Research Article

Empirical Analysis of The Competitiveness of High-Tech Export Goods Based on Porter's Diamond Model*

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Abstract: Export-based growth strategies have led to increasing economic competition between countries. A country's global competitiveness is shaped by the influence of various factors, and determining these factors is of great importance. This study, which examines the determinants of competitiveness, is based on Porter's (1990) Diamond Model. In addition, three different models were developed in line with Dunning's (1992) contributions to Porter's Diamond Model and an alternative perspective. In this research, which covers Türkiye and 11 European Union member countries, annual data between 1995-2019 were used. In the study, the competitiveness index developed by Balassa was calculated for two different groups of goods that require high technology and are included in the Harmonized System. To explore the relationships among the variables, the Seemingly Unrelated Regression (SUR) method was applied. The empirical findings revealed that determinants such as market demand, resource conditions, industry support structures, competitive strategies, regulatory policies, and productivity levels have statistically significant both positive and negative effects on international competitiveness. In addition, it has been determined that the effects of these variables differ both across the examined commodity groups and countries.

Keywors: International Competitiveness, Porter's Diamond Model, Revealed Comparative Advantages, Panel SUR
Jel Codes: F14, C33, L62

İleri Teknoloji Gerektiren İhraç Malların Rekabet Gücünün Porter'ın Elmas Modeline Dayanarak Ampirik Analizi

Öz: İhracata dayalı büyüme stratejileri, ülkeler arasındaki ekonomik rekabetin giderek artmasına neden olmuştur. Bir ülkenin küresel rekabet gücü, çeşitli faktörlerin etkisiyle şekillenmekte olup, bu faktörlerin belirlenmesi büyük önem taşımaktadır. Rekabet gücünün belirleyici unsurlarının incelendiği bu çalışmada Porter'ın (1990) Elmas Modeli temel alınmıştır. Ayrıca, Dunning'in (1992) Porter'ın Elmas Modeli'ne sunduğu katkılar ve alternatif bir bakış açısı doğrultusunda üç farklı model geliştirilmiştir. Türkiye ve Avrupa Birliği'ne üye 11 ülkeyi kapsayan bu araştırmada, 1995-2019 yılları arasındaki yıllık veriler kullanılmıştır. Çalışmada, Harmonize Sistem kapsamında yer alan ve yüksek teknoloji gerektiren iki farklı mal grubu için Balassa tarafından geliştirilen rekabet gücü endeksi hesaplanmıştır. Değişkenler arasındaki ilişkileri belirlemek amacıyla Görünürde İlişkisiz Regresyon (SUR) yöntemi uygulanmıştır. Ulaşılan ampirik bulgular, pazar talebi, kaynak koşulları, endüstri destek yapıları, rekabet stratejileri, düzenleyici politikalar ve verimlilik düzeyleri gibi belirleyici unsurların uluslararası rekabet gücü üzerinde istatistiksel olarak anlamlı hem olumlu hem de olumsuz etkiler yarattığını ortaya koymuştur. Ayrıca, bu değişkenlerin etkilerinin hem incelenen mal grupları hem de ülkeler bazında farklılık gösterdiği tespit edilmiştir.

Anahtar Kelimeler: Uluslararası Rekabet Gücü, Porter'ın Elmas Modeli, Açıklanmış Karşılaştırmalı Üstünlükler, Panel SUR
Jel Kodları: F14, C33, L62

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1. Introduction

International competitiveness (ICP) serves as a commonly utilized metric for assessing a country's macroeconomic performance and can be examined at the firm, industry, and national levels. The basis of the concept of competitiveness is productivity, that is, production per worker. Research has shown that businesses that compete with world-leading companies in a sector increase their overall performance in the sector (Durand & Giorno, 1987; Carbaugh, 2005).

Studies on international competitiveness trace their theoretical foundations back to Adam Smith's Theory of Absolute Advantage and David Ricardo's Theory of Comparative Advantage. Over time, the evolving body of research has focused on how trade flows are shaped in the context of comparative advantage, particularly emphasizing the opportunity costs associated with domestic production of different goods (Liu, 2017).

The concept of international competitiveness was first formally defined in the early 1980s in a report by the UK Treasury (1983). The report indicated that ICP denotes the ability of a country's producers to compete successfully with imported goods, both in international markets and within the domestic market. Competitiveness is generally evaluated based on a country's economic size and level of development, and its portion in the domestic market (Capobianco-Uriarte et al., 2019).

The most basic feature of international competitiveness is that it is expressed by the competitive advantage of a country's firms compared to firms in other countries. The Institute for Management Development (IMD) calculates the ICP based on the weighted average of more than 300 competitiveness indicators classified under four main categories (Depperu & Cerrato, 2005; Salvatore, 2013). Competitiveness is a concept that can have different meanings depending on the context and level and is addressed at three separate but interconnected levels. These levels are classified as the micro level, which expresses the competitiveness of businesses, the meso level, which is evaluated on a sectoral basis, and the macro level, which analyzes the competitiveness of countries (Ajitabh & Momaya, 2004; Ülengin et al., 2014). Porter emphasizes that competition in international markets occurs not between countries but between firms. Accordingly, competitiveness at the firm level can be described as a business's ability to offer higher product and service quality compared to its competitors in both local and global markets, as well as its ability to develop superior marketing strategies (Ajitabh & Momaya, 2004; Aktan, 2010).

Porter (1990) defines an industry as a group of firms producing similar or interchangeable products. Industry-level competitiveness refers to a concept of competition that includes not only cost factors but also productivity factors. The more different the production structures of industries are, the more significant differences will occur between firms in terms of cost and productivity, and this will lead to a divergence in the competitiveness between industries (Drescher & Maurer, 1999; Flanagan et al., 2007; Azgün, 2017). In recent years, with the impact of globalization, the importance of country-specific factors among the factors determining competitiveness has been increasingly emphasized. It has been stated that the structural characteristics of an economy have an impact on the competitiveness of both firms and sectors. Since elements such as infrastructure and education system constitute the basic building blocks of the country's economy, they can contribute to the increase of national competitiveness by creating a direct impact on businesses and industries (Depperu & Cerrato, 2005; Carbaugh, 2005; Carayannis & Sagi, 2001).

Considering the economic effects of the increase in competitiveness, the importance of this study is more clearly understood. This study seeks to determine the determinants of international competitiveness for Türkiye and 11 European Union member states across two product categories. The main starting point of this study is based on modern theories explaining international competitiveness. In this context, Porter and Dunning's approaches will be analyzed empirically on two different groups of goods. It is anticipated that the data-supported testing of these approaches will make significant contributions to the relevant literature. Porter (1990) has demonstrated that the competitive power of

sectors and therefore nations is fed by different sources. However, empirically measuring and testing the effectiveness of these sources is not a common practice in the literature. In general, new theories explaining international competitiveness have been addressed at a more theoretical level and have not been sufficiently supported by empirical studies. One of the elements that differentiates this study from other studies is that an alternative model is proposed based on the Porter and Dunning approaches. The model in question is a synthesis of existing approaches, draws attention to the fact that competitiveness is affected by the efficiency of resources and empirically tests this relationship.

This study makes a significant contribution to literature by going beyond traditional and new trade theories in explaining international competitiveness and by empirically testing Porter's Diamond Model and Dunning Approach. While competitiveness is usually addressed at a theoretical level and through index comparisons, this study concretely reveals the impact of proxy variables on different commodity groups and countries through dynamic panel data analysis. In addition, the alternative model developed synthesizes existing theoretical frameworks by addressing competitiveness with a more holistic and efficiency-based approach and prepares the ground for policy recommendations.

The literature review reveals that studies on international competitiveness predominantly involve the calculation of competitiveness indices, through which countries are compared and ranked based on the index values of specific product groups. However, it is evaluated that such comparisons may be insufficient in developing policy recommendations to increase competitiveness. Therefore, in this study, econometric analysis of the factors determining international competitiveness using the dynamic panel method provides an important contribution.

In the first part of the study, modern theories explaining international competitive power will be included. In the second part, research on competitiveness, international competitiveness and factors affecting the export performance of countries will be examined. The findings will be presented in a table form and the variables discussed in the literature will be explained in line with the variables used in this study.

In the third section, the product groups examined in the empirical study, the analyzed period range, the countries covered by the study and the representative variables of the determinants affecting the international competitiveness will be discussed. In addition, the preliminary tests applied to reach the final estimator, the details of the model created, the general parameter estimation results for the relevant countries and the model comparisons will be presented. At the end of the study, the empirical findings will be evaluated and policy recommendations will be developed.

2. Theoretical Framework

2.1. Porter Approach

Michael E. Porter, widely recognized as a leading authority in competitive strategy and in analyzing the social and environmental aspects of business activities, introduced the "Diamond Model" as a framework to evaluate the competitive advantage of nations (Kharub & Sharma, 2017). In this model, Porter (1990) explored how certain countries achieve a competitive edge over others in the framework of global competition. Porter further highlighted the inadequacy of the theories proposed by Adam Smith and David Ricardo in accounting for the competitive strength of contemporary nations, especially in terms of technological advantage (Afzal et al., 2019; Amiri Aghdaie et al., 2012). Porter emphasized that a country's level of welfare is directly related to its competitiveness and defined sectoral competitiveness as the competitive advantage a country offers in the international market (Snowdon & Stonehouse, 2006; Zhao, 2018).

Porter's Diamond Model explains a country's sectoral competitive advantage through four basic elements. These elements are factor conditions, demand conditions, related and supporting industries, firm strategy, structure and rivalry (Fang et al., 2018).

Porter also suggests government policies and the chance factor (exogenous shocks) as two additional factors that support and complement national competitiveness but do not provide lasting competitive advantages (Smit, 2010). According to Porter's thesis, these factors interact with one another to create conditions that foster innovation and contribute to the development of advanced competitive advantage (Aghdaie et al., 2012).

2.2. Factor Conditions

Porter (1990) emphasizes that fundamental production elements—such as labor, land, natural resources, capital, and infrastructure—play a significant role in shaping economic activities. The availability of these factors also contributes to the formation of the balance between exports and imports (Tsiligiris, 2018). Porter divided these factors into four groups: basic, advanced, generalized and specialized factors. For example, climate and unskilled labor are among the basic factors, while qualified labor and knowledge are included in advanced factors. While educated labor is shown as an example of generalized factors, labor productivity is evaluated within the scope of specialized factors (Afzal et al., 2019; Bakan & Doğan, 2012; Jin & Moon, 2006). Competitive advantage is assumed to arise from differences in factor conditions.

2.3. Demand Conditions

The second important factor determining national competitive advantage in a sector is the domestic demand conditions for the product or service offered by the sector. These conditions cover various dimensions such as quantity, quality and innovation level of demand in the domestic market. The impact of domestic demand on economies of scale significantly shapes the innovation processes and development speeds of firms within the country. The Porter Model sees the nature of domestic demand as a driving force in the quality improvement processes of firms. In addition, similarities and differences between domestic market demand and global demand can also play a decisive role in a country's competitiveness (Porter, 1990; Tsai et al., 2021; Tsiligiris, 2018).

2.4. Related and Supporting Industries

The third important element that determines the national competitive advantage in a sector is the existence of supporting and related sectors in the country that have both horizontal and vertical relations with the target sector at the international level. Related sectors include industries that share certain customer groups, factors of production, or technologies, while supporting sectors are defined as industries with strong supplier networks and efficient distribution systems. The existence of these sectors contributes significantly in increasing the competitiveness of companies (Mehrizi & Pakneiat, 2008; Porter, 1990; Tsiligiris, 2018). Industries that achieve success at the national level are often linked vertically (buyer-supplier relationship) or horizontally (common customer base, technology sharing, etc.). While vertical clusters ensure the establishment of high quality standards, horizontal clusters contribute to the development of competitive firms (Bakan & Doğan, 2012).

2.5. Firm Strategy, Structure and Rivalry

Porter (1990) believes that a nation's competitive advantages stem from continuous innovation and industrial upgrading and that domestic competition is more important than international competition. However, Porter argues that in order to attain world-class competitiveness, firms must be exposed to more intense pressures and challenges such as operating within a highly competitive domestic market, meeting strong demand for quality, benefiting from the support of related industries, and possessing specialized production factors (Tsai et al., 2021; Tsiligiris, 2018).

2.6. Government

Monetary, financial, and business policies implemented by governments; along with support strategies, regulatory frameworks, trade legislation, exchange rate management, money supply, inflation rates, public expenditures, and both macroeconomic and microeconomic policies, can have a direct effect on the competitiveness of firms, sectors, and nations. In addition, official and unofficial political agreements and political and economic relations established or terminated with other countries also play a decisive role in competitiveness (Aghdaie et al., 2012). Porter (1990) suggests that governments influence factor conditions by implementing policies related to public participation, education, and financial market regulation. Additionally, they can shape domestic demand conditions by establishing product standards and regulatory frameworks. Competition laws, tax policies, and other regulatory frameworks can have a direct impact on the structure and strategy of both supporting industries and firms (Wu, 2006).

2.7. Chance

Chance refers to external factors that can influence or provide an advantage to a country or industry, yet remain beyond the direct control of firms or governments. Due to differing industry structures and stages in their life cycles, businesses may interpret and respond to such unforeseen events in various ways. Porter (1990) argues that firms continuously encourage innovation and development, striving to capitalize on emerging, unexpected opportunities (Wu, 2006).

2.8. Dunning Approach

Many academics and researchers who conduct research on international competitiveness criticize the Diamond Model developed by Porter for focusing only on domestic dynamics and not giving enough space to global connections. Dunning, one of the first academics to criticize the model, stated that Porter bases competitive advantage on only four basic sources and ignores investment and entrepreneurship factors. Dunning also emphasizes that the model does not sufficiently take into account the interaction between the national economy and multinational corporations (Manavkat, 2014; Süygün, 2013). Dunning (1993) emphasized the increasing importance of multinational corporations and stated that these corporations have an indirect or direct impact on the competitiveness of countries. Dunning, who critiqued Porter's Diamond Model for not giving enough space to the globalization factor, developed the Double Diamond Model to eliminate this deficiency. The model highlights the significance of multinational companies and foreign direct investment in shaping competitive advantage (Ariç, 2013; Tombak, 2018; Yılmaz, 2018).

The Dunning approach provides a significant extension of Porter's Diamond Model to the global dimension, emphasizing the role of international interactions on competitiveness. According to Dunning, companies and countries are influenced by each other in their strategy-making processes, which shows that competitive advantages are shaped not only at the national but also at the global level (Ariç, 2013). Dunning states that in addition to Porter's four basic factors, the interaction between these factors, the innovation system and firm-state relations should also be taken into account. Dunning also states that foreign direct investments affect the formation of these factors and that multinational companies can both positively affect the demand structure in local markets and cause negative consequences by disrupting the supplier structure (Akiş, 2008). Concretizing this approach through the example of Canada, Dunning (1992) demonstrated that the changing competitive conditions with the free trade zones of the USA invalidated Canada's protectionist policies and as a result Canadian firms became not only exporters but also competitive producers (Çivi et al., 2008).

3. Literature Review

In this section, the factors affecting international competitiveness are presented by grouping them according to their similarities in representation variables. Variable selection is based on studies on national competitive advantage within the scope of Porter's Diamond Model and the Dunning Approach. Findings are clustered specifically around factor conditions, demand conditions, related and supporting industries, firm strategy, structure and rivalry, and government regulations.

Labor productivity has been directly used in the literature as one of the proxy variables of factor conditions (Srivastava et al., 2006; Sardy & Fetscherin, 2009; Molendowski & Żmuda, 2014; Chung, 2016). In addition to studies finding a positive significant relationship between labor productivity and competitiveness (Dhiman & Sharma, 2019; Falk & Lemos, 2019; Khyareh & Rostami, 2022), there are also studies finding a negative significant relationship (Jakšić et al., 2019). On the other hand, there are also studies indicating that there is no significant relationship between the two variables (Hamulczuk & Pawlak, 2022). One of the indicators of factor conditions is the capital stock proxy variable (Srivastava et al., 2006; Shafaei, 2009; Fang et al., 2018; Kiran et al., 2019). While there are studies finding a positive significant relationship between capital stock and competitiveness (Arık & Erdem, 2019), there are also studies finding a negative significant relationship (Karagöz, 2021; Çitil, 2022). However, studies indicating that there is no significant relationship between the two variables have also been observed (Narayan & Bhattacharya, 2018).

Foreign direct investments have also been used as a proxy variable for factor conditions (Kiran et al., 2019; Vu & Pham, 2016; Chung, 2016; Wijnands et al., 2015; Molendowski & Żmuda, 2014; Balcarova, 2013; Kalimeris, 2012; Shafaei, 2009; Sardy & Fetscherin, 2009; Gugler & Brunner, 2007; Dunning, 1993). While there are studies finding a positive significant relationship between foreign direct investments and competitiveness (Uysal & Mohamoud, 2018; Hardi et al., 2021; Khyareh & Rostami, 2022; Irewole & Arévalos, 2022), there are also studies finding a negative significant relationship (Chamindani, 2018; Boikova et al., 2021; Jalata, 2021; Tandra et al., 2022). However, there are also studies indicating that there is no significant relationship between the two variables (Weerasinghe & Perera, 2019; Yanar & Çelik, 2021). Finally, there are also studies using human capital as a proxy variable for factor conditions (Sardy & Fetscherin, 2009). In addition to studies finding a positive significant relationship between human capital and competitiveness (Beigy et al., 2022; Yanar & Çelik, 2021), there are also studies finding a negative significant relationship (Arık & Erdem, 2019). However, there are also studies that find no significant relationship between the two variables (Genç et al., 2010).

Studies using per capita income as a proxy variable for demand conditions stand out intensely (Kiran et al., 2019; Balcarova, 2013; Vu & Pham, 2016; Wijnands et al., 2015; Chung, 2016; Castro-Gonzales et al., 2016; Chiu & Lin, 2012; Liu & Hsu, 2009; Moon et al., 1998; Molendowski & Żmuda, 2014; Sardy & Fetscherin, 2009). While there are studies that find a positive significant relationship between per capita income and competitiveness (Torok & Jambor, 2016; Epaphra, 2016; Sigue, 2020; Kea et al., 2020; Karagöz, 2021; Tiyastuti et al., 2022), there are also studies that find a negative significant relationship between per capita income and competitiveness (Bhavan, 2016; Liew et al., 2021; Nursodik et al., 2021; Tandra et al., 2022). However, there are also studies indicating that there is no significant relationship between the two variables (İlkay & Atik, 2019; Khan et al., 2023). In addition, it has been observed that there are studies finding positive-negative significant and insignificant relationships between these variables in different commodity groups and different agricultural products (Bojnec & Fertö, 2009; Narayan & Bhattacharya, 2018).

There are studies that use R&D expenditures as a representative variable of related and supporting industries (Tsiligiris, 2018; Kharub & Sharma, 2017; Srivastava et al., 2006). In addition to the studies finding a positive significant relationship between R&D expenditures and competitiveness (Muratoğlu & Muratoğlu, 2016; Arık & Erdem, 2019;

Falk & Lemos, 2019; Canbay, 2020; Çelik, 2021; Boikova et al., 2021; Beigy et al., 2022; Khyareh & Rostami, 2022; Akhuand & Abbas, 2023), there are also studies finding a negative significant relationship between R&D expenditures and competitiveness (Bojnec & Fertö, 2009).

There are studies using the economic complexity index as a proxy variable for the main determinant of firm strategy, structure and rivalry (Mboya & Kazungu, 2015). Studies finding a positive and significant relationship between the economic complexity index and competitiveness have also been observed (Akın & Güneş, 2018; Olasehinde-Williams & Oshodi, 2021; Beigy et al., 2022).

There are studies that use exchange rate as a proxy variable for government regulations (Karácsony, 2008; Shafaei, 2009). In addition to the studies finding a positive significant relationship between exchange rate and competitiveness (Abbas & Waheed, 2017; Yego & Sihai, 2018; Hapsari & Yuniasih, 2020; Jalata, 2021; Hardi et al., 2021; Khyareh & Rostami, 2022), there are also studies finding a negative significant relationship between the two variables (Yanar & Çelik, 2021; Khalid et al., 2021; Irewole & Arévalos, 2022). On the other hand, studies that found no significant relationship between the two variables were also observed (Weerasinghe & Perera, 2019; Jakšić et al., 2020; Karagöz, 2021; Nurjati, 2021). However, there are also studies that use inflation as a proxy variable for government regulations (Karácsony, 2008; Shafaei, 2009). In addition to studies finding a negative significant relationship between inflation and competitiveness (Weerasinghe & Perera, 2019; Sigue, 2020; Kea et al., 2020; Khyareh & Rostami, 2022; Irewole & Arévalos, 2022), there are also studies indicating that there is no significant relationship between the two variables (Hardi et al., 2021; Olasehinde-Williams & Oshodi, 2021).

Total factor productivity was used as a proxy variable for productivity conditions, which are among the main determinants of the alternative approach. There are studies finding that total factor productivity has a positive and significant effect on competitiveness (Liao & Liu, 2009; Özdemir, 2019; Jakšić et al., 2020). However, in addition to studies that found a bidirectional (Hacker & Hatemi-J, 2003; Uçak & Arısoy, 2011) and one-way (Çeştepe et al., 2020) causality relationship between two variables, there are also studies that did not find a causality relationship between two variables (Mahadevan, 2007).

Although studies conducted on different proxy variables generally reveal positive and significant results in relations with competitiveness, negative or insignificant relations have also been identified in some cases. While variables such as labor productivity, capital stock, foreign direct investment, human capital, and per capita income often have a competitiveness-enhancing effect, the effects vary depending on the context, sector, and country. While R&D expenditure and economic complexity generally offer positive effects, government policy variables such as exchange rates and inflation have produced more inconsistent results. Total factor productivity used in the alternative approach generally has a positive and significant effect on competitiveness. These differences highlight the importance of case-specific analyses rather than a single generalization. The results of the proxy variables used in the study are expected to have a positive impact on competitiveness, with the exception of inflation.

As a result of the literature review, it is seen that there are limited number of studies on the determinants of international competitive advantage within the framework of Porter's Diamond Model. It is noteworthy that existing studies show methodological diversity. In some studies, the effects of the determinants in the Diamond Model on competitiveness were analyzed with empirical methods (Kiran, 2019), while in some studies, multi-criteria decision-making (MCDM) approaches were preferred (Chung, 2016). On the other hand, in some studies, primary data were collected through surveys and the effects of these factors on competitiveness were examined (Ndlangamandla et al., 2016). Although these studies have made significant contributions to international competitiveness based on the Diamond Model, it is observed that literature in this field does not give sufficient space to Dunning. The fact that the Dunning approach has not

been tested empirically with the Diamond Model points to a significant gap in the field. In this context, the research in question aims to empirically analyze and provide a comparative assessment of both modern theories – Porter's Diamond Model and Dunning Approach – in the perspective of the determinants of international competitive advantage.

4. Model, Dataset, Method and Empirical Findings

4.1. Model and Dataset

In this study, the Revealed Comparative Advantage (RCA) index, which is most frequently used in the literature and developed by Balassa (1965), was preferred in the calculation of the ICP index of two commodity groups within the scope of the Harmonized System (HS). The RCA index was selected because it is widely used in measuring competitiveness and is important in showing whether a particular country has a comparative advantage in a particular product. Separate coefficient calculations were made for the commodity groups covered by this index. Later, in order to analyze international competitiveness, models were created within the framework of new theories introduced to the international trade literature by Porter and Dunning, and an alternative model was developed in addition to these models. Detailed information about the variables used in the models is displayed in Table 1. Model-1 is based on Porter's approach, Model-2 is based on Dunning's perspective, and Model-3 offers an alternative perspective to these two approaches.

Model 1:

$$RCA_{it} = \beta_0 + \beta_1 RD_{it} + \beta_2 ECI_{it} + \beta_3 LP_{it} + \beta_4 CS_{it} + \beta_5 ER_{it} + \beta_6 PGDP_{it} + \beta_7 INF_{it} + \varepsilon_{it} \quad (1)$$

Model 2:

$$RCA_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 RD_{it} + \beta_3 ECI_{it} + \beta_4 ER_{it} + \beta_5 PGDP_{it} + \beta_6 INF_{it} + \varepsilon_{it} \quad (2)$$

Model 3:

$$RCA_{it} = \beta_0 + \beta_1 TFP_{it} + \beta_2 FDI_{it} + \beta_3 RD_{it} + \beta_4 ECI_{it} + \beta_5 ER_{it} + \beta_6 PGDP_{it} + \beta_7 INF_{it} + \beta_8 HC_{it} + \beta_9 CS_{it} + \varepsilon_{it} \quad (3)$$

While determining the section names of the commodity groups for which the RCA index is calculated within the framework of the HS classification system, the Harmonized Commodity Definition and Coding System of the European Statistical Office (EUROSTAT) for 2022 and the Harmonized Commodity Definition and Code System of the Turkish Statistical Institute (TURKSTAT) for 2017 were employed as sources. The study focuses on the 16th and 17th HS commