classification. The classification is an updated version of Hatzichronoglou's (1997) classification based on the SITC Rev.4 classification by EUROSTAT. The export statistics from the UN Comtrade database were used to calculate the export data of high-tech products obtained from the World Bank for European Union member countries and Turkey (World Bank, n.d.).

5.1.2. R&D expenditures

It is thought that R&D expenditures have a productivity-enhancing effect in economies (Mansfield, 1972; Pessoa, 2010) and play an active role in the emergence of products and production techniques (Godoe, 2000; Greve, 2003; Özçelik & Taymaz, 2004). Of course, it will not be surprising that these products and production methods, which have undergone R&D and innovation processes, also contain high technology. For this reason, in this study, since it is thought that R&D expenditures positively affect high technology exports, this variable is also included in the models. R&D expenditures are expected to have an increasing effect on high technology exports.

5.1.3. Openness to trade

To survive and increase their competitiveness in the face of the destructive effects of competition in international market conditions, companies that continue their commercial life in economies will be forced to invest in new products and production methods. Companies will increase R&D investments and accelerate innovation activities in this manner in order to differentiate themselves from competitors. As a result, new products or production methods that emerge as a result of these R&D and innovation investments will strengthen companies' positions in international competition (Schumpeter, 1943; Grupp, 1995; Vernon, 1966). For these reasons, it is thought that openness to trade has effects on high technology exports and this variable is also used in the models.

Although different methods have been used to measure trade openness in the literature (See. Squalli & Wilson, 2011; Fujii, 2019; Alcalá & Ciccone, 2004; Li, Morck, Yang, & Yeung, 2004), in this study, “trade” data calculated by using the share of import and export figures from the World Bank in GDP will be used in order to measure trade openness.

5.1.4. Gross domestic product (GDP)

GDP is a variable that has not been overlooked in the literature on high-tech exports. The effects of high technology exports on growth have been examined and it has been shown that the export of such value-added products has positive effects on the economy (Telatar, Değer & Doğanay, 2016; Alper, 2017). In this study, since it is thought that the increase in economic size may have an effect on high technology exports through the increase in resources that can be allocated to factors such as technology and innovation, this variable is also included. Increases in GDP are expected to positively affect high-tech exports.

5.1.5. Foreign direct investments (FDI)

Foreign direct investments create an environment for the emergence of new technological knowledge, products or production methods after the investing company brings its technological know-how to the country where it goes and the economy that receives the investment assimilates this new technological knowledge (Berthélemy & Démurger, 2000). This situation also provides an increase in productivity with the use of new technologies in the economy, which can contribute to the vitality of the economy (Bernard & Jensen 2004; Cooke & Watson, 2011; Madsen, 2009; Schumpeter, 1943, s. 75-78; Brahm, 1995, s. 71-72). FDI was also included in this study as a result of the reasons mentioned above. FDI is expected to have a positive impact on high technology exports.

5.1.6. Institutional quality

It has been stated in the literature that institutional quality has an effect on high technology exports, and various variables and indices have been used to measure institutional quality. The fact that institutional quality is above a certain level is an indicator of trust for companies that maintain their lives in the economy, and the formation of a stable environment both economically and socially brings this factor to our attention as an important issue (Zhu, Fu, Lai & Xuan, 2009; Cabral & Veiga, 2010; Vu, 2019).

The "regulatory quality index" was used in the study to provide a different perspective on the variables commonly used to measure institutional quality in the literature. This index was created to try to measure the extent to which governments' economic policies and the regulations they impose contribute to the development of the economy's private sector. The index has values ranging from -2.5 to +2.5, and as the values decrease, it is recognized that government policies and regulations cannot contribute to the development of the private sector. Kaufmann, Kraay, & Mastruzzi (2010) created this index, which is calculated for over 200 countries. High regulatory quality is thought to have a positive impact on high technology exports.

5.1.7. Human capital

The importance of human capital begins at the stage of development of high-tech products. Well-educated workforce has a great impact on such R&D and innovation studies from the idea stage to these studies. Furthermore, human capital will be useful in the later development processes of value-added products or knowledge. As a result, it is possible that the value-added products that emerge as a result of such studies will contain high technology, thereby increasing high technology exports, export quality, and export diversity in economies (Gökmen & Turen, 2013; Tebaldi, 2011; Vogiatzoglou, 2009; Yaşar, 2020; Göçer, 2013). Human capital, is included in this study for these reasons and therefore, is expected to have a positive impact on high-tech exports.

In order to measure human capital, the share of the highly educated workforce in the total workforce in the economies is taken into account. In the aforementioned higher education classification, in accordance with the International Standard Classification of Education (ISCED), undergraduate, graduate and doctorate degrees and education levels equivalent to these degrees are taken into account (UNESCO Institute for Statistics, 2012).

5.1.8. Military expenditures

Countries have given importance to military structures in terms of their own security and military weapons have taken an important place in this structure. Although this international arms race was tried to be kept under control with some international arms treaties, the effort to establish technological superiority over military equipment continued without slowing down. It has started to be seen as a necessity to have technologically superior military equipment in terms of deterrence, and for this reason, governments have started to allocate resources to military research. The information obtained as a result of these researches strengthened the technological knowledge and technological infrastructure of the countries, and later on, the civil sectors also benefited from this knowledge (See. Brooks, 1975; Dunne & Watson, 2005; Mowery, 2010; Broude, Deger, & Sen, 2013; Steinbock, 2014; Trebat & De Medeiros, 2014).

For these reasons, considering that military expenditures affect new innovation studies at some point and increase the technological knowledge in the countries, it is predicted that it may also be effective on high technology exports, and this variable is also included in the models established in the study. Military expenditures is expected to have positive effects on high technology exports.

5.1.9. Business freedom

In the literature, the relationship between innovation studies and the concept of freedom in economies has been the subject of examination. The effects of economic freedoms on innovation studies in national economies were discussed and it was said that freedoms had an impact on innovations (Zhu & Zhu, 2017; Lehmann & Seitz, 2017; Díaz-Casero, Díaz-Aunión, Sánchez-Escobedo, Coduras, & Hernández-Mogollón, 2012).

The emergence of new companies in the economies and the innovation studies and R&D investments of these new companies may increase the technological capacity of the countries and lead to an increasing effect on high technology exports in foreign trade. Therefore, easy integration of the newly established companies into the market, minimizing the bureaucratic obstacles in the establishment phase, and providing support from the governments to these newly established companies may attract investors.

Such that; The Heritage Foundation has created the business freedom index to measure the effectiveness of the regulations made by governments in terms of starting, maintaining and closing businesses, as well as the convenience they provide to businesses. This index, which is one of the indicators of economic freedom, takes a value between 0 and 100, and as the value increases, it becomes an indicator of the existence of a freer environment in economies (Heritage Foundation, 2022).

As a result, in an economy, the convenience and freedom provided to investors in establishing companies and businesses can increase the number of companies to be established and pave the way for innovation studies and R&D investments to be made by these companies at some point. Such a situation may have an increasing effect on high technology exports in economies. For these reasons, we also used this variable in the models established, considering that the Business freedom index may positively affects high technology exports.

5.1.10. Gross capital formation (GCF)

It is known that GCF strengthens the innovation and technology infrastructure in the national economies and can be a driving force for the innovation studies and R&D investments of the companies that live in the economy (Massell, 1960; De Marchi & Rocchi, 2005; Satrovic, Muslija, Abul, Gligoric, & Dalwai, 2021).

GCF is thought to have an increasing effect on high technology exports, as it can increase companies' innovation efforts and strengthen the technological infrastructure in national economies. Thus, it has been included in econometric analyzes in this study and is expected to have an increasing effect on high technology exports.

5.1.11. Energy dependency

While energy efficiency has effects on the economic performance of national economies (Sevencan, 2018), the existence of a relationship between energy efficiency and technological development is also discussed (Fisher-Vanden, Jefferson, Jingkui, & Jianyi, 2006).

In addition to these, it is thought that energy dependence affects the economic performance of some economies. So that; Since energy can be an important input for manufacturing industries in economies, in this study, we will examine the possible effects of energy dependence on high technology exports and other variables. The increase in foreign dependency on energy is expected to affect high technology exports negatively.

Finally, detailed information about the variables used in Table 5.1.1 and the abbreviations to be used for the variables in the next steps can be examined.

Table 5.1.1. *Variable definitions and data sources*

Variables	Definitions	Sources
HTEX	High-technology exports (current US$)	World Bank (World Development Indicators)
HTEXM	High-Technology export (% of manufactured export)	World Bank (World Development Indicators)
RND	GDP (current US$)*Research and development expenditure (% of GDP) / 100	OECD Database (for R&D expenditure) & World Bank (World Development Indicators)
TRAOP	Trade (% of GDP)	World Bank (World Development Indicators)
GDP	Gross Domestic Product (current US$)	World Bank (World Development Indicators)
FDI	Foreign direct investment, net inflows (BoP, current US$)	World Bank (World Development Indicators)
REGQ	Regulatory Quality Index: Estimate	World Bank (Worldwide Governance Indicators)
EDULAB	Labor force with advanced education (% of total working-age population with advanced education)	World Bank (World Development Indicators)
MILEXP	Military expenditure (current US$)	World Bank (World Development Indicators)

Table 5.1.2. *(cont.) Variable definitions and data sources*

BUSFREE	**Business Freedom Index**	**Heritage Foundation**
GCF	Gross capital formation (current US$)	World Bank (World Development Indicators)
ENRGY	Energy dependence	EUROSTAT

5.2. Models

Different models were established in this study to determine the factors affecting the high technology exports. We paid attention to how the variables used in the models interact with each other. The relevant models are given below. The model number will be used in the following steps when mentioning the models.

- **Model$_1$:** $\text{HTEX}_{ti} = \alpha_{ti} + \beta_{1ti}\,\text{RND}_{ti} + \beta_{2ti}\,\text{TRAOP}_{ti} + \beta_{3ti}\,\text{EDULAB}_{ti} + \beta_{4ti}\,\text{REGQ}_{ti} + \beta_{5ti}\,\text{FDI}_{ti}$
- **Model$_2$:** $\text{HTEX}_{ti} = \alpha_{ti} + \beta_{1ti}\,\text{TRAOP}_{ti} + \beta_{2ti}\,\text{EDULAB}_{ti} + \beta_{3ti}\,\text{MILEXP}_{ti} + \beta_{4ti}\,\text{BUSFREE}_{ti} + \beta_{5ti}\,\text{FDI}_{ti}$
- **Model$_3$:** $\text{HTEX}_{ti} = \alpha_{ti} + \beta_{1ti}\,\text{GDP}_{ti} + \beta_{2ti}\,\text{TRAOP}_{ti} + \beta_{3ti}\,\text{GCF}_{ti} + \beta_{4ti}\,\text{REGQ}_{ti} + \beta_{5ti}\,\text{FDI}_{ti}$
- **Model$_4$:** $\text{HTEXM}_{ti} = \alpha_{ti} + \beta_{1ti}\,\text{ENRGY}_{ti} + \beta_{2ti}\,\text{REGQ}_{ti} + \beta_{3ti}\,\text{FDI}_{ti}$
- **Model$_5$:** $\text{HTEX}_{ti} = \alpha_{ti} + \beta_{1ti}\,\text{TRAOP}_{ti} + \beta_{2ti}\,\text{REGQ}_{ti} + \beta_{3ti}\,\text{FDI}_{ti} + \beta_{4ti}\,\text{MILEXP}_{ti}$
- **Model$_6$:** $\text{HTEX}_{ti} = \alpha_{ti} + \beta_{1ti}\,\text{RND}_{ti} + \beta_{2ti}\,\text{EDULAB}_{ti}$

6. EMPIRICAL ANALYSIS

The aim of this study is to determine the factors that influence high-tech exports in EU member countries and Turkey, as well as the degree of impact of these factors, using data from 2007 to 2020. For this purpose, panel data analyses will be performed with the models developed using the previously mentioned variables, and the tests and results will be shared and interpreted in this section.

For the variables to be used in the study, 14-year data from 29 countries were compiled. The number of countries will be referred to as N values and the time interval as T values in the following stages. The tests will be applied in the study using the Stata16 package program.

The analysis will be made by taking into account the situations such as the N values to be used are more than the T values and there are missing data in the panels for some variables; that is, there is an unbalanced data set for some variables in some models. So that; Due to the high N values, it was decided to conduct a short-term panel OLS analysis at the first stage. Since the tests will be continued under the assumption of homogeneity, it is planned to use the fixed effects model in the tests to be performed in order to collect possible heterogeneity (Eberhardt, 2011).

6.1. Stationarity Tests

To avoid spurious correlation problems in the analyses and provide the stationarity condition for the OLS analysis, the stationary states of the variables should be used in the tests to be made. For this reason, it is necessary to measure the stationarity of the variables by applying unit root tests. Since there are quite a few unit root tests developed for this purpose in the literature, first of all, a cross-section dependency test will be performed in order to determine the most appropriate unit root test for the models established in the study (Eberhardt, 2011; Yerdelen Tatoğlu, 2020). To test the cross-section dependency in the series, the CD test developed by Pesaran (2004) was applied with the help of the Stata16 package program, and the results are shared in Table 6.1.1 given below. This test is also suitable for the data set to be used, as it can be applied to unbalanced panels.

Table 6.1.1. *Cross-section dependency and 2nd generation panel unit root test results*

Variables	**Pesaran CD Test (xtcdf)**	**CADF Test (Level, Trend, Lag:1) (pescadf)**	**CADF Test (Level, No Trend, Lag:1) (pescadf)**	**CADF Test (1st Difference, No trend Lag:0) (pescadf)**
HTEX	(0.000)	(0.927)	(0.903)	(0.000)
HTEXM	(0.002)	(0.984)	(0.590)	(0.000)
RND	(0.000)	(1.000)	(0.998)	(0.000)
TRAOP	(0.000)	(1.000)	(0.895)	(0.040)
GDP	(0.000)	(1.000)	(1.000)	(0.000)
FDI	(0.000)	(0.001)	(0.000)	(0.000)
REGQ	(0.112)	(0.844)	(0.282)	(0.000)
EDULAB	(0.000)	(0.548)	(0.015)	(0.000)
MILEXP	(0.000)	(0.888)	(0.976)	(0.000)
BUSFREE	(0.000)	(0.987)	(0.139)	(0.000)
GCF	(0.000)	(0.366)	(0.000)	(0.000)
ENRGY	(0.003)	(0.914)	(0.998)	(0.000)

Note: The results are the “prob>F” values of the tests.

Based on the incoming analysis results, cross-sectional dependence was detected in all variables except for the REGQ variable. In this case, the unit root test to be performed in order to determine the stationarity should be resistant to cross-section dependence. Thus, the necessity of applying to the 2nd generation unit root tests has arisen instead of the 1st generation unit root tests (Yerdelen Tatoğlu, 2020; Hurlin & Mignon, 2007).

1st generation unit root tests do not consider the cross-sectional dependencies in the series in terms of their characteristics. However, the assumption that there is no correlation between units creates a very restrictive situation. Later, although the 1st generation tests were expanded and eliminated the cross-section dependence to some extent, they were still insufficient in some cases. Moreover, they were not widely accepted in the literature, and their usage areas remained quite limited. For these reasons, 2nd generation unit root tests have emerged (Moon & Perron, 2004; Bai & Ng, 2004, 2010; Hadri & Kurozumi, 2012; Pesaran, 2007), and resistant tests that took consideration the cross-section dependencies have begun to be developed (Yerdelen Tatoğlu, 2020 p. 67-107; Hurlin & Mignon, 2007).

In this study, the "CADF" test developed by Pesaran (2007), which considers the cross-sectional dependence, was used. This test can be applied in the unbalanced panel series used in the study.

In the first stage, considering that there may be an autocorrelation problem in the series, the lag value was determined as "1," and tests were carried out for both the cases with and without the trend. When the results in Table 6.1.1 given above are examined, it is understood that other variables, except FDI, are not stationary in the level, that is, they have unit-roots.

In the next step, the stationarity of the variables at the first difference was examined. Furthermore, the lag value was chosen as "0", considering that the possible autocorrelation was eliminated at the first difference. The results show that all variables are stationary at the first difference. After this stage, it is recommended to continue the panel OLS analysis by taking the first difference of the variables due to the structure of the longitudinal data set used in the study (Eberhardt, 2011). However, in this study, if there are some possible long-term relationships in the series, cointegration analyzes were also performed in order to detect them.

6.2. Cointegration Analysis

In studies, cointegration analyses can be performed when the series used are not stationary in level. Cointegration analyses look at the series combinations and determine whether this combination results in a stationary process. The fact that the series are cointegrated, that is, their combination creates a stationary process, shows the existence of a long-term relationship between these series (Yerdelen Tatoğlu, 2020, p. 190-208; Hsiao, 2014, p. 394-397; Woolridge, 2018, p. 616-620).

There are tests used for cointegration analysis that considers cross-sectional dependence, as in unit-root tests. In addition, these tests differ from each other according to whether the series is homogeneous or heterogeneous. For this reason, in order to determine the suitability of the cointegration test to be used with the data set to be used, first of all, it should be checked whether there is a cross-section dependency in the series. However, heterogeneity or homogeneity of the panels is also essential for selecting the test. The results of the Pesaran (2004) test performed previously and given in Table 6.1.1 showed a cross-section dependency in the series. Whether the panels are homogeneous or heterogeneous will be decided by looking at the results of Swamy's (1970) S test and Pesaran & Yamagata's (2008) homogeneity test. Homogeneity test results are given in Table 6.2.1.

Table 6.2.1. *Homogeneity and panel cointegration tests*

	Homogeneity Tests		**Panel Cointegration Test**
	Swamy (1970) S Test (prob>chi2) -xtrc-	Pesaran & Yamagata (2008) Test (adj. p-value) -xthst-	Gengenbach, Urbain & Westerlund (2016) Test (p-value) -xtcaec-
indep. Variables		**dep. var. HTEX**	
RND	0.0000	0.028	>0.1
TRAOP	0.0000	0.0000	>0.1
GDP	0.0000	0.0000	<=0.01
FDI	0.0038	0.939	>0.1
REGQ	0.0003	0.753	>0.1
EDULAB	0.0044	0.395	>0.1
MILEXP	0.0000	0.0000	>0.1
BUSFREE	0.0022	0.354	>0.1
GCF	0.0000	0.011	>0.1
		dep. var. HTEXM	
ENRGY	0.1857	0.959	>0.1
REGQ	0.0349	0.375	>0.1
FDI	0.9997	0.171	<=0.05

Due to the homogeneity tests performed, it is understood that there is heterogeneity for most variables in the panels. Based on these results, it was decided to use the panel cointegration test developed by Gengenbach, Urbain & Westerlund (2016). This test can be applied for heterogeneous panels with cross-section dependence, as well as allowing to work with unstable panels.

According to the cointegration analysis results given in Table 6.2.1 above, it was seen that only HTEX dependent variable acted cointegrated with GDP, and HTEXM dependent variable acted cointegrating with FDI. However, since no cointegration was found in all other variables, long-term analyzes were not performed.

After the cointegration analysis, the first differences of the variables were taken with the help of the Stata16 package program, and the analyzes were continued in this way.

6.3. Multicollinearity

The fact that there is a linear relationship between the variables used in econometric analyses, especially in regression models, may cause biased estimation results to be produced in the analyses. Although it is thought that this problem will not pose a significant problem in panel data models due to the high number of observations, it was beneficial to control this situation before the analyses were made (Yerdelen Yerdelen Tatoğlu, 2021).

"Variance Inflation Factors (VIF)" will be used to determine the multicollinearity problem between the variables. If the results in this method are less than the critical value of 5, it is concluded that there is no multicollinearity in the tested model. Values from 5 to 10 are moderate; Values of 10 and above indicate the existence of a high degree of multicollinearity, and the problem should be resolved (Yerdelen Tatoğlu, 2021; Alin, 2010).

The average VIF results (mean values) of the established models are given in the analysis results given in Table 6.3.1 below. "Min" and "Max" values are the lowest VIF and highest VIF values from the variables used in the models.

Table 6.3.1. *Variance inflation factors (VIF) test results*

MODELS	VIF TEST (MEAN)	VIF TEST (MAX)	VIF TEST (MIN)
Model 1	1.01	1.02	1.00
Model 2	1.02	1.04	1.01
Model 3	2.39	4.51	1.01
Model 4	1.01	1.01	1.00
Model 5	1.01	1.01	1.00
Model 6	1.00	1.00	1.00

When the results were examined, it was understood that there was no multicollinearity problem in the established models, and the tests were continued without any changes.

6.4. Determination of the Efficient Estimation Model

In order to determine the effective estimator models to be used in the analysis, simply; In the absence of unit and/or time effects, it can be said that the use of the classical model is more appropriate, whereas, in the presence of unit and/or time effects, the use of fixed or random-effects model is more appropriate (Yerdelen Tatoğlu, 2021, p. 176-209; Wooldridge, 2018, p. 426-483).

Although it has been decided that the fixed effect model is more appropriate for the analysis due to the reasons arising from the structure of the longitudinal panel data set used in this study, the results of other estimator models will also be included. In addition, the use of the fixed-effect model may be more effective in collecting possible heterogeneity for tests performed under the homogeneous assumption (Eberhardt, 2011, p. 7).

In addition to these, with the help of tests created to determine the effective estimator model, whether there are unit and time effects in the models can be examined. In this study, "F," "Likelihood Ratio," "Hausman," and "Resistance Hausman" tests, which are frequently used in the literature and mentioned below, will be used to determine which estimator method is more suitable for the established models.

- **F test:** It was proposed by Moulton & Randolf (1989) to test the effectiveness of the fixed effects model against the classical (pooled) model and has been a widely used method in the literature (Yerdelen Tatoğlu, 2021, p.176-209; Baltagi, 2021, p. 85-102).

- **Likelihood test:** The likelihood test is used to test the effectiveness of the random effects model against the classical (pooled) model. Both the "F test" and "Likelihood test" detect whether there are unit and/or time effects on the models (Yerdelen Tatoğlu, 2021, p.176-209; Baltagi, 2021, p. 85-102).
- **Hausman test:** In cases where the classical model is not effective, the next step is to choose between fixed effect and random effect models. At this point, the specification test developed by Hausman (1978) can be used. This test can measure whether the random effect model is more effective than the fixed effect model (Yerdelen Tatoğlu, 2021, p.176-209; Baltagi, 2021, p. 85-102).
- **Robust Hausman test:** In some cases, deviations from the assumption, such as heteroskedasticity and/or autocorrelation, impair efficiency in the tested models. In this case, using the version of the Hausman test that uses variances resistant to deviations from the assumption, such as these, may yield more accurate results (Yerdelen Tatoğlu, 2021, p.176-209).

The test performed for the established models and the results of these tests are given in Table 6.4.1 below.

Table 6.4.1. *Tests for the determining the efficient model.*

MODELS	F Test (Prob>F)	Likelyhood Test (Prob>chi2)	Hausman Test (Prob>chi2)	Robust Hauman Test (Prob>chi2)	Efficient Model
Model 1	(.532)	(0.2913)	NA	NA	Pooled Effect
Model 2	(.034)	(0.0116)	(0.8824)	(0.8921)	Random Effect
Model 3	(.963)	(0.9609)	NA	NA	Pooled Effect
Model 4	(.273)	(0.9455)	NA	NA	Pooled Effect
Model 5	(.026)	(0.0065)	(0.8329)	(0.7683)	Random Effect
Model 6	(.226)	(0.0036)	(0.6949	(0.0908)	Random Effect

Since the "F" and "Likelihood" tests in Model 1, Model 3, and Model 4 showed that the classical model was more effective than the random and fixed effects models, the "Hausman" tests were not applied to determine which of the random and fixed effects were effective in these models. For Model 2 and Model 5, it was observed that both fixed effects and random effects models were more suitable than the classical model, and then “Hausman” and “Robust Hausman” tests were conducted to choose between fixed and random effects models. Although the classical model was more effective than the fixed effects model according to the "F" test results in Model 6, it was observed that the random-effects model was more effective than the classical model in the "Likelihood" test results. Although random effects seem to be more effective for Model 6, "Hausman" and "Robust Hausman" tests were applied in order not to ignore possible heteroskedasticity or autocorrelation in the series, and the result was that random effects were more effective as expected.

6.5. Detection of Heteroscedasticity and Autocorrelation in Panels

When working with panel data models, it is assumed that there is no heteroscedasticity and autocorrelation in the panels. That is, the studied series should be homoscedastic, and there should be no periodic correlations. However, these situations create a restrictive effect similar to the assumption that there is no cross-section dependency in the series. For these reasons, researchers have developed new analysis methods and created resistant estimators according to the presence of heteroscedasticity and/or autocorrelation in the analyzes to be made (Yerdelen Tatoğlu, 2021, p. 227-273; Greene, 2020, p. 337-364, 462-467; Gujarati & Porter, 2009, p. 365-453).

In addition to these, many tests have been developed to detect heteroscedasticity and autocorrelation in panels. These tests vary according to the effective model to be used and whether which of the balanced or unbalanced series are being studied. Different tests will be applied to detect deviations from such assumptions in this study. The tests that will be used to detect heteroscedasticity are given below.

- **Wald Test:** This test is one of the tests that can be applied to detect heteroscedasticity in classical models (Yerdelen Tatoğlu, 2021). For this reason, it was decided to use the Wald test for classical models in this study.
- **Modified Wald Test:** It is the adapted version of the Wald test to detect heteroscedasticity by units (Yerdelen Tatoğlu, 2021; Greene, 2020). It will be used in this study as it is a suitable test for detecting heteroscedasticity in fixed-effects models.
- **Levene, Brown & Forsythe Test:** Brown & Forsythe (1974) developed a more advanced and more up-to-date test over the heteroscedasticity test developed by

Levene (1960) (Yerdelen Tatoğlu, 2021). This test can be used for random-effects models.

To determine the autocorrelation situation that may be encountered in the series, different tests will be used, as in heteroscedasticity. These tests are given below.

- **Bhargava, Franzini, & Narendranathan Test and Baltagi & Wu Test:** Bhargava, Franzini, & Narendranathan (1982) developed a test based on Durbin-Watson statistics to test autocorrelation in the fixed-effects model. Baltagi & Wu (1999), on the other hand, updated Bhargava, Franzini & Narendranathan's test a little more to make it work on unbalanced panels. This test can also be used for random-effects models (Yerdelen Tatoğlu, 2021; StataCorp, n.d.).
- **Woolridge Test:** The test developed by Wooldridge (2002) can be used in classical models for the detection of autocorrelation. Nonetheless, this test can also give unbiased results when working with small samples (Yerdelen Tatoğlu, 2021; Wiggins & Brian, n.d.).

Autocorrelation and Heteroscedasticity tests and their results are given in Table 6.5.1 below.

Table 6.5.1. *Test results for heteroscedasticity and autocorrelation*

	Heteroskedasticity			**Autocorrelation**		
	Fixed Effect	Random Effect	Pooled Effect	Fixed Effect	Random Effect	Pooled Effect
MODELS	Modified Wald Test (Prob>chi2)	Levene, Brown & Forshyte Test (Prob>F)	Wald Test (P-value>chi2)	Bhargava, Franzini, & Narendranathan/Baltagi & Wu Test	Bhargava, Franzini, & Narendranathan/Baltagi & Wu Test	Wooldridge Test (Prob>F)
Model 1 (Pooled)	(0.0000)	(0.0000)	(0.0000)	(1.9309339) (2.243161)	(1.9309339) (2.243161)	(0.3624)
Model 2 (Random)	(0.0000)	(0.0000)	(0.0000)	(2.3923135) (2.4408384)	(2.3923135) (2.4408384)	(0.2345)
Model 3 (Pooled)	(0.0000)	(0.0000)	(0.0161)	(1.7446293) (2.1039458)	(1.7446293) (2.1039458)	(0.8606)
Model 4 (Pooled)	(0.0000)	(0.0000)	(0.0069)	(1.7415206) (1.8584248)	(1.7415206) (1.8584248)	(0.0314)
Model 5 (Random)	(0.0000)	(0.0000)	(0.0001)	(2.3538947) (2.4046758)	(2.3538947) (2.4046758)	(0.3607)
Model 6 (Random)	(0.0000)	(0.0000)	(0.0000)	(1.938498) (2.2590737)	(1.938498) (2.2590737)	(0.4843)

When the probability and critical values from the analyses shown in Table 6.5.1 above are considered, it is clear that the models have heteroscedasticity. However, autocorrelation was found only in model 4 and no autocorrelation was found for other models.

6.6. Driscoll-Kraay Standard Error Estimator Results

Driscoll & Kraay's (1998) standard errors are robust to the existence of heteroskedasticity and autocorrelation problems with general forms of cross-sectional dependence. This estimator also produces consistent results when N is large, and T is small, and it can be utilized in both balanced and unbalanced panel settings. Furthermore, the estimator, which can be used for fixed and random effects models as well as the classical model, can also capable of handling missing values.

Since there is heteroscedasticity and cross-sectional dependency in the established models and the N values in the data set to be used are higher than the T values, it was decided to employ the Driscoll-Kraay standard errors estimator in the analyzes. This estimator is also suitable for our unbalanced dataset.

In the first stage, the Driscoll-Kraay pooled effect model estimator was applied for all models, and the analysis results are given in Table 6.6.1 below.

Table 6.6.1. *Driscoll-Kraay pooled effect estimation results*

VARIABLES	Model 1 ΔHTEX	Model 2 ΔHTEX	Model 3 ΔHTEX	Model 4 ΔHTEXM	Model 5 ΔHTEX	Model 6 ΔHTEX
ΔTRAOP	7.03e+07***	7.40e+07***	3.58e+07**		7.24e+07***	
	(7007706)	(1.45e+07)	(1.32e+07)		(1.46e+07)	
ΔFDI	.0036596	.0046276	.001906	7.30e-13	.0039403	
	(.0066434)	(.006687)	(.0051952)	(1.76e-12)	(.0065648)	
ΔEDULAB	2.48e+08***	3.88e+08***				3.24e+08***
	(7.33e+07)	(1.25e+08)				(1.05e+08)
ΔREGQ	5.26e+09**		4.19e+09**	3.121818***	4.12e+09**	
	(2.03e+09)		(1.42e+09)	(.8119543)	(1.70e+09)	
ΔRND	1.140471***					1.152321***
	(.2216874)					(.2316893)
ΔMILEXP		1.057758***			1.090342***	
		(.1748373)			(.1734852)	
ΔBUSFREE		1.34e+08***				
		(3.36e+07)				
ΔGDP			.0150626**			
			(.0049784)			
ΔGCF			.0529708**			
			(.0228232)			
ΔENRGY				-.037111**		
				(.0136428)		
_CONS	-1.60e+07	4.00e+08*	2.32e+08	.0119719	3.34e+08	3328894
	(1.68e+08)	(2.04e+08)	(2.28e+08)	(.0980159)	(2.14e+08)	(2.50e+08)
Obs.	376	348	377	376	348	376
Countries	29	29	29	29	29	29
F	27.13	22.24	37.68	14.17	45.84	17.12
Prob > F	0.0000	0.0000	0.0000	0.0003	0.0000	0.0003
R-squared	0.2845	0.1739	0.3675	0.0311	0.1719	0.2498
Max Lag	2	2	2	2	2	2
Root MSE	3.8e+09	3.7e+09	3.7e+09	1.9406	3.7e+09	3.9e+09

Note: The values in parentheses are the "Standard error" values obtained. The signs ***, **, * at the end of the values represent 1%, 5% and 10% significance levels, respectively.

Afterward, analyzes were made for random effects models and shown in table 6.6.2.

Table 6.6.2. *Driscoll-Kraay random effect estimation results*

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
VARIABLES	ΔHTEX	ΔHTEX	ΔHTEX	ΔHTEXM	ΔHTEX	ΔHTEX
ΔTRAOP	7.03e+07***	7.40e+07***	3.58e+07**		7.24e+07***	
	(7007706)	(1.45e+07)	(1.32e+07)		(1.46e+07)	
ΔFDI	.0036596	.0046276	.001906	7.17e-13	.0039403	
	(.0066434)	(.006687)	(.0051952)	(1.76e-12)	(.0065648)	
ΔEDULAB	2.48e+08***	3.88e+08***				3.24e+08***
	(7.33e+07)	(1.25e+08)				(1.05e+08)
ΔREGQ	5.26e+09**		4.19e+09**	3.108214***	4.12e+09**	
	(2.03e+09)		(1.42e+09)	(.7992777)	(1.70e+09)	
ΔRND	1.140471***					1.152321***
	(.2216874)					(.2316893)
ΔMILEXP		1.057758***			1.090342***	
		(.1748373)			(.1734852)	
ΔBUSFREE		1.34e+08***				
		(3.36e+07)				
ΔGDP			.0150626**			
			(.0049784)			
ΔGCF			.0529708			
			(.0228232)			
ΔENRGY				-.0369483**		
				(.0139253)		
_CONS	-1.60e+07	4.00e+08*	2.32e+08**	.0119293	3.34e+08	3328894
	(1.68e+08)	(2.04e+08)	(2.28e+08)	(.1085384)	(2.14e+08)	(2.50e+08)
Obs.	376	348	377	376	348	376
Countries	29	29	29	29	29	29
Wald chi2	135.66	111.21	188.41	43.90	183.36	34.24
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.2845	0.1739	0.3675	0.0311	0.1719	0.2498
Max Lag	2	2	2	2	2	2

Note: The values in parentheses are the "Standard error" values obtained. The signs ***, **, * at the end of the values represent 1%, 5% and 10% significance levels, respectively.

Finally, analyzes were made for fixed-effects models, and the results obtained in Table 6.6.3 are shared.

Table 6.6.3. *Driscoll-Kraay fixed effect estimation results*

VARIABLES	Model 1 ΔHTEX	Model 2 ΔHTEX	Model 3 ΔHTEX	Model 4 ΔHTEXM	Model 5 ΔHTEX	Model 6 ΔHTEX
ΔTRAOP	6.74e+07***	7.79e+07***	3.44e+07**		7.61e+07***	
	(7127018)	(1.35e+07)	(1.29e+07)		(1.43e+07)	
ΔFDI	.0038759	.0051322	.0019693	6.54e-13	.0043774	
	(.0067057)	(.0070248)	(.0052684)	(1.73e-12)	(.0068703)	
ΔEDULAB	2.87e+08***	4.34e+08***				3.58e+08**
	(8.51e+07)	(9.33e+07)				(1.20e+08)
ΔREGQ	5.48e+09**		4.43e+09**	3.044099***	3.95e+09*	
	(2.17e+09)		(1.73e+09)	(.7437086)	(1.83e+09)	
ΔRND	1.204266***					1.21869***
	(.2161786)					(.2313515)
ΔMILEXP		1.09438***			1.125748***	
		(.1933398)			(.1910641)	
ΔBUSFREE		1.34e+08***				
		(2.95e+07)				
ΔGDP			.0140067**			
			(.0053067)			
ΔGCF			.0573461**			
			(.0244402)			
ΔENRGY				-.0361497**		
				(.0160184)		
_CONS	-2.03e+07	4.02e+08*	2.40e+08	.0109849	3.30e+08	-7992635
	(1.90e+08)	(1.91e+08)	(2.41e+08)	(.1008086)	(2.04e+08)	(2.68e+08)
Obs.	376	348	377	376	348	376
Countries	29	29	29	29	29	29
F	34.86	34.72	42.91	19.55	29.46	15.68
Prob > F	0.0000	0.0000	0.0000	0.0001	0.0000	0.0004
R-squared	0.2960	0.1839	0.3742	0.0307	0.1804	0.2618
Max Lag	2	2	2	2	2	2

Note: The values in parentheses are the "Standard error" values obtained. The signs ***, **, * at the end of the values represent 1%, 5% and 10% significance levels, respectively.

When the results of analyses that given above of random and pooled effects, it can be seen that the estimation results were almost identical. The results of the fixed effects estimates, on the other hand, are very similar to the other two. Subsequent interpretations will be made by considering the fixed-effect model results.

As a result of the analyzes from Model 1 and Model 6, it can be understood that R&D investments are the most important driving force of high technology exports. So that; According to the results of the fixed-effects model analysis, it can be seen that a 1% increase in R&D expenditures will create a 1.2% increase in high technology exports. In this respect, this finding is similar to the studies of Göçer (2013) and Sandu & Ciaconel (2014).

On the other hand, military expenditures are a critical factor for high technology exports. Based on the results from Model 2 and Model 5, it can be understood that a 1% increase in military expenditures will create an increase of approximately 1.10%.

Therewithal, it can be observed that the trade openness of the economy (Models 1,2,3, and 5) and the existence of institutional quality (Models 1,3,4,5) increase high technology exports in these countries. For example, for Model 1, a 1% increase in trade openness increases high technology exports in economies by 6.74 units, while a 1-point increase in institutional quality creates an increase of 5.48 units.

It has been shown by previous studies that another critical factor in high technology exports is human capital and that human capital is also a necessary factor for R&D and innovation studies (See. Gökmen & Turen, 2013; Tebaldi, 2011; Vogiatzoglou, 2009). Similarly, in this study, it is understood from the results that human capital has an increasing effect on high technology exports. Such that; In the case that the share of well-educated personnel in the workforce used to measure human capital in Model 2 increases by 1%, high technology exports show an increase of 4.34 units.

It has been determined that the business freedom index, which measures how easily it is possible to start, maintain and close a business in economies along with the conveniences and regulations provided by the governments to the investors, who will establish new companies and businesses, also have effects on high technology export. Model 2 shows that a 1-point increase in the business freedom index creates a 1.34-unit increase in high technology exports.

When the results from Model 2 are examined, it can be seen that there are statistically significant and positive effects of GDP and GCF on high technology exports. However, these effects are insignificant for selected countries.

Similarly, although it is understood from the Model 4 results that energy dependency has statistically significant effects on high technology exports and that these effects are negative as expected, these effects do not have a substantial effect on the sample of EU countries and Turkey. On the other hand, 1 point increase in energy dependency creates a decrease of 0.036% in high technology exports.

Finally, although the possible effects of FDI on high technology exports were also tried to be examined in the models, no statistically significant effect of FDI on high technology exports was found in the established models. The financial crisis, which started in the USA in 2008 and then left devastating effects in the European Union countries (See. Terazi & Şenel, 2011; Rohrschneider & Whitefield, 2016; Yurtsever, 2011); then the minor debt crises in some European countries in 2018 (See. Hausken & Welburn, 2020; Golab, Jie, Powell, & Zamojska, 2018; Diamantopoulou & Pierrakakis, 2019; Katsanidou & Lefkofridi, 2020); Later on, the closures experienced after the covid-19 pandemic that came in 2019 may have been effective the decrease in foreign investments entering the countries. Because when the data is examined, it can be observed with the help of Appendix-2, Appendix-3, and Appendix-4 in the Appendices that while the increases in high technology exports of European countries continued to occur in general also after 2008, foreign investments decreased. Moreover, this result is similar to the studies of (Zhang, 2007; Yu & Hu, 2015; Li, 2019; Teng & Lo, 2019) in this respect.

7. CONCLUSION AND REMARKS

As mentioned in the previous sections, exports of value-added products such as high-tech products have significant benefits for economies. In this respect, high technology exports both increase the competitiveness of the companies in the economies in international trade and contribute to the prevention of trade deficits by providing foreign exchange inflows to the economies. In addition, exports of such products also allow foreign exchange fluctuations in economies to move more stable. Based on all these effects, it can be stated that high technology exports play an essential role in achieving a healthy growth trend in economies.

In the growth theories developed by economists, the importance of technology and technological development has been stated, and the effects of these developing technologies on economic life, through both production capacity increases and the production of value-added products, have been studied. These studies also showed the difference in technological development between developed countries with strong technological infrastructure and developing countries, and accordingly, the differences in the export of value-added products to the detriment of developing countries. Thus, the importance of R&D and innovation investments in developing countries has increased, and how the quality of exports can be increased with value-added products has been the subject of examination.

With the increased importance placed on high-tech exports, the classification of such technology-intensive products has been widely debated, and theories and methods for measuring the development of exports and high-tech products in economies have begun to emerge.

In this study, it has been studied on which factors affect high technology exports in economies and how they affect. It is aimed to guide the decision-makers in the economy by examining the determinants of high technology exports through the sample created with the data obtained from the EU member states and Turkey. The data used includes the statistics of the countries mentioned between 2007 and 2020.

For this, high technology export data, created based on Hatzichronoglou's (1997) high-tech products classification updated by EUROSTAT according to SITC Rev.4 product classification, were used.

Econometric panel data analyzes were made with the data obtained from the data banks of international organizations such as the World Bank, OECD, EUROSTAT, Heritage Foundation. The effects of the independent variables used on high technology exports, which is the dependent variable, were examined. To test these effects, ten different independent variables were used in the study and six different models were established.

Before the panel OLS analysis, the stability levels of the variables were tested, and whether there was a possible long-term relationship between the variables was also tested. Afterward, the first differences of the variables were taken, and then the appropriate estimation model to be used in the established models was determined. In addition, the existence of deviations from the assumptions (heteroskedasticity, autocorrelation, cross-section dependence, and multicollinearity) in the series were examined and the appropriate estimator was determined according to the results. It was determined that the Driscoll-Kraay standard errors estimator was the most suitable estimator for the established models, and thus panel OLS analyzes were continued.

From the results obtained, it has been understood that R&D investments are one of the most critical factors in increasing high technology exports. It has been determined that military expenditures have an increasing impact on high technology exports, as in R&D investments. Moreover, it has been demonstrated that openness to trade, institutional quality, and human capital plays an active role in increasing high technology exports in economies. Further to that, it has been determined that the high business freedom in economies also has positive effects on high technology exports. GDP and GCF variables were also included in the analysis. The results show that, although a critical effect cannot be mentioned, these variables have a statistically significant positive effect on high technology exports. Similarly, although it is not very essential, it can be seen that the energy dependence of the countries has a statistically significant and negative effect on high technology exports. Finally, it has been shown that foreign investments are insufficient to explain high technology exports for the countries mentioned earlier and do not have a statistically significant effect.

Thus, the importance of R&D and innovation investments in economies is understood once again. Countries that are trying to increase their export quality and value-added product exports will have positive results if they make R&D investments, encourage such investments, and engage in subsidy activities. As stated in the previous sections, although it is observed that R&D investments have increased in recent years in developing countries, it is understood that these investments are still far below developed countries. In addition, attention should be paid to the existence of human capital, which is an essential element for factors such as R&D, innovation investments, and high technology exports. So, the presence of a well-educated workforce can create positive effects on economies both indirectly by accelerating R&D and innovation studies and directly by increasing high technology exports. On the other hand, the development of military technologies and the use of these technologies by the private sector can play an active role in increasing the quality of exports. In addition, the existence of a quality institutional structure in economies also has an impact on these studies. Accordingly, decision makers' policies towards creating a stable environment in economies and increasing institutional quality are supportive factors for companies' R&D and innovation activities, thus increasing the quality of exports made together with high technology exports. Similarly, the fact that governments provide business establishment facilities for investors and companies and make regulations accordingly affect exports by creating new companies. Another point to be considered is the openness of the economy. Companies that must compete in the international market will make new R&D and innovation investments in order to maintain their competitiveness and differentiate from their competitors. Export capacities will increase with the new products and production methods that will emerge as a result of these investments, while the quality of exports will increase with the export of high technology products.

8. CONTRIBUTIONS AND LIMITATIONS

The study used six different models and ten different variables to examine the factors affecting high technology exports. Some of these variables have previously been investigated in the literature, and others have been attempted to be introduced into the literature with this study. Military expenditures and energy dependency have been brought to the literature. In addition, to bring a different perspective to the literature, the existence of institutional quality was measured using the regulatory quality index variable, and the existence of economic freedoms was measured using the business freedom index variable. GDP and GCF variables, which have been mentioned in some studies before but have not been emphasized much, are also included in the models.

Realizing that the high-tech export data used in the literature are primarily based on the old SITC Rev.3 classification, data created using the SITC Rev.4 classification updated in 2006 were used in this study. In addition, EU member states and Turkey were selected as samples, and the analyses were made using these countries' 2007-2020 data.

While the study was continuing, some limiting situations were encountered. Since the data used is based on the SITC Rev.4 classification, the pre-2007 statistics of the countries are not available. For this reason, the observation range was limited between 2007 and 2020. Nevertheless, the lack of observation values for some variables in some countries caused the formation of unbalanced panels, and the analyzes made taking this situation into account, creating a restrictive effect. In addition, to collect possible heterogeneity due to the longitudinal panel structure of the studied panel data set, it has become necessary to stick to the results of the fixed-effects model.

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APPENDICES

APPENDIX-1. SITC Rev.3 High Technology Product List with Codes and Definitions *(Hatzichronoglou, 1997; UN Secretariat, 1986)*

SITC Rev.3 Codes			Definitions
			AEROSPACE
			7921+7922+7923+7924+7925+79291+79293+(714 -71489-71499)+87411
	7921		Helicopters
	7922		Aeroplanes and other aircraft, mechanically propelled (other than helicopters), of an unladen weight not exceeding 2000 kg
	7923		Aeroplanes and other aircraft, mechanically propelled (other than helicopters), of an unladen weight exceeding 2000 kg but not exceeding 15000 kg
	7924		Aeroplanes and other aircraft, mechanically propelled (other than helicopters), of an unladen weight exceeding 15000 kg
	7925		Spacecraft (including satellites) and spacecraft launch vehicles
		79291	Propellers and rotors and parts thereof
		79293	Under-carriages and parts thereof
714			Engines and motors, non-electric (other than those of groups 712, 713 and 718); parts, n.e.s., of these engines and motors
		(-71489)	Other gas turbines
		(-71499)	Parts for gas turbines of heading 714.89
		87411	Direction finding compasses; other navigational instruments and appliances
			COMPUTERS & OFFICE MACHINES
			75113+75131+75132+75134+(752-7529)+75997
		75113	Automatic typewriters; word-processing machines
		75131	Electrostatic photo-copying apparatus operating by reproducing the original image directly onto the copy (direct process)
		75132	Electrostatic photo-copying apparatus operating by reproducing the original image via an intermediate onto the copy (indirect process)
		75134	Non-electrostatic photocopying apparatus of the contact type
752			Automatic data-processing machines and units thereof; magnetic or optical readers, machines for transcribing data onto data media in coded form and machines for processing such data, n.e.s.
	(-7529)		Data-processing equipment, n.e.s.
		75997	Parts and accessories of group 752

APPENDIX-1. (cont.) SITC Rev.3 High Technology Product List with Codes and Definitions *(Hatzichronoglou, 1997; UN Secretariat, 1986)*

ELECTRONICS -TELECOMMUNICATIIONS

76381+76383+(764 - 76493 - 76499)+7722+77261+77318+77625+77627+7763+7764+7768+89879

		76381	Video-recording or reproducing apparatus, whether or not incorporating a video tuner
		76383	Other sound-reproducing apparatus
764			Telecommunications equipment, n.e.s., and parts, n.e.s., and accessories of apparatus falling within division 76
		(-76493)	……with the apparatus and equipment of groups 761 and 762 and subgroups 764.3 and 764.8
		(-76499)	……with the apparatus falling within group 763
	7722		Printed circuits
		77318	Optical fibre cables
		77625	Microwave tubes (excluding grid-controlled tubes)
		77627	Other valves and tubes
	7763		Diodes, transistors, and similar semiconductor devices; photosensitive semiconductor devices (including photovoltaic cells, whether or not assembled in modules or made up into panels); light-emitting diodes
	7764		Electronic integrated circuits and microassemblies
	7768		Piezoelectric crystals, mounted; parts, n.e.s., of the electronic components of group 776
		89879	Recorded media, n.e.s.

PHARMACY

5413+5415+5416+5421+5422

5413	Antibiotics, not put up as medicaments of group 542
5415	Hormones, natural or reproduced by synthesis; derivatives thereof, used primarily as hormones; other steroids used primarily as hormones, not put up as medicaments of group 542
5416	Glycosides; glands or other organs and their extracts; antisera, vaccines and similar products
5421	Medicaments containing antibiotics or derivatives thereof
5422	Medicaments containing hormones or other products of subgroup 541.5 but not containing antibiotics

APPENDIX-1. (cont.) SITC Rev.3 High Technology Product List with Codes and Definitions *(Hatzichronoglou, 1997; UN Secretariat, 1986)*

SCIENTIFIC INSTRUMENTS
774+8711+8713+8714+8719+87211+(874 - 87411-8742)+88111+88121+88411+88419+89961+89963+89966+89967

774			Electrodiagnostic apparatus for medical, surgical, dental, or veterinary purposes, and radiological apparatus
	8711		Binoculars, monoculars, other optical telescopes, and mountings therefor; other astronomical instruments and mountings therefor (excluding instruments for radio astronomy)
	8713		Microscopes (other than optical microscopes); diffraction apparatus; parts and accessories thereof, n.e.s.
	8714		Compound optical microscopes (including those for photomicrography, cinephotomicrography or microprojection)
	8719		Liquid crystal devices, n.e.s.; lasers (other than laser diodes); other optical appliances and instruments, n.e.s.
		87211	Dental drill engines, whether or not combined on a single base with other dental equipment
874			Measuring, checking, analysing and controlling instruments and apparatus, n.e.s.
		(-87411)	Direction-finding compasses; other navigational instruments and appliances
	(-8742)		Drawing, marking-out or mathematical calculating instruments (e.g., drafting machines, pantographs, protractors, drawing sets, slide-rules, disc calculators); instruments for measuring length, for use in the hand (e.g., measuring rods and tapes, micrometers, callipers), n.e.s.; measuring or checking instruments, appliances and machines, n.e.s.; profile projectors; parts and accessories therefor
		88111	Photographic (other than cinematographic) cameras
		88121	Cinematographic cameras
		88411	Contact lenses
		88419	Optical fibres and optical fibre bundles and cables; sheets and plates of polarizing material; unmounted optical elements, n.e.s.
		89961	Hearing-aids (excluding parts and accessories)
		89963	Orthopaedic or fracture appliances
		89966	Other artificial parts of the body
		89967	Pacemakers for stimulating heart muscles (excluding parts and accessories)

APPENDIX-1. (cont.) SITC Rev.3 High Technology Product List with Codes and Definitions *(Hatzichronoglou, 1997; UN Secretariat, 1986)*

ELECTRICAL MACHINERY
77862+77863+77864+77865+7787+77884

		77862	Tantalum fixed capacitors
		77863	Aluminium electrolytic fixed capacitors
		77864	Ceramic dielectric fixed capacitors, single layer
		77865	Ceramic dielectric fixed capacitors, multilayer
	7787		Electrical machines and apparatus, having individual functions, n.e.s.; parts thereof
		77884	Electric sound or visual signalling apparatus (e.g., bells, sirens, indicator panels, burglar and firealarms), other than those of heading 778.34 or 778.82

CHEMISTRY
52222+52223+52229+52269+525+531+57433+591

		52222	Selenium, tellurium, phosphorus, arsenic and boron
		52223	Silicon
		52229	Calcium, strontium and barium; rare earth metals, scandium and yttrium, whether or not intermixed or interalloyed
		52269	Other inorganic bases; other metal oxides, hydroxides and peroxides
525			Radioactive and associated materials
531			Synthetic organic colouring matter and colour lakes, and preparations based thereon
		57433	Polyethylene terephthalate
591			Insecticides, rodenticides, fungicides, herbicides, anti-sprouting products and plant-growth regulators, disinfectants and similar products, put up in forms or packings for retail sale or as preparations or articles (e.g., sulphur-treated bands, wicks and candles, and fly-papers)

APPENDIX-1. (cont.) SITC Rev.3 High Technology Product List with Codes and Definitions *(Hatzichronoglou, 1997; UN Secretariat, 1986)*

NON-ELECTRICAL MACHINERY
71489+71499+71871+71877+71878+72847+7311+73131+73135+73142+73144+73151+73153+73161+73163+73165+73312+73314+73316+7359+73733+73735

	71489	Other gas turbines
	71499	Parts for the gas turbines of heading 714.89
	71871	Nuclear reactors
	71877	Fuel elements (cartridges), non-irradiated
	71878	Parts of nuclear reactors
	72847	Machinery and apparatus for isotopic separation, and parts thereof, n.e.s.
7311		Machine tools for working any material by removal of material, by laser or other light or photon beam, ultrasonic, electrodischarge, electrochemical, electron beam, ionic beam or plasma-arc processes
	73131	Horizontal lathes, numerically controlled
	73135	Other lathes, numerically controlled
	73142	Other drilling machines, numerically controlled
	73144	Other boring-milling machines, numerically controlled
	73151	Milling machines, knee-type, numerically controlled
	73153	Other milling machines, numerically controlled
	73161	Flat-surface grinding machines, numerically controlled, in which the positioning in any one axis can be set up to an accuracy of at least 0.01 mm
	73163	Other grinding machines, numerically controlled, in which the positioning in any one axis can be set up to an accuracy of at least 0.01 mm
	73165	Sharpening (tool- or cutter-grinding) machines, numerically controlled
	73312	Bending, folding, straightening or flattening machines (including presses), numerically controlled
	73314	Shearing machines (including presses), numerically controlled, other than combined punching and shearing machines
	73316	Punching or notching machines (including presses), including combined punching and shearing machines, numerically controlled
7359		Parts, n.e.s., and accessories suitable for use solely or principally with the machine tools of groups 731 and 733
	73733	Machines and apparatus for resistance welding of metal, fully or partly automatic
	73735	Machines and apparatus for arc (including plasma-arc) welding of metal, fully or partly automatic

ARMAMENT
891

891		Arms and ammunition

APPENDIX-2. FDI, Net, BoP, Current US$, Million *(World Bank, n.d.)*

Countries	**2007**	**2008**	**2009**	**2011**	**2013**	**2015**	**2017**	**2019**	**2020**
Malta	-20.952	1.325	-7.546	-12.185	-9.281	-10.233	-10.829	-10.868	-11.124
Cyprus	-1.032	2.072	-2.995	6.927	3.885	15.285	-578	124	-4.470
Austria	10.174	21.602	1.258	15.161	10.580	5.836	-3.411	6.437	9.965
Belgium	-13.094	32.864	-44.015	-34.518	17.272	26.844	31.989	-4.723	-1.866
Bulgaria	-12.903	-9.179	-3.535	-1.611	-1.638	-2.098	-1.512	-1.392	-2.407
Croatia	-4.266	-3.855	-1.695	-1.309	-1.004	-230	-1.293	-3.814	-751
Czech Republic	-8.964	-2.258	-1.952	-2.593	380	2.026	-1.834	-5.976	-3.152
Denmark	5.523	16.555	2.390	-436	6.328	5.407	5.837	10.135	7.504
Finland	-5.460	10.751	4.921	2.457	-2.236	-18.241	-3.464	-8.568	7.300
Estonia	-646	-687	-503	-2.490	-247	140	-1.085	-1.214	-3.212
France	48.449	68.002	70.296	20.278	-13.974	8.404	12.703	5.541	40.314
Germany	89.805	67.071	43.037	10.373	26.094	68.433	36.297	85.529	-1.131
Greece	3.303	-2.525	-325	726	-3.643	314	-3.283	-4.373	-2.655
Hungary	-2.352	-1.457	-972	-1.962	-278	-2.891	-2.376	-102	-2.803
Ireland	-4.011	34.913	541	-25.222	-21.251	-47.434	-55.346	-97.444	-124.509
Italy	54.018	77.207	1.761	17.407	743	2.121	677	1.682	22.014
Latvia	-1.944	-1.091	-44	-1.412	-494	-670	-581	-1.000	-753
Lithuania	-1.726	-1.173	965	-1.065	-437	-680	-933	-1.273	-629
Luxembourg	70.916	31.760	17.377	-34.638	-152.345	119.959	166.208	79.183	9.514
Netherlands	-137.408	77.059	44.419	39.563	87.174	68.324	59.816	42.865	-50.907
Poland	-17.445	-9.908	-8.094	-13.656	-4.206	-10.152	-7.836	-11.709	-12.505
Portugal	4.543	-2.240	-1.950	5.940	-8.651	-2.385	-8.405	-8.688	-5.535
Romania	-9.437	-13.355	-4.624	-2.313	-3.915	-3.287	-5.567	-5.442	-3.404
Slovak Republic	-3.415	-4.117	973	-2.734	273	-102	-2.727	-2.451	2.191
Slovenia	331	251	687	-890	-72	-1.404	-565	-857	328
Spain	78.247	1.691	6.149	18.153	-14.263	33.299	14.576	7.403	22.346
Sweden	9.748	-6.672	17.514	16.795	26.576	4.646	15.240	7.110	5.036
United Kingdom	160.880	103.242	-62.945	53.822	-8.222	-105.510	46.685	-50.469	-84.326
Turkey	-19.941	-17.302	-7.032	-13.812	-9.927	-14.167	-8.487	-6.628	-4.592

APPENDIX-3. FDI, Net Inflows, % of GDP *(World Bank, n.d.)*

Countries	**2007**	**2008**	**2009**	**2011**	**2013**	**2015**	**2017**	**2019**	**2020**
Malta	449,08	163,22	16,61	80,99	4,83	32,82	29,42	27,96	29,95
Cyprus	9,57	44,16	249,11	146,73	108,64	145,95	62,99	163,04	-1,33
Austria	17,69	1,46	3,56	5,32	0,10	-2,09	3,24	-2,95	-4,20
Belgium	20,50	36,80	16,01	31,27	-5,68	-4,22	-7,42	-5,62	-3,37
Bulgaria	31,25	18,91	7,49	3,65	3,56	4,37	3,39	3,22	3,87
Croatia	7,67	7,42	4,87	1,98	1,66	0,09	0,82	6,27	2,06
Czech Republic	7,26	3,72	2,54	1,82	3,48	0,90	5,14	4,26	2,62
Denmark	3,70	0,62	1,17	3,94	0,20	0,61	1,09	-1,09	0,44
Finland	8,57	6,79	-3,48	-2,18	-1,81	7,46	6,71	5,81	-0,88
Estonia	13,51	8,12	9,51	4,82	4,37	-3,13	6,45	9,87	11,54
France	3,15	2,32	0,68	1,54	1,12	1,76	1,38	2,11	0,50
Germany	1,48	0,83	1,66	2,60	1,80	1,86	2,97	1,74	2,93
Greece	0,61	1,61	0,83	0,39	1,23	0,65	1,72	2,44	1,75
Hungary	50,37	47,42	-2,13	7,56	-2,64	-4,21	-8,48	60,06	108,42
Ireland	22,19	8,45	22,83	9,92	29,72	81,30	17,38	-11,68	7,62
Italy	2,98	-0,39	0,75	1,50	0,91	0,72	0,57	1,55	-1,17
Latvia	8,74	4,00	-0,57	5,53	3,28	2,98	3,78	3,17	2,80
Lithuania	6,55	3,61	-0,96	4,32	1,65	2,50	2,90	6,28	7,92
Luxembourg	-57,53	12,09	50,04	14,33	24,55	20,81	-10,37	21,07	84,72
Netherlands	86,48	20,54	11,00	36,68	37,47	42,14	25,62	-18,60	-16,34
Poland	5,83	2,73	3,19	3,51	0,15	3,15	2,23	2,82	2,91
Portugal	2,50	2,97	2,28	4,01	6,95	0,64	4,83	4,30	2,06
Romania	5,79	6,38	2,66	1,29	2,02	2,43	2,81	2,95	1,45
Slovak Republic	5,84	4,60	1,70	5,46	1,02	1,72	4,43	2,17	-0,31
Slovenia	3,92	1,94	-0,69	1,70	0,21	4,01	2,46	3,97	0,91
Spain	4,63	4,54	0,64	1,81	3,50	1,93	2,40	1,78	2,63
Sweden	9,39	8,00	2,05	1,22	0,22	2,03	5,25	3,18	5,25
United Kingdom	6,75	8,62	0,60	1,01	1,94	1,53	4,64	0,08	1,13
Turkey	3,24	2,58	1,32	1,93	1,42	2,23	1,29	1,22	1,06

APPENDIX-4. High-technology Exports, % of Manufactured Exports *(World Bank, n.d.)*

Countries	**2007**	**2008**	**2009**	**2011**	**2013**	**2015**	**2017**	**2019**	**2020**
Austria	12,98	12,66	13,44	13,26	15,37	15,03	12,88	11,48	12,26
Belgium	8,46	8,94	11,36	8,67	10,64	12,33	11,49	14,14	15,25
Bulgaria	6,29	6,97	8,66	7,81	8,28	8,43	9,63	10,85	11,30
Croatia	9,50	9,52	11,31	8,69	12,49	10,71	8,73	8,29	9,68
Czech Republic	15,24	15,77	17,43	18,70	17,33	17,73	17,82	20,71	22,58
Cyprus	31,30	32,02	32,53	30,36	13,08	12,71	13,35	19,87	12,24
Denmark	18,32	16,92	18,93	15,27	15,82	17,17	12,50	12,08	13,17
Estonia	11,80	10,81	10,32	22,23	20,68	22,71	17,93	16,94	20,46
Finland	21,77	21,49	18,02	11,08	9,02	10,18	9,66	9,21	9,98
France	20,10	21,43	24,09	25,09	27,16	28,18	26,00	26,91	23,14
Germany	15,46	15,07	16,79	16,34	17,29	17,82	15,81	16,38	15,50
Greece	9,11	10,85	12,23	11,25	8,47	12,91	12,11	12,51	13,25
Hungary	26,00	24,97	26,73	25,18	19,37	17,08	17,18	17,36	17,43
Ireland	30,77	28,87	26,49	24,91	24,98	28,34	29,19	25,97	25,66
Italy	7,11	7,16	8,25	7,97	7,77	8,15	7,80	7,76	8,89
Latvia	7,50	7,45	8,76	9,47	15,42	18,92	17,72	17,22	20,04
Lithuania	11,50	11,83	10,60	10,61	11,02	12,78	12,58	12,03	12,01
Luxembourg	10,71	8,01	10,32	9,05	6,84	7,11	8,81	6,57	5,62
Malta	53,02	50,44	48,03	47,41	38,71	30,79	30,38	29,62	34,62
Netherlands	29,03	26,01	28,00	25,21	24,64	24,05	22,90	23,03	23,14
Poland	3,77	5,23	7,08	6,62	8,74	10,77	10,67	9,85	9,86
Portugal	8,60	8,24	4,79	4,12	4,70	5,08	5,99	6,94	7,11
Romania	4,41	6,92	10,37	11,64	7,40	9,41	9,78	11,07	11,94
Slovak Republic	5,39	5,09	6,34	7,52	11,01	11,16	11,77	9,91	10,00
Slovenia	5,69	6,48	6,85	6,21	6,74	7,01	6,51	7,35	7,80
Spain	5,60	5,58	6,47	6,59	6,97	6,89	7,00	6,85	7,77
Sweden	16,80	17,25	18,77	18,69	18,02	18,13	15,11	14,50	15,13
United Kingdom	20,86	20,60	20,45	23,29	23,57	22,32	22,61	23,08	23,00
Turkey	2,14	1,84	2,01	2,11	3,13	3,44	3,23	3,03	3,15