Chapter 4

Determinants of High-Technology Product Exports in Selected Countries[1]

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Abstract

In the 21st century, the effect of globalization has increased competition among countries. Along with this increasing competition, the concept of technology has become more important for nations. For countries, high-technology products and effectiveness in value-added imports and exports are among the significant factors for the sustainability of growth. For this reason, the determinants of high technology have become an important research topic. This study employs panel data analysis for 105 selected countries over the period 2010-2019 and selects the System-GMM method. Through this analysis, the impact of high-technology determinants on high-technology exports is measured. In the analysis, the dependent variable is high-technology exports, while the independent variables are the education index, foreign direct investments, trade openness ratio, GDP, and patent applications. As a result of the analysis, the one-period lagged value of high-technology exports, L.lnHTE, was found to be significant at the 1% level in the System GMM models. According to the one-step GMM model, there is a significant relationship at the 1% level between high-technology exports and the independent variables. According to the two-step GMM model, a statistically significant and positive relationship at the 1% level was identified between high-technology exports and the education index, foreign direct investments, and trade openness variables. Furthermore, in the two-step GMM model, a statistically significant and positive relationship at the 5% level exists between high-technology exports and both GDP and patent applications.

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1. Introduction

The advancement of technology holds significant importance for many sectors, primarily for the economy. The technology possessed by countries influences numerous sectors from a macro perspective, such as the economy, health, education, and security. From a micro perspective, it has a positive effect on saving time and minimizing costs for individuals and firms. The completion of countries' economic development is directly proportional to the technology they produce. Therefore, technology becomes an element of international competition for nations (Erdinç & Aydınbaş, 2020, p. 496; Özer et al. 2018, p. 58). Countries gaining an advantage in this competition depends on the new and high-technology products they manufacture. Consequently, to ensure sustained competitiveness and economic growth, countries must increase the production of high-technology goods within their exports (Akay, 2021, p. 1129). High-technology production signifies the manufacturing of high value-added products that yield high returns (Konak, 2018, p. 58). It also leads to higher quality and productivity through the more efficient use of resources employed in production (Özkan & Yılmaz, 2017, p. 2). Furthermore, high income elasticity is a fundamental characteristic of high-technology products (Buzdağlı, Uzun, & Emsen, 2019, p. 476).

High-technology products were classified by the OECD in 2011 according to technological level into the following categories: high-technology, medium-high-technology, medium-low-technology, and low-technology. The aerospace, computer, and pharmaceutical industries fall into the high-technology category. Motor vehicles, most chemical industries, and electrical equipment belong to the medium-high-technology industries group. Basic metals, plastics containing rubber, and shipbuilding are classified as medium-low-technology. Finally, the low-technology group includes processed food, textiles, clothing, and footwear. The distribution of value-added based on this classification provides information about the development level of countries (Kabaklarlı, Duran, & Üçler, 2018, p. 48).

Technology and High Technology: The concept of technology can be explained by multiple definitions. Technology refers to the sum of knowledge and skills used in producing the tools and instruments created to meet individuals' needs, and since the 19th century, it has significantly influenced economic and social life within society (Türedi, 2013, p. 299). Technology is a crucial factor as a driving force for growth. It can be defined as the total stock of knowledge and experience related to the process, management, marketing, and after-sales support of a produced good (Kibritçioğlu, 1998,

p. 211). Technology signifies the consideration of the tools, techniques, and methodological analyses used in industry as a whole (Harman, Oktar, & Görgülü, 1985, p. 16).

Furthermore, the phenomenon of the social system, which is a significant factor in the formation of economic and political choices, is also an important concept for the development of technology. Societal values are important for the development and direction of technology. Similarly, technology can also be a determining factor for the lifestyle of a society.

In economic literature, technological progress and technological change correspond to different meanings. While technological progress is considered at the macro level and indicates a process where capital-intensive production is prominent, technological change encompasses both capital-intensive and labor-intensive production processes. Technological change does not always mean progress, i.e., a step forward. Sometimes it merely signifies a change in the production process. Shifting from capital-intensive production to labor-intensive production is a technological change, but technological progress refers to a capital-intensive process at the macro level (Bayraktutan & Bıdırdı, 2016, p. 3-4). The dictionary meaning of technology is to process raw information and, after R&D expenditures, to carry out production to offer people more qualified products and services (Batur & Uygun, 2012, p. 74).

While factors such as labor, natural resources, economic and political stability, education level, R&D intensity, and innovation lead to differences in the economic development and growth of developed and developing countries, the most important factor clarifying the state of this gap is the technological infrastructure upon which production is based (Kabaklarlı et al., 2018, p. 1). In the 21st century, technology, as a determinant of the positions countries hold against each other and their economic capacity, is of great importance.

Competitiveness between countries and, consequently, their advantages in foreign trade depend on their potential to produce and renew technology. Developed countries compete with each other because they are aware of the benefits technology will provide, while developing countries have strived to develop themselves in the field of technology (Çelebi, 2002, p. 157; Yıldız, 2024, p. 383). Developing countries can enhance their production performance by developing the products they will export through imported technology transfer (Durmuş, 2020, p. 29). Developing countries that cannot achieve sufficient development in technology run a foreign trade deficit in the long run. Developed countries can create technological difference and superiority over developing countries through the share they allocate to R&D expenditures (Çelebi, 2002, p. 158). When developed countries in the field of technology fail to convert innovation activities into production for various reasons, the value-added return the country can obtain from technology is limited, and this situation negatively affects growth and development within the country's economy (Akyol & Demez, 2020, p. 57).

Technological development in a country affects its education, health, economy, and many other sectors. For countries and firms, technology contributes to time savings and cost reductions. Technological advancements lead to increased economic and political competition worldwide (Erdinç & Aydınbaş, 2020, p. 499). Advanced technology is used to describe high-quality goods and services produced with minimal input and cost per unit of time in the production process. New technology emerging from the rapid reflection of accumulated knowledge and experience gained in scientific and technological fields to the production and service sectors is defined as high technology (Harman et al., 1985, p. 17).

High technology is used to refer to goods and services. In other words, goods and services obtained through innovation explain the concept of high technology. Firms and industries that achieve superiority in technology gain importance in terms of high-technology supply. These firms, possessing scientific and technological experience and knowledge, invest in high technology by directing their labor force towards R&D expenditures (Kabaklarlı et al., 2018, p. 1). R&D expenditures will increase exports in the high-technology field and, as a result, contribute positively to GDP (Kılıç, Bayar, & Özekicioğlu, 2014, p. 116). The OECD has based its criteria for a product to be considered a high-technology product on the R&D intensities within the manufacturing industry (Erdinç & Aydınbaş, 2020, p. 497). This classification used by the OECD has been defined by grouping it for four different sectors. The classification is as follows: high-technology, medium-high-technology, medium-low-technology, and low-technology (Buzdağlı et al., 2019, p. 477).

Table 1: Technology Classification According to the OECD	
High Technology	• Aerospace, Aircraft and Spacecraft • Pharmaceuticals • Office, Accounting, and Computer Equipment • Radio, Television, and Communication Equipment • Medical, Precision, and Optical Instruments
Medium-High Technology	• Motor Vehicles, Trailers, and Semi-Trailers • Chemicals excluding Pharmaceuticals • Other Transport Equipment (e.g., railways) • Machinery and Equipment (non-electrical)
Medium-Low Technology	• Building and Repairing of Ships and Boats • Rubber and Plastic Products • Coke, Refined Petroleum Products, and Nuclear Fuel • Other Non-Metallic Mineral Products • Basic Metals and Fabricated Metal Products
Low Technology	• Wood Products, Paper Products, Printing, and Publishing • Food Products, Beverages, and Tobacco • Textiles, Textile Products, Leather, and Footwear • Manufactured Products, Recycling

Source: *Adapted from the OECD (2022) classification based on R&D intensity in the manufacturing sector (ISIC Rev.4).*

The OECD bases its criterion for classifying a product as high-technology on the intensity of R&D investments relative to the product's manufacturing cost. Being positioned in the high-technology sector within this classification and ensuring sustainable economic development through the export of high value-added products from this sector is economically crucial for a country's development (Sungur, Aydın, and Eren, 2016, p. 187). It is observed that developed economies which prioritize high-technology exports also place significant importance on R&D expenditures (Yavuz and Uysal, 2020, p. 207). The perspective that emphasizes technology's role in production, suggesting it will lead to major leaps in production, positively influence growth, and consequently provide an advantage over other countries, is referred to as the Schumpeterian Approach (Srholec, 2007, p. 2).

A key characteristic of high-technology products is their high income elasticity (Akay, 2021, p. 1129). In developed countries, an income elasticity greater than one has a growth-enhancing effect, whereas in developing countries, an income elasticity less than one for primary goods means their production and export will negatively impact economic growth (Aytekin, 2020, p. 60). Countries that produce high-technology products obtain high value-added, which not only benefits the national economy positively but also helps determine the development gap between nations (Konak, 2018, p. 57).

Examining the features of high-technology products reveals that they are superior to other technologies and, due to their complexity, require rapid knowledge renewal, continuous research effort, and a solid technological foundation. High-technology industries engage in commercial activities as a result of innovations (Cenikli, 2020, p. 17). However, the commercialization of new high-technology products is one of the most costly stages of product development processes (Easingwood and Koustelos, 2000, p. 27). From the perspective that emphasizes technology's commercial value, high-technology products and services should be regarded as the output of a planned industrial approach, R&D, and innovation (Demirci and Ersoy, 2008, p. 1). The dependence of an industry or firm on science and technology can be measured by determining its R&D intensity (Cenikli, 2020, p. 17). High technology is used to define the technologies of the current period, not the past or the future. A product considered high-technology in the past may be classified as a low-technology product in today's classification due to the rapid change in technology (Akgün and Polat, 2011, p. 30).

Characteristics of High-Technology Products:

- High-technology products have a dynamic and novel structure.
- High-technology products have the potential to generate new inventions.
- Products containing high technology can influence the social behaviors and economic habits of a community.
- High technology possesses the characteristic of being based on science.
- High-technology products create pressure in foreign trade competition, making planning and strategy development crucial for governments (Harman et al., 1985, p. 23).

Table 2: Countries with the Highest Export Market Share in High-Technology Sectors and Türkiye (%)							
Leading Countries	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
	Aerospace & Aviation Industry						
United States	30,05	32,09	33,41	33,14	31,55	31,38	30,14
France	17,38	17,38	15,98	15,47	14,84	14,89	15,53
Germany	13,20	12,52	12,34	12,28	11,67	11,36	11,81
United Kingdom	9,74	9,13	9,23	9,27	9,97	9,60	9,42
Türkiye	0,27	0,28	0,26	0,26	0,47	0,32	0,39
Computers, Electronics & Optics Industry							
China	27,84	27,11	28,15	26,40	25,92	26,24	26,18
United States	8,04	8,00	8,13	8,19	7,66	7,26	7,29
South Korea	5,72	5,82	5,99	5,76	6,41	6,76	5,63
Singapore	5,59	5,46	5,40	5,33	5,18	4,90	4,78
Türkiye	0,14	0,15	0,13	0,11	0,10	0,10	0,10
Pharmaceutical Industry							
Germany	15,20	15,35	15,08	14,66	15,19	15,74	14,08
Switzerland	12,46	12,72	12,77	13,56	13,40	12,80	13,29
United States	8,71	9,08	10,19	9,62	8,70	8,34	8,84
France	7,60	6,83	6,10	5,91	5,80	5,59	5,57
Türkiye	0,21	0,21	0,22	0,19	0,18	0,21	0,22

Source: *Created using data from the OECD - Main Science and Technology Indicators (MSTI) (2013-2019).*

According to Table 2:

- In the aerospace and aviation industry between 2013 and 2019, the country with the largest increase in export market share was the United States. The US's export market share, which was 30.05% in 2013, rose to 30.14% in 2019. Countries that experienced a decline in export market share were France and Germany. France's market share decreased from 17.38% in 2013 to 15.53% in 2019. Similarly, Germany's share declined from 13.20% to 11.81% over the same period. The United Kingdom's market share remained almost unchanged at around 9%.

- In the Information and Communication Technology (ICT) - computers, electronics, and optics industry, dominance is clearly held by China. China increased its export market share from 27.84% in 2013 to 28.15% in 2015, and despite moderate declines afterwards, its share stood at 26.18% in 2019. This decline does not pose a threat to China's dominance in this sector. The United States increased its share from 8.04% in 2013 to 8.19% in 2016, but it declined to 7.29% by 2019. Similar trends can be observed for South Korea and Singapore following the US. Türkiye appears as the country with the lowest export market share in the ICT industry among the countries examined.
- Examining the pharmaceutical industry table, Germany is seen as a dominant country in export market share. Germany increased its share from 15.20% in 2013 to 15.74% in 2018, asserting its leadership in the sector. Germany's rise was followed by Switzerland with 13.29% and the United States with 8.84% in 2019. France was the country that experienced a decline in its export market share trend. Türkiye, similar to its position in the ICT and aerospace industries, has the lowest export market share in the pharmaceutical sector among the countries studied.

The Importance of High Technology in International Competition: There is no single, universally accepted definition of international competitiveness in the literature. Generally, competitiveness refers to the productive power of firms, industries, countries, or country groups in terms of income and employment within the global competitive environment. It entails comparing a product produced in one country with its counterparts in other countries based on characteristics like quality, price, and reliability (Kelleci, 2009, p. 13). National competitiveness encompasses three key features (**Çivi**, 2001, p. 25):

- The primary goal for countries wanting to be competitive is to increase national welfare. An increase in national welfare can be achieved by emphasizing all activities related to investment, production, and trade, and through the collaborative work of the country's institutions.
- To avoid falling behind competitor countries, nations must develop unique new capabilities and features in the production, management, and distribution of goods and services.

- There are numerous indicators that measure and demonstrate a country's competitiveness.

In the literature, the concept of competitiveness is linked to the technological structure of countries. The increase in national welfare and quality of life standards is directly proportional to the share of high technology within exports (Cenikli, 2020, p. 24). However, for this to happen, conditions such as countries' ability to incorporate high technology into their exports, improving their infrastructure for a healthy growth model, and strengthening their human capital must be met. Achieving exports depends on countries producing low-cost but high-quality products. For this, the country's level of technology, qualified labor force, and R&D expenditures become determining factors (Göçer, 2013, p. 218). Because the competitive environment involves constant innovation and change, businesses seek innovation. While pursuing this, new and alternative techniques suitable for the market structure must be developed. The success of businesses in constant competition can be measured by the concepts of cost, quality, flexibility, speed, and the continuity of innovation (Zerenler, Türker, and Şahin, 2007, p. 655).

Table 3: Global Competitiveness Index

Current Environment	• Infrastructure (Transport, Energy, Telecommunications) • Macroeconomic Stability • Institutional Quality (Rule of Law, Regulatory Efficiency)	New methods for security and protection of rights
		New measurement methods related to electricity, energy, and water infrastructure
		Advanced macroeconomic indicators
Human Capital	• Health (Life Expectancy, Public Health) • Education & Skills (Quality of Schooling, Workforce Competencies) • Digital Literacy and Adaptability	New indicators related to working life
		New assessments regarding human capital skills
Market Conditions	• Market Size (Domestic and International) • Degree of Competition (Antitrust Laws, Market Dominance) • Demand Conditions (Sophistication of Local Customers)	Customs and taxation facilitation measures
		Elements that will support capacity increase
Innovation Ecosystem	• Research & Development (R&D) Expenditure • Business Dynamism and Entrepreneurial Culture • Scientific and Technological Capacity • Collaboration between University and Industry	Measurement of Information and Communication Technologies
		New measurements related to market capacity
		Entrepreneurship development and regulation
		Ensuring labor force diversity

Source: *The Global Competitiveness Report, 2016-2017.*

The Global Competitiveness Index report determines the methods through which countries can compete based on their level of development.

In economics, the factors of institutions, health, infrastructure, primary education areas, and the macroeconomic environment are defined as a factor-driven economy. Here, countries can compete based on factors (natural resources, unskilled labor). This involves low wages and, consequently, low productivity, meaning competition is based on price through the production of simple goods.

As a country becomes more competitive, i.e., as its development level increases, both productivity and wages rise. At this point, countries are defined as having an efficiency-driven economy. Countries achieve more efficient production by improving product quality. Better quality products, more developed financial markets, and larger domestic and foreign markets enhance competitiveness.

Finally, countries reach a stage focused on innovation. This stage is defined as the innovation-driven stage. Here, businesses gain competitiveness by employing the most sophisticated production processes and creating new and unique products (Global Competitiveness Index Report, 2014-2015, p. 10).

Table 4: Competitiveness Index and Country Rankings

Countries / Year		Competitiveness Index		Country Rankings	
		2019	**2022**	**2019**	**2022**
1	Denmark	81,17	100	10	1
2	Switzerland	82,33	98,92	5	2
3	Singapore	84,78	98,11	1	3
4	Sweden	81,25	97,71	8	4
5	Hong Kong	83,14	94,89	3	5
6	Netherlands	82,39	94,29	4	6
7	Taiwan, China	80,2	93,13	12	7
8	Finland	80,22	93,04	11	8
9	Norway	78,1	92,96	17	9
10	USA	83,67	89,88	2	10
11	Türkiye	62,14	51,44	61	52

Source: *IMD, 2022.*

The Global Competitiveness Index influences countries' productivity levels through institutions, policies, and factors. Microeconomic and macroeconomic infrastructures assess nations' international competitiveness. The table above attempts to identify the competitiveness index values of countries for 2019-2022 and their respective positions in the global rankings. In the global competitiveness ranking, Denmark held the top position worldwide in 2022. Denmark was followed by Switzerland, Singapore, Sweden, and Hong Kong, respectively. Türkiye, with an index value of 62.14 in 2019, was ranked 61st in the global standings. By 2022, while its index value was 51.44, it ranked 52nd globally. This ranking indicates that Türkiye needs to improve its competitiveness.

Criteria Determining High Technology: Societal structures have transitioned into a new era alongside changes and developments in technology (Konak, 2018, p. 66). For countries to achieve high-technology product export capacity, it requires the combined use of various components in the production of these goods (Güneş & Akın, 2019, p. 13). The determinants of high-technology product exports have been examined in numerous studies. Variables considered as determinants include economic growth (GDP), R&D expenditures, number of patent applications, fixed capital investment, number of skilled employees, trade openness ratio, foreign direct investments, and the savings rate. This section will address these variables.

- R&D Expenditures: To avoid obsolescence and sustain their presence in international competition, countries must push the boundaries of innovation. The share of GDP allocated to R&D spending is crucial for fostering innovations (Güneş & Akın, 2019, p. 13-14). Differences in income and growth, often interpreted as degrees of superiority between countries, are fundamentally linked to R&D expenditures. R&D spending by countries increases the production of high-technology goods, and since the resulting products are high value-added, they support economic growth by increasing the country's Gross Domestic Product. Here, R&D expenditures have been identified as a positive factor in high-technology product exports (Kılıç et al., 2014, p. 2). While R&D spending by firms creates profit motives for future periods, from a national perspective, it is about gaining strength within the competitive landscape (Erdinç & Aydınbaş, 2020, p. 7).
- Number of Patent Applications: Patents are the most vital legal instrument for protecting intellectual property rights (Langinier &

Moschini, 2002, p. 1). Patents, by granting the owner all rights over new products and production techniques and being considered an R&D indicator, are also significant for technological advancements. An increase in the number of patent applications and grants in countries producing high-technology goods signifies the development of technologies, the creation of new technologies, and a numerical increase in new products in that country. China is the prime example of this (Konak, 2018, p. 13).

- Fixed Capital Investments: Another criterion determining high technology is fixed capital investment. Fixed capital investments positively impact the national economy in the long term by increasing production, employment, and productivity (**Özen**, 2015, p. 152). Fixed capital investments can be considered a positive factor in technological development and the increase of high-technology product exports (Cenikli, 2020, p. 17). China, being a country with high fixed capital and a leader in the export of advanced technology products, supports the previous statement (Erdinç & Aydınbaş, 2020, p. 501).
- Number of Skilled Employees: Firms engaged in production activities to high standards are more successful in countries with a qualified workforce. Producing qualified goods requires workers with high levels of human capital. As the number of educated individuals in a country increases, the number of skilled employees also rises in parallel. This explanation supports the expectation that the number of skilled employees will positively influence high-technology product exports (The Global Human Capital Report, 2017, p. 3).
- Trade Openness Ratio: Another variable influential in and often included in analyses of high-technology product exports is the trade openness ratio. The trade openness ratio positively affects the performance of high-technology product exports. Simultaneously, it allows for sourcing missing inputs for high-technology products manufactured domestically from abroad (Güneş & Akın, 2019, p. 13-14).
- Foreign Direct Investments (FDI): Inward technology transfers can foster innovation. Therefore, FDI, directly or indirectly, can enhance high technology in a country (Gökmen & Turen, 2013, p. 218). Countries with a capital gap have a greater need for foreign direct investments to increase production, exports, and productivity. Multinational firms have several reasons for making direct investments:

one is the relatively cheaper factor costs in the host country, allowing the firm to reduce costs and increase profitability in production. The second is the wide market share of the target country. Finally, investors may seek to utilize the knowledge, technology, and human capital accumulation – i.e., positive externalities – present in the host country (Güneş & Akın, 2019, p. 15).

- Savings Rate: Increasing the savings rate is crucial for investments in countries. Producing high-quality goods in terms of qualification in a country depends on the conversion of savings into investments in high value-added product areas. Countries that are high-technology exporters have deemed the savings rate important in this field (Güneş & Akın, 2019, p. 16).

2. Foreign Trade Theories and Technology

The foundation of international trade theory is based on Adam Smith's work, "The Wealth of Nations." Smith, considered the founder of the Classical School of Economics, addressed free foreign trade and the benefits of specialization in this trade in his work. Smith's "Theory of Absolute Advantage," one of the foreign trade theories, posits that a country should specialize in producing the good it can produce at a lower cost compared to other countries, export the products it has specialized in to those countries, and import from other countries the products that are costly for it to produce. Here, the cost concept refers only to the homogeneous labor factor.

Smith's theory proved insufficient in explaining international trade, leading to David Ricardo's "Theory of Comparative Advantage," which aimed to fill this gap and contribute to future literature. According to this theory, even if a country is more efficient and superior in producing all goods compared to other countries, it should specialize in the good it produces at a comparatively lower cost and import the goods in which it is less superior. The advantages of comparative cost, put forward by Ricardo to explain international trade, are seen as an element supporting national welfare and growth (Ricardo, 2018, p. 91). John Stuart Mill, criticizing Ricardo's theory, also incorporated demand conditions in international trade. According to Mill's "Law of Reciprocal Demand," the determination of terms of trade depends on knowing the intensity of one country's demand for the other country's goods (Öztürk, 2003, p. 112).

E. Heckscher and B. Ohlin attempted to explain the points where comparative advantages were lacking with the "Factor Endowment Theory." The Heckscher-Ohlin theory explains that a country, having a cost advantage in a particular factor used intensively in producing a good, should concentrate on producing goods that use that factor intensively to gain a comparative advantage and specialize in that area by producing those goods more cheaply (Bayraktutan, 2003, p. 178). From the 1960s onwards, the increase in intra-industry trade led to the emergence of new trade theories. New trade theories gained importance in explaining the reasons for trade between goods that are qualitatively different, due to countries' varying structures and development levels (Yüksel & Sarıdoğan, 2011, p. 201). Keesing and Kenen's "Skilled Labor Theory" attributed the cause of international trade among developed countries to differences in skilled labor. In other words, skills play a significant role in trade (Ağcadağ & Gövdere, 2021, p. 4). Countries rich in skilled labor specialize in production by intensively using this factor in manufacturing goods and participate in international trade. The Skilled Labor Theory is essentially another version of the Heckscher-Ohlin Theory and is also known as the "Neo Factor Endowment Theory" (Bayraktutan, 2003, p. 180).

The "Technological Gap Hypothesis," one of the new trade theories, explains how developed industrial countries, by inventing a new product or production method, become the initial exporters of such goods (Ağcadağ & Gövdere, 2021, p. 6). Since this theory is protected by certain laws (patents, intellectual property rights), imitating the new product or obtaining it through free trade is quite difficult (Yüksel & Sarıdoğan, 2011, p. 201). However, with the expiration of these laws, the products can be imitated or supplied through free trade, leading to cheaper production of these goods in countries with cheaper labor and natural resources. As a result, countries that were initially exporters by producing new products eventually become importers (Dura, 2000, p. 7).

Another foreign trade theory is the "Product Cycle Hypothesis" put forward by Raymond Vernon, which is a developed form of the Technological Gap Hypothesis. The theory primarily tries to explain the foreign trade between the country introducing a new product and the country imitating it (Öztürk, 2003, p. 122). According to this hypothesis, the emergence of new products in foreign trade depends on technology supported by skilled labor and R&D expenditures. The Product Cycle Hypothesis concerns the shift of the product's initial exporter country towards the imitator country (Yüksel & Sarıdoğan, 2011, p. 201).

The "Monopolistic Competition Theory" or "Theory of Imperfect Competition," developed by Chamberlin and Robinson, is a theory forming the basis of international trade theories. The aforementioned theories criticized the views that goods are homogeneous in markets where perfect competition conditions are accepted for goods and factor markets. Thus, firms wanting to become more efficient and differentiate their products create conditions of monopolistic competition. Foreign trade occurs as countries specialize in a small number of products to benefit from economies of scale; trading countries become exporters of the new and improved product and import other product varieties that are substitutes for these products (Yüksel & Sarıdoğan, 2011, p. 202).

4. Exports and High Technology

Export, in the most general terms, means a country selling the products it produces to other countries. However, export entails not only selling goods and services produced within its own borders to other countries but also selling products imported from other countries to yet other countries (Konak, 2018, p. 69). Because resources in the world are scarce and human needs are infinite, no country can meet its needs solely with its own resources. This situation supports the necessity for countries to depend on each other and indicates the importance of trade (Kabal, 2007, p. 11).

After the industrial revolution, industrialization policies began to be implemented in many developed or developing countries, resulting in transitions from agricultural societies to industrial societies. Innovations primarily enabled the industrial revolution while, on the other hand, directing foreign trade firms into constant competition and compelling them to produce higher quality products at lower costs. Schumpeter explained the power of technology in competition through the concept of innovation.

According to Schumpeter, innovation is defined as follows: producing a product that did not exist, improving an existing product to turn it into a new product, developing new production methods during this transformation, finding new raw material sources to enter new markets, and developing new organizational methods to achieve this formation (Uzay, Demir, & Yıldırım, 2012, p. 148-149).

Exports are of great importance for increasing a country's gross national product and its production (Tebaldi, 2011, p. 343). The knowledge and capability endowments possessed by countries greatly influence increasing their production. Explaining the concept of "capabilities" here will be useful. Hidalgo emphasizes that capabilities generally include social communication networks, beyond the tangible and intangible inputs used in production, and that they are the building blocks of production. Accordingly, at any given time, countries are endowed with certain capabilities, while products contain specific capabilities. The complexity of a product is related to the number of capabilities it possesses, while a country's economic complexity is related to the capabilities it possesses. According to Hidalgo; "what" a country produces and exports has become a more important issue than "how much" it produces and exports (Hidalgo, 2009, p. 2). A country's ability to produce a wide range of products does not, by itself, imply a complex production structure when these products are ordinary in terms of technological content and knowledge intensity (Çınar et al. 2021, p. 176).

The importance of exports for both developed and developing countries can be summarized as follows:

- It stimulates competition by expanding market share in foreign trade.
- Increased competition in international trade improves efficiency in the economy by developing alternative uses for resources and through the diffusion of technical knowledge and new technologies. It enables the emergence of new skills and, consequently, the production of high-quality products (Grossman & Helpman, 1990, p. 2).
- Competition among countries provides some significant advantages. Decreasing labor costs increase not only domestic demand but also foreign demand for new products, creating new investment opportunities. Foreign investments lead to positive developments for countries, such as enabling specialization and benefiting from comparative advantages (Rivera-Batiz & Romer, 1991, p. 1-4).
- Exports enable countries with limited domestic production scope to produce on an economic scale.
- Exports also have a positive impact on the balance of payments. As countries with increasing shares in foreign trade experience foreign currency inflows, it helps reduce the foreign exchange pressure on the country's external debt. Thus, the purchase of goods and services increases, enhancing the country's import capacity for products that will be domestically produced and supporting economic growth (Şimşek, 2003, p. 43-44).

The Importance of High Technology for Export Performance: After the Industrial Revolution, industrialization policies began to be implemented in many developed and developing countries, leading to transitions from agricultural to industrial societies. Innovations primarily facilitated the formation of the Industrial Revolution while, on the other hand, directing firms in foreign trade towards constant competition, paving the way for producing higher quality products at lower costs. Schumpeter explained the power of technology in competition through the concept of innovation. Schumpeter defined the concept of innovation as follows: producing a product that does not exist or improving an existing product to make it a new product, developing new production methods during this transformation, finding new raw material sources to enter new markets, and developing new organizational methods to achieve this formation. Some firms innovate to reduce production costs and increase demand, aiming to raise their profit margins and market shares in exports (Uzay et al., 2012, p. 149).

Schumpeter embraced the concept of creative destruction. This idea posits that firms competing in a free market must continuously innovate and develop new production stages. Firms that act contrary to this idea face the threat of being eliminated from the market. Schumpeter argued that the impulse driving capitalism is new production methods, new consumption patterns, and new markets (Aghion & Howitt, 1990, p. 2).

A product that meets new consumer needs and is in higher demand can be considered a new product. As the degree of innovation increases, so does the product's level of appeal. Producing new knowledge is quite costly. In foreign trade competition, generating new knowledge is the most significant profit countries can achieve (Harman et al., 1985, p. 22).

The concepts of process innovation and product innovation are crucial here. Reducing costs requires process innovation, while product diversification requires product innovation. Product innovations encompass R&D activities and are important for dynamic industries, whereas process innovation becomes crucial in stages where productivity increases and price competition are more intense (Uzay et al., 2012, p. 148-149).

The capacity of countries to develop their economies depends on multiple factors: high-technology sectors, export competence, and high value-added products are among the significant ones. In today's competition, export capability and technology products are distinguishing features for global markets (Gökmen & Turen, 2013, p. 217). Governments implement incentivizing policies to help countries increase their export share. Accordingly, the impact of innovation in the production and export process involving high technology, high-technology product trade, and the resulting economic performance has been demonstrated (Tebaldi, 2011, p. 343).

In today's world, the criterion determining a country's potential is not so much the quantity of its existing resources but rather the level of its knowledge, the practical application of that knowledge, the quality of its human capital, and how the economy defines innovative action by the country. The competitiveness of developed countries in foreign trade is based on the development of high technologies and the subsequent entry of high-technology products and services into the world market. Long-term economic growth rates in developed countries occur under the conditions of a knowledge-based economy, supporting and expanding the global knowledge base (Gerasymchuk & Sakalosh, 2007, p. 195). With globalization and technological advancements, the world has become an information society, borders have begun to disappear, and economies have entered a process of liberalization. This process has made increasing labor quality, producing knowledge and incorporating it as a factor of production into the model, and the continuity of education mandatory. As a result of such changes, human capital and knowledge capital have begun to replace physical capital. Thus, productivity increases for scarce factors of production, leading to higher savings, while cost reductions support economic growth (Köse & Gültekin, 2020, p. 95).

The ability of countries to compete in foreign trade and their export performance depend on the technological intensity of the products they produce (Akay, 2021, p. 1129). The sector experiencing the fastest growth in foreign trade is the one with intensive high-technology exports. Therefore, the share of high-technology products is greater within the exports of developing countries (Srholec, 2007, p. 228). The importance of high-technology product production within exports can be listed under several headings:

- Firstly, high-technology products are the sector achieving the highest growth momentum in foreign trade (Baesu et al., 2015, p. 372). High-technology products, which possess advanced and rapidly changing technologies, represent the sector with the highest barriers to entry (Zhang, 2007, p. 112). Depending on the proportion of high-technology products in exports, a transition to a knowledge-based economy has occurred in one respect (Moraes & Ivette, 2018, p. 2). Technological advancement in production can increase both the volume of exports and export revenues for countries and firms. This situation provides an opportunity for countries and firms to be strong in foreign trade and to sustain this strength (Erdinç & Aydınbaş, 2020, p. 498).

- The competitiveness of countries in foreign trade can be determined based on the criterion of productivity level. Competitiveness is influenced by multiple parameters (e.g., relative prices), but countries' ability to maintain and increase their competitive share in the long run is explained by technological transformation and the resulting productivity gains. Increased productivity is directly related to technological capacity in production and the potential of a qualified workforce. A strategy aimed at devaluing national currencies for competitiveness can lead countries into a race to the bottom in terms of exchange rates and potentially result in failure in this race (Eşiyok, 2014, p. 105).

The tables below address the share of high-technology exports within manufacturing exports for developed and developing countries.

Table 5: Share of High-Technology Exports in Manufacturing Exports for Developed Countries

Country	2010	2012	2014	2016	2018	2020
Canada	15,499	15,615	14,665	14,098	15,421	15,303
France	26,294	26,662	27,440	27.909	25.917	23.144
Germany	16,884	17,221	17,206	18,079	15,744	15,499
Italy	8,014	7,592	7,735	8,289	7,475	8,891
Japan	19,081	18,201	17,751	17,592	17,269	18,601
South Korea	32,074	28,217	30,058	30,523	36,390	35,708
Netherlands	27,825	25,457	24,526	23,985	22,491	23,140
Switzerland	25,807	26,057	26,657	27,334	13,317	12,844
United Kingdom	23,286	23,446	22,192	23,545	22,319	22,997
United States	22,606	20,163	20,467	22,411	18,474	19,483

Source: World Bank World Development Indicators, 2022.

According to the data for developed countries in Table 5, South Korea is the leading nation with the highest share of high-technology exports within its manufacturing exports. Maintaining its leadership among these countries from 2010, South Korea held a share of 32.074% in 2010 and continued this trend until 2020. South Korea is followed by the Netherlands, France, Switzerland, the United Kingdom, and the United States. Among the developed countries, Switzerland experienced the sharpest decline in its share in 2020. Canada and Germany did not experience significant fluctuations in their shares between 2010 and 2020. The country with the lowest share of high-technology exports within its manufacturing exports is Italy.

Table 6: Share of High-Technology Exports in Manufacturing Exports for Developing Countries						
Country	**2010**	**2012**	**2014**	**2016**	**2018**	**2020**
Argentina	7,684	6,636	7,061	8,982	5,402	6,903
Brazil	12,589	11,887	12,371	15,999	14,743	11,350
China	32,123	30,848	29,695	30,242	31,467	31,273
Czechia	17,864	18,580	17,365	16,868	19,551	22,579
Egypt	0,953	0,616	1,252	0,504	0,865	2,677
India	7,723	7,699	9,217	7,660	9,040	11,032
Indonesia	12,077	10,677	9,281	7,998	8,212	8,425
Russia	9,373	9,056	12,088	15,745	11,318	9,204
Türkiye	2,194	2,154	3,379	3,038	2,673	3,152

Source: *World Bank, 2022.*

The table above examines developing countries, and we can clearly observe China's dominance in the high-technology sector. China is a country with the potential to compete with developed nations and has the highest share of high-technology exports compared to other developing countries. Looking at the table, the countries with the lowest share of high-technology production within their export portfolio among developing countries are Egypt and Türkiye. Czechia, Brazil, and Indonesia have similar competitive shares amongst themselves; however, it is observed that the Czech Republic increased its export share in the high-technology sector in 2020. India, starting with a rate of 7.7% in 2010, achieved positive growth by 2020, reaching an 11% export market share. Although Russia showed good development in 2016, it experienced a decline again by 2020.

Table 7: Share of Information and Communication (ICT) Goods Exports in Total Exports (%)		
Yıl	**Türkiye**	**Worls**
2000	3,68	15,12
2001	3,36	14,63
2002	4,48	14,80
2003	4,20	14,93
2004	4,64	15,20
2005	4,39	14,28
2006	3,71	14,23
2007	2,68	13,15
2008	1,82	12,24
2009	1,97	13,08
2010	1,83	12,86
2011	1,65	11,64
2012	1,73	11,46
2013	1,71	11,32
2014	1,87	11,42
2015	1,79	11,94
2016	1,47	12,13
2017	1,33	12,35
2018	1,23	12,47
2019	1,14	12,65
2020	1,00	14,32

Source: World Bank Database

The table above examines the share of Information and Communication Technology (ICT) goods exports in total exports for Türkiye and the world. Compared to the global average, Türkiye significantly lags in ICT goods exports. In 2000, the share of ICT goods exports in Türkiye's total exports was 3.6%, but this declined to 1% by 2020. For the world, the share of ICT goods exports in total exports was 15.1% in 2000, declining to 14.3% by 2020. A common point for both Türkiye and the world is the proportional increase observed in 2004.

The Role of Manufacturing and High-Value Exports in Economic Development: One of the most crucial development strategies for countries is to enhance export performance through high-quality and competitive production. Economic growth, driven by increasing trade volume and openness, is significantly influenced by a country's export performance. Therefore, being competitive in foreign trade is becoming increasingly important.

Relying on cheap labor and low-price competition to enter international markets can lead to negative outcomes in the terms of trade and cause a decrease in revenues from international trade. Consequently, it is necessary to increase earnings by producing and exporting high value-added products (Güneş & Akın, 2019, p. 12).

A country's level of development can be determined by the position of its manufacturing industry within the national economy. For countries, the composition of exports has started to become more important than the sheer volume of exports. To explain the process and transformation within the export composition of the manufacturing sector, distinctions have been attempted by considering technology, knowledge level, and labor quality.

For the manufacturing sector to become a driving force in economic growth, the share of high-technology products in the production and export composition must increase. Poorer countries tend to have a narrower manufacturing base, while developed countries can possess a broader one. Industrial composition changes depending on the country's development level. As income rises, the composition of the manufacturing industry shifts, defined in some studies as a transition "from light industry to heavy industry." Changes in the value-added of the manufacturing sector indicate the process and evolution of its structure. Therefore, an increase in the share of manufacturing value-added in GDP represents positive developments for a country.

One of the most important features of the manufacturing sector is that it possesses higher labor productivity compared to the agriculture and service sectors. Employment growth in manufacturing also supports an increase in average labor productivity. For instance, products that can enhance productivity in the agricultural sector (like machinery, fertilizer, and pesticides) and in the service sector (like transportation vehicles, communication, and information technologies) are developed and produced by the manufacturing industries.

Industrial value-added represents the net output obtained from the difference between an industry's gross output and its intermediate consumption. It is one of the best indicators of a country's level of industrialization. The share of manufacturing value-added in GDP shows the position of the manufacturing sector in the economy and the country's development capacity.

Table 8: Manufacturing Value Added as a Percentage of GDP for Developed Countries (%)

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Canada	10,2	10,3	10,2	10	9,9	9,9	9,9	9,8	9,8	9,6	8,5
France	10,3	10,6	10,5	10,4	10,5	10,4	10,5	10,4	10,2	10,1	9,4
Germany	19,6	20,4	20	19,9	20,4	20,3	20,7	20,9	20,8	19,9	17,4
Italy	14,1	14,2	14	14,1	14,2	14,4	14,6	14,9	15	14,8	14,3
Japan	20,5	20	20,1	19,7	20,2	20,8	20,6	21,1	21,4	21,8	19,7
South Korea	21,7	20,9	21	21	20,9	20,4	20,6	19,9	18,9	18,6	18,3
Netherlands	10,6	10,9	10,9	10,8	10,9	10,8	10,8	11,1	11,3	11,2	10,9
Switzerland	17,1	18,4	17,7	17,8	17,7	17,5	17,9	18,4	18,9	19,1	19,2
United Kingdom	10,1	10,2	9,9	9,6	9,6	9,4	9,2	9,2	9,3	9	8,6
United States	12,3	12,2	11,8	11,9	11,9	11,7	11,3	11,4	11,5	11,5	10,7

Source: **UNIDO, 2022.**

The table above provides the manufacturing value-added as a percentage of GDP for developed countries. In 2010, South Korea was the leading country with a value of 21.7%, and despite slight declines until 2020, it maintained its importance and position in the economy. Similarly, Japan, having the second-highest manufacturing value-added ratio, is among the countries that have preserved their economic development strength. Germany, Switzerland, and Italy are among the countries with good performance in terms of industrialization level, as indicated by their manufacturing value-added shares. Among the developed countries, the nations observed to have the lowest manufacturing value-added are the United Kingdom and Canada. The fact that almost every country experienced a decline in 2020 suggests that this was likely due to the global pandemic, which affected the entire world.

5. Literature

Braunerhjelm & Thulin (2008) analyzed the relationship between R&D expenditures and high-technology exports for OECD countries between 1981-1999 using panel data analysis. They concluded that a one-unit increase in R&D expenditures led to a three-unit increase in high-technology exports, while market size had no significant effect.

Vogiatzoglou (2009) examined the determinants of high-technology exports for 28 countries (2000-2005) using panel data analysis. The study found that determinants like R&D expenditures and human capital played a decisive role in the export of these products, while the real exchange rate (price competitiveness) had negative effects.

Özer & Çiftçi (2009) analyzed the relationship between R&D expenditures and total exports, high-technology product exports, and ICT exports for 19 OECD countries (1993-2005). They identified a positive and high-correlation relationship between R&D expenditures and both total exports and high-technology product exports.

Gökmen & Turen (2013), using panel cointegration analysis for 15 EU countries (1995-2010), found that economic freedom, foreign direct investment (FDI), and human development had a significant positive impact on high-technology product exports. Granger causality results indicated causality from FDI, human development, and economic freedom to high-technology exports, and from high-technology exports and economic freedom to human development.

Göçer (2013) investigated the impact of R&D expenditures on high-technology product exports for 11 Asian countries (1996-2012) using panel data analysis. The study concluded that a 1% increase in R&D expenditures led to a 6.5% increase in high-technology product exports and a 0.6% increase in ICT exports. Causality analysis showed that increases in R&D directly affected high-technology and ICT exports and indirectly affected the trade balance.

Sandu & Ciocanel (2014) studied the relationship between innovation and high-technology product exports for 27 European countries (2006-2010) using panel data analysis. Using public and private sector R&D expenditures and employment in knowledge-intensive sectors as innovation indicators, they found a positive relationship. Private sector R&D expenditures had a greater impact on high-technology exports than public R&D. A 1% increase in public R&D led to an 8% increase in exports after two years, while a 1% increase in private R&D led to a 9% increase in the same year.

Baesu et al. (2015), using panel data analysis comparing fixed and random effects models for EU countries (1994-2011), found that the number of employees in high-tech industries positively affected the number of patents, while R&D expenditure per capita had a negative impact. Other factors like education spending, government R&D, economic development, number of S&T employees, and export levels had no effect on innovation performance in the high-tech sector.

Kızılkaya et al. (2016), analyzing BRICT countries (2001-2011) with panel data, found that trade openness, R&D expenditures, and patent applications positively affected high-technology exports.

Mehrara et al. (2017), using Bayesian Model Averaging (BMA) and Weighted Average Least Squares (WALS) for 24 developing countries (1996-2013), concluded that rule of law (for institutional quality), imports (as a measure of openness), human capital, and GDP were the most important variables affecting high-technology exports in developing countries.

Kızılkaya et al. (2017), studying 12 developing countries (2000-2012) with panel data, found that FDI and trade openness positively influenced high-technology product exports.

Kabaklarlı et al. (2018), analyzing OECD countries (1989-2015) using panel data, concluded that FDI and patent applications positively affected high-technology product exports. They emphasized the importance of innovation and noted a shift in export structures towards technology-intensive products like ICT, computing, pharmaceuticals, aerospace, and electronics, which are linked to productivity and GDP growth.

Gaur et al. (2020), empirically analyzing 15 developed and developing countries (2007-2018), found that R&D expenditures and gross capital formation significantly increased high-technology exports. Outward-oriented policies with lower tariffs, developed financial markets, and higher GDP per capita facilitated high-technology exports. A one-unit increase in the real effective exchange rate increased high-technology exports by 0.104 units.

Erdinç & Aydınbaş (2020), examining 16 selected countries (2007-2018) with panel data (comparing fixed effects, random effects, and GMM models), found a significant positive relationship between high-technology product exports and both GDP and the number of patent applications. A statistically positive relationship was also found with the number of scientific journal articles.

Akay (2021) performed time-series clustering analysis on high-technology export data for Türkiye and EU countries (2007-2018) to determine Türkiye's position. Using artificial neural networks, the relative importance of determinants for Türkiye was assessed. The number of patent applications had a 100% impact level on high-technology exports in Türkiye. FDI had a 59.5% effect, R&D expenditures ranked third with 25.3%, and the Trade Openness Ratio was the least influential variable at 15.6%.

6. Methodology

6.1. Panel Data - Dynamic Panel Data Model and the GMM Method

Panel data analysis offers several advantages over other econometric research methods. The most important feature of panel data analysis is that it combines time series and cross-sectional series, creating a dataset with both time and cross-sectional dimensions. The panel data model has certain advantages over time series analysis. Firstly, in panel data models, the use of both cross-sectional and time series data increases the number of observations. This raises the degrees of freedom and reduces the likelihood of a high degree of linear relationship among the explanatory variables. Therefore, the panel data method allows for more reliable econometric estimates (Hsiao et al., 2002, p. 3 Çifçi et al., 2018, p. 115).

Another advantage of panel data analysis is that it enables the construction and testing of more complex behavioral models than those possible with only cross-sectional or time series data. This advantage ensures that omitted variables, which can lead to significant deviations in estimation results in studies using only time series or cross-sectional data, do not pose a major problem in panel data analysis (Hsiao et al., 2002, p. 3). However, panel data analysis brings along the characteristics and problems of time series as well. To minimize these problems, static and dynamic models of panel data analysis have been investigated. The Generalized Method of Moments (GMM) and its system version, one of the dynamic panel data analysis methods, have begun to be widely used (Dökmen, 2012, p. 46).

Dynamic models are defined as models where lagged values of the dependent variable are included as independent variables (Adam, 2024, p. 84).

The general representation of dynamic models is as follows (Hsiao et al., 2002, p. 69).

- $Y_{it} = Y_{(i,t-1)} + \beta 1\ X_{it} + \eta i + \lambda t + \varepsilon_{it}$ i=1,….,,N and t=1,….,T (1)
- X_{it}, "Kx1" the vector of independent variables in the dimension;;
- β_1, "Kx1" the matrix of coefficients in the dimension;
- $Y_{i,t-1}$, the lagged value of the dependent variable Y_it
- η*i* unobserved individual effects
- λ_t, unobserved time-specific effects
- ε_{it} epresents the effect of unobserved variables that vary across cross-sectional units and over time (the error term). In the model, it is assumed that ηi and λt are constant.

In dynamic models, the correlation between the lagged value of the dependent variable and the error term leads to biased and inconsistent results in the estimates (Baltagi, 2005, p. 135). To address this issue of bias and inconsistency, instrumental variables are used in place of the lagged dependent variable. The relationship established in the dynamic model creates an endogeneity problem between the explanatory variables and the error term. In this case, the GMM estimation methods, a dynamic panel data method developed by Arellano and Bond (1991), are used to solve the problems of endogeneity and autocorrelation (Arellano and Bond, 1991, p. 278).

Among the estimators based on the GMM method, the estimator developed by Arellano and Bond (1991) is widely used. This approach, known as Difference GMM, addresses the model within the framework of the first differences of the variables to eliminate specific effect components and uses lagged values of the independent variables as Instrumental Variables. Another dynamic model estimator based on the GMM method is the System GMM approach developed by Arellano and Bover (1995). This approach is based on combining the difference equation with the level equations. Blundell and Bond (1998) revealed that Difference GMM has weak estimation power in finite samples and its coefficient estimates are biased, and they determined that System GMM has higher estimation power (Yaşar, 2021; Dökmen, 2012, p. 46).

The situations where the two aforementioned GMM estimators are used are listed below (Yaşar, 2021):

- When the time dimension (T) in the panel data is smaller than the cross-sectional dimension (N), i.e., when the number of observations is greater than the time span;
- For cases where a linear functional relationship exists;
- For cases involving a single, dynamic dependent variable influenced by its past values;
- When the independent variables are not strictly exogenous;
- For cases with fixed individual effects;
- Finally, GMM estimators are used in the presence of heteroskedasticity and autocorrelation over time, but not across cross-sectional units.

6.2. GMM Estimation Methods

Arellano (2003) presented the GMM model as follows:

$Y_{it}=Y_{i(t-1)}+X_{it}\ \beta+n_i+u_{it}$, and $E(u_{it}/X_{i1},\ldots\ldots,X_{iT}\,n_i=0\ (t=1,\ldots..T)$ (2)

The model includes lagged values of X and lagged values of Y. In the model, X is not correlated with past, present, or future values of the error term u. In other words, "x" is an exogenous variable and is only related to the individual effect "n".

In static panel data models, the use of lagged values of the dependent variable leads to a correlation between these lagged values and the error term, which can cause serious problems. Therefore, there are differences between dynamic panel models and fixed or random effects models (Bahar and Bozkurt, 2010, p. 261; Yaşar, 2021).

When first-difference equations are applied, the variability between groups can be eliminated from fixed and random effects models. However, in this case, the model is:

$Y_{it}-Y(_{it}-1)=\beta\ (X_{it}-X(_{it}-1))+\delta(Y(_{i,t-1})-Y(_{i,t-2}))+(\varepsilon_{it}-\varepsilon(_{it}-_1)$ (3)

takes this form. However, here too, problems arise due to correlation issues between the lagged dependent variables $(Y_{(it-1)}-Y_{(it-2)})$ and $(\varepsilon_{it}-\varepsilon_{(it-1)})$. To resolve these problems, it is recommended to use some instrumental variables that enable the estimation of the dynamic model (Anderson and Hsiao, 1981; Arellano and Bond, 1991, p. 598-604).

At this point, Anderson and Hsiao (1981) suggest using lagged variables with different lag levels, such as $Y_{(it-2)}$ and $Y_{(it-3)}$, which are more lagged values, as instrumental variables instead of $Y_{(it-1)}$. They emphasize that these lagged variables to be used are correlated with the explanatory variables but cannot be correlated with the error term. Dynamic panel data models can be estimated consistently with such instrumental variables, but inefficient estimators can be obtained (Arellano and Bond, 1991, p. 279). These inefficient estimators result from not using all possible instrumental variables. If lagged observations like $Y_{(it-2)}$, $Y_{(it-3)}$, or $Y_{(it-3)}$ are not correlated with $(\varepsilon_{it}-\varepsilon_{(it-1)})$, then these variables considered are valid lagged variables. Therefore, all valid lagged variables should be used as instrumental variables for dynamic panel data models. Thus, GMM estimators, which eliminate differences in unobserved individual effects, use all possible lags of the dependent and independent variables as instrumental variables (Arellano and Bond, 1991, p. 278-283). For this purpose, GMM estimators are used in two stages. One-step estimation (GMM1) assumes that the error terms have constant variance across groups and over time, while two-step estimation (GMM2) considers that the error terms may be heteroskedastic.

There are some modeling tests suggested by Arellano and Bond (1991) to be used along with the GMM technique in dynamic panel data model estimations. The first is the Wald test, used to test the joint significance of the independent variables. The second is the Sargan test, conducted regarding the validity of the instrumental variables used in the GMM estimation (Yaşar, 2021; Bozkurt, 2008, p. 98-99).

GMM-System Technique: A high number of autoregressive parameters or a persistently high ratio of residual error variance to unit effect variance causes the Arellano-Bond estimator to weaken. The method of orthogonal deviations is used to prevent problems arising from the complete loss of some data when first differences are taken. Arellano and Bover (1995) recommend using the System GMM method, one of the dynamic panel data model estimators, and the use of efficient instrumental variables. This aims to prevent the data loss that occurs as a result of taking first differences (Arellano and Bover, 1995, p. 30-31).

Using the past differences of variables as instrumental variables is expressed as the Difference GMM method developed by Arellano and Bond, while using the level variables as instrumental variables instead of difference equations is expressed as the System GMM method (Arellano and Bover, 1995, p. 30).

According to Roodman (2009), there are three basic conditions for the reliability of the System GMM method:

- The condition of no second-order autocorrelation in the model must be met.
- The number of instrumental variables should not exceed the number of observations.
- The lagged value of the dependent variable in the model must be less than one.

Blundell and Bond (1998) compared the System GMM estimation method with other GMM estimators and concluded that the System GMM estimator is a better and more reliable estimator. Blundell et al. (2000), using a Monte-Carlo simulation, found that System GMM estimation gives better estimation results (Blundell and Bond, 2001, p. 2-3). The System GMM estimator not only increases precision but also reduces finite sample bias (Baltagi, 2005, p. 147). System GMM estimators make it possible to include the lagged values of the dependent and independent variables as instrumental variables in the model (Arellano and Bond, 1991, p. 277). Roodman (2009) further developed the Arellano and Bover / Blundell and Bond method used for System GMM estimation. The output obtained from the estimation using this method provides more test results. Furthermore, with the added options, it ensures consistent results are obtained in the presence of both heteroskedasticity and autocorrelation. The characteristics of the lag structure are more flexible than the standard Arellano and Bover / Blundell and Bond method, and the endogeneity of variables can also be modeled. This method can be used in models where N is large and T is small (Roodman, 2009, p. 86).

In the analysis with the System GMM method, efficiency is increased by using more instrumental variables. For the System-GMM method, models are estimated using the "xtabond2" command in the "Stata-17" statistical package program (Yaşar, 2021). The most important advantage of this command is that it allows endogenous and exogenous variables to be included in the model as instrumental variables separately (Roodman, 2009, p. 87).

As in GMM estimation, performing some tests is also recommended for System GMM estimation. For this, firstly the Wald test and secondly the Sargan test are performed. Unlike GMM estimation, in System GMM estimation, the Difference-Sargan test statistic is used for the validity of the additional instrumental variables included in the model. This statistical test is calculated by the difference between two separate Sargan tests calculated with the System GMM and GMM-Dif estimates. Finally, AR(1) and AR(2) tests are performed to test for autocorrelation in the model (Yaşar, 2021; Bozkurt, 2008, p. 99).

Specification Tests in GMM Analysis: There are a number of specification tests recommended to be used along with the GMM technique in the estimation of dynamic panel data models. These tests are the Wald test, which measures the joint significance of the independent variables, and the Sargan and Hansen tests, which are conducted regarding the validity of the instrumental variables used in GMM estimations. Additionally, the presence of autocorrelation in the error terms of the model is examined with AR(1) and AR(2) tests (Labra and Torrecillas, 2018, p. 48).

The Sargan and Hansen test statistics help in testing the exogeneity of the instrumental variables in the analysis. The Sargan test examines the suitability (strict exogeneity) of the instrumental variables used in the analysis. The first stage of the test involves performing a regression analysis using all instrumental variables and obtaining the error terms from this analysis. In the second stage, the obtained error terms are analyzed as the dependent variable of a regression that does not include the instrumental variables. The Sargan statistic is expressed using the R^2 value obtained from the second analysis as follows:

$$SAR = (n-k)\,R^2 \qquad (4)$$

In the text above, "n" represents the number of observations and "k" represents the number of variables in the first-stage regression. With the number of instrumental variables being "s" and the number of endogenous variables being "q", the SAR value follows a chi-square distribution with (s-q) degrees of freedom. The null hypothesis of the test is that all instrumental variables are valid. If this hypothesis is rejected, it is concluded that at least one instrumental variable is inappropriate. The Sargan test is used in one-step estimations and in samples that do not carry excessive risk. If the estimation is done with a homoskedastic weight matrix, as in the one-step case, the Sargan test is sufficient.

The Hansen test, on the other hand, detects over-identification in the presence of a heteroskedastic matrix (Baum, Schaffer, and Stillman, 2003, p. 3). Therefore, the Hansen test is recommended for detecting over-identification in two-step estimations. The null hypothesis (H0) of the Hansen test is the same as that of the Sargan test; both test for the presence of over-identifying restrictions. H1 = The over-identifying restrictions are valid. The criterion for rejecting or failing to reject the hypothesis is as follows: If the obtained probability value (p-value) is equal to or greater than 0.05, the instruments used in the estimation are valid, and there is no over-identification (prob > $chi^2 \geq 0.05$). If the probability value is less than 0.05, it indicates that the instruments are not valid and that there is over-identification in the model. Therefore, the null hypothesis is rejected (Yaşar, 2021). To prevent the over-identification problem in the model, the number of units or groups must be greater than the number of instruments used. Consequently, when using long panels, it becomes necessary to reduce the number of instruments (Labra and Torrecillas, 2018, p. 40-41).

Following the Sargan and Hansen tests, the validity of subsets of instrumental variables is tested using the Difference-in-Sargan test or the Difference-in-Hansen test. The Difference-in-Sargan and Difference-in-Hansen tests are used to test the null hypothesis that the additional moment conditions required for System GMM are valid. The higher the p-value obtained from these tests, the stronger the validity of the subset of instrumental variables (Heid, Langer, and Larch, 2012). In addition to these tests, the presence of autocorrelation in the error terms of the model is examined using AR(1) and AR(2) tests (Labra and Torrecillas, 2018, p. 40-41).

7. Dataset, Analysis, and Findings

This study examines the impact of significant high-technology determinants on the share of high-technology product exports. For 105 selected countries (those for which data accessibility was possible) between 2010 and 2019, the variables specified in the table below were used. The study was analyzed using the System-GMM estimator for a dynamic panel data model. The dependent variable in the model is high-technology exports as a share of total exports; the independent variables used in the dataset are the education index, foreign direct investment, GDP, trade openness ratio, and total patent applications.

Table 12: Definition of Variables Used in the Model		
Variables	**Definitions**	**Source**
YTI	**High-technology exports (% of manufacturing exports)**	World Bank (TX.VAL.TECH.MF.ZS)
EI	**Education Index**	UNDP
DYY	**Foreign direct investment, net inflows (% of GDP)**	World Bank (BX.KLT.DINV.WD.GD.ZS)
GDP	**GDP (constant 2015 US$)**	World Bank (NY.GDP.MKTP.KD)
TI	**Trade openness ratio (% of GDP)**	World Bank (NE.TRD.GNFS.ZS)
PT	**Total patent applications**	World Bank ([IP.PAT.RESD + IP.PAT.NRES)

The following hypothesis has been formulated regarding the impact of the selected independent variables on high-technology product exports in the study. In the dynamic panel data model constructed with the above data, the lagged value of high-technology exports, which is taken as the dependent variable, is used as an independent variable.

$$LnYTI_{it}=LnYTI(_{it-1})+ \beta_0+\beta_1 \; LnEI_{it}+\beta_2 \; LnDYY_{it}+\beta_3 \; LnGDP_{it}+\beta_4 \; LnTI_{it}+\beta_5 \; LnPT_{it}+\varepsilon_{it} \qquad (5)$$

- $i=1,\ldots\ldots,105$ *and* $t=2010,\ldots\ldots2019$
- β_0 : Contant
- $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$: Coefficients to be estimated
- ε_{it} : Error term
- i : Country
- t : Time.
- **(YTI_it)** represents high-technology exports as a share of total exports.
- **(YTI_(it-1))** represents the one-period lagged value of the dependent variable (high-technology exports).
- **(EI_it)** represents the Education Index.
- **(DYY_it)** represents Foreign Direct Investment.

- **(GDP_it)** represents Gross Domestic Product.
- **(TI_it)** represents the Trade Openness ratio.
- **(PT_it)** represents the total number of Patent Applications.

Tablo 13: Descriptive Statistics.					
Variable	**Obs**	**Mean**	**St.**	**Min.**	**Maks.**
lnYTI	1050	1.9002	1.2987	-5.9215	4.183
lnEI	1040	-.3715	.2642	-1.7148	-.0587
lnGDP	1050	25.3559	1.9248	21.9814	30.6255
lnTI	1029	4.3736	.558	2.4728	6.0927
lnPT	821	7.0294	2.5567	1.0986	14.2486
LnDYY	994	1.083	1.161	-6.394	5.635

Table displays the number of observations, median, standard deviation, minimum, and maximum statistics for the dependent and independent variables used in the analysis. Upon examining the descriptive statistics of the variables, it is observed that the difference between the minimum and maximum values is relatively small. However, the standard deviation is found to be high, correlating with the increase in patent applications. Additionally, the difference between the minimum and maximum values for patent applications is quite substantial. Nevertheless, the standard error values are at a desirable level, and these values of the variables are deemed suitable for the parametric tests to be conducted.

Table 14: Analysis Results

Dependent Variable LnYTI	(1) OLS Pooled	(2) Fixed Effect	(3) One Step GMM	(4) Two Step GMM
L.lnYTI	.8035*** (.0553)	.2315** (.1012)	.3083*** (.0492)	.3077*** (.0365)
lnEI	.2082 (.1408)	1.1834 (.874)	.7118*** (.1156)	.7549*** (.2242)
lnDYY	.0205 (.0174)	.0135 (.0171)	.2401*** (.0541)	.1415*** (.0409)
lnGDP	.0114 (0317)	.362 (.3201)	.1216*** (.0272)	.0965** (.0473)
lnTI	.1271** (.0523)	-.0398 (.1936)	.2519*** (.0627)	.3232*** (.0851)
lnPT	.0469** (.0197)	.1405 (.0914)	.0966*** (.0207)	.0845** (.0334)
_cons	-.7341 (.8013)	-82199 (8.5413)	-3.5877*** (.6859)	-2.9718** (1.212)
Obs.	697	697	631	631
Year Dummy	YOK	YOK	VAR	VAR
AR(1)			0.000	0.032
AR(2)			0.269	0.523
Sargan Test			0.485	0.485
Hansen Test				0.263
Wald Test			0.0000	0.0000
Number of Instrumental Variable			50	50

Note 1: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.
Note 2: The values in parentheses represent the t-statistics based on robust standard errors estimated using the *Windmeijer (2005) finite-sample correction.*

The table presents the results of the analysis applied to the model. To measure the joint significance of the independent variables, the Wald test was used. The Sargan and Hansen tests were conducted to assess the validity of the instrumental variables used for the GMM estimator. Additionally, the presence of autocorrelation in the error terms of the model was examined using AR(1) and AR(2) tests (Labra and Torrecillas, 2018, p. 48).

The Wald test statistic in Table 14 measures whether the model as a whole is significant. The hypotheses established to measure the significance of the Wald test statistic are as follows:

- H0: "The independent variables do not have sufficient explanatory power for the dependent variable."
- H1: "The independent variables have sufficient explanatory power for the dependent variable."

According to the Wald test result, the H0 hypothesis stating that "the independent variables do not have sufficient explanatory power for the dependent variable" is rejected. Therefore, by rejecting the null hypothesis, the models are found to be significant as a whole.

The Sargan and Hansen tests examine the validity of the "instrumental variables". The H1 hypothesis for the Sargan and Hansen tests is "the instrumental variables are valid", i.e., "the over-identifying restrictions are valid". The H1 hypothesis is "the instrumental variables are not valid". According to the Sargan and Hansen test results, since the probability value (p-value) is greater than 0.05, the H0 hypothesis stating that "the instrumental variables are valid" is accepted ($p > 0.05$). Accordingly, it can be interpreted that "the over-identifying restrictions are valid".

The Arellano-Bond AR(1) and AR(2) tests allow for testing the autocorrelation problem in the model. The hypotheses for the AR(1) and AR(2) tests are:

- H0: There is no autocorrelation in the model.
- H1: There is autocorrelation in the model.

In GMM estimators, more accurate results can be achieved when first-order autocorrelation is present but second-order autocorrelation is absent. The absence of second-order autocorrelation is considered sufficient to obtain more accurate results in the model. According to the AR(1) and AR(2) test results in the table, first-order autocorrelation is detected in the model, while second-order autocorrelation is not found.

The analyses began initially with Pooled Ordinary Least Squares (OLS) and Fixed Effects estimations. The Pooled OLS estimator forms the upper bound, and the Fixed Effects estimator forms the lower bound. Thus, the lower bound is 0.231, and the upper bound is 0.803. In the Pooled OLS estimation, the lagged value of the dependent variable (high-technology exports) was significant at the 1% level, while trade openness and patent applications were significant at the 5% level. The Education Index, Foreign

Direct Investment, and GDP were not significant in the Pooled OLS estimation. From this, it can be inferred that trade openness and patent applications affect high-technology exports more than the other variables. In the Fixed Effects estimation, the lagged high-technology exports (the lagged value of the dependent variable) is statistically significant at the 5% level. The other independent variables were statistically insignificant.

According to the panel data analysis results, the lagged value of high-technology exports (L.lnHTE) is significant at the 1% level in the System-GMM model. According to the One-step GMM model, there is a statistically significant relationship at the 1% level between high-technology exports and all other independent variables. According to the Two-step GMM model; there is a statistically significant and positive relationship at the 1% level between high-technology exports and the Education Index, Foreign Direct Investment, and Trade Openness variables. Furthermore, there is a statistically significant and positive relationship at the 5% level between high-technology exports and GDP and Patent Applications.

According to the analysis, the Education Index (lnEI) is significant at the 1% level in both the One-step and Two-step GMM estimations. A 1% increase in the Education Index increases high-technology exports by 0.711% in the One-step GMM model and by 0.754% in the Two-step GMM model. Foreign Direct Investment (lnFDI) has a significant effect on high-technology exports at the 1% level in both the One-step and Two-step GMM models. A 1% increase in the Education Index increases high-technology exports by 0.240% and 0.141% in the One-step and Two-step GMM models, respectively. Gross Domestic Product (lnGDP) was found to be statistically significant at the 1% level in the One-step model and at the 5% level in the Two-step model. A 1% increase in GDP led to an increase of 0.121% for the One-step GMM model and 0.096% for the Two-step GMM model. The Trade Openness variable was insignificant in the Pooled OLS and Fixed Effects estimations but was significant at the 1% level in the One-step GMM and at the 5% level in the Two-step GMM. A 1% increase in the Trade Openness variable led to an increase of 0.251 in the One-step GMM and 0.323 in the Two-step GMM. Finally, the Patent Applications variable was significant at the 5% level in the Pooled OLS model but yielded an insignificant result in the Fixed Effects model. A 1% increase in Patent Applications led to an increase of 0.096 in the One-step GMM and 0.084 in the Two-step GMM.

Conclusions and Recommendations

Technological advancements are a fundamental force for economic development and growth for countries. However, it is not sufficient for countries to merely produce technology. Therefore, countries must produce high value-added products within their export share. The value-added shares of produced products are distinguished according to their technology levels. This classification, made by the OECD in 2011, separates products into high-technology, medium-high-technology, medium-low-technology, and low-technology. Since high-technology products are high value-added products, they ensure sustainability for countries' development and growth.

The developed and developing countries discussed in the second section were selected for the purpose of comparing certain indicators. It can be said that the share allocated to R&D expenditures is higher in developed countries, resulting in an accompanying increase in patent applications, and the economy grows, making the countries more open to foreign trade. Developing countries, on the other hand, aim for economic development and try to produce technology-intensive products by procuring the necessary inputs from developed countries. When the tables are examined, significant declines are seen in the data for both developed and developing countries in 2020. Based on this, it can be interpreted that the Covid-19 pandemic, declared a pandemic by the World Health Organization, had negative effects in all countries.

In this study, the panel data analysis method was used for 105 selected countries with annual data for the 2010-2019 period. Analyses were completed using Pooled Ordinary Least Squares, Fixed Effects, and the System GMM method. The impact of high-technology product export determinants on total high-technology exports was examined using the one-step and two-step System GMM methods. According to the study results, the lagged value of high-technology exports (L.lnHTE) was found to be significant at the 1% level in the System GMM models. According to the One-step GMM model, there is a statistical significance at the 1% level between high-technology exports and the independent variables. According to the Two-step GMM model, a statistically significant and positive relationship at the 1% level was found between high-technology exports and the Education Index, Foreign Direct Investment, and Trade Openness variables. Furthermore, there is a statistically significant and positive relationship at the 5% level between high-technology exports and GDP and Patent Applications.

According to the analysis, all independent variables determined as high-technology determinants in the System GMM model were significant for high-technology exports. An increase in the number of patent applications in a country means that new technology is being produced and developed, and the number of new products is increasing numerically. Patents are the transformed state of R&D into production. Therefore, patents have a positive relationship with R&D expenditures and GDP. A high Trade Openness ratio, considered as another variable, positively affects a country's trade volume. The Trade Openness ratio enables a country to source missing inputs for high-technology exports from other countries. Therefore, countries should increase their trade openness ratio in foreign trade competition. Another high-technology determinant used in the study is Foreign Direct Investment. Due to capital inadequacy, countries' need for foreign direct investments increases in production, exports, and productivity growth. For these determinants affecting high-technology exports, countries allocating more resources is crucial for the sustainability of economic growth.

In light of the literature reviewed in the thesis, the findings align with the results of Kabaklarlı (2018), Erdinç and Aydınbaş (2020), Gökmen and Turen (2013), Kızılkaya et al. (2017), Mehrara et al. (2017), and Akay (2021), who found that foreign direct investment, patent applications, GDP, and trade openness have a positive effect on high-technology exports. In the study by Baesu et al. (2015), the effect of patent applications on high-technology exports was positive, while the effect of R&D expenditures per capita was found to be negative. This result is also consistent with the analysis findings of this thesis.

In the literature, the determinants of high-technology product exports have been investigated with different analytical studies. However, no study was found that applied the System GMM method using multiple variables, countries, and years with a broader sample set. When previous studies are examined, it is seen that one or a few of the high-technology determinants were addressed and their relationship with high-technology product exports was investigated. In this study, high-technology determinants are addressed in a more holistic manner. The effect of the high-technology determinants used in the thesis on high-technology product exports is interpreted using the System GMM method, which is one of the dynamic model estimators. In future studies, using more current data and more variables, the impact strength of high-technology determinants in each developed and developing country could be tested with a different analysis method. Another suggestion could be to examine the effect of foreign direct investment determinants on high-technology exports.

Based on the analysis results, countries should support all kinds of initiatives that positively affect high technology. They should increase the share allocated to R&D expenditures to obtain more output. By giving more importance to education and science, they should positively influence the scientific publications of the young population. More incentives should be provided for young entrepreneurs, and policies to increase the number of patents should be developed. Special institutions should be established to discover new talents, and innovation-focused training should be provided there. Education should not remain only theoretical; at the same time, schools equipped with technology should be opened, allowing for original work and project preparation. Thus, young people developing themselves in these places will be able to increase the rate of qualified labor force by working in factories or institutions possessing smart systems and devices.

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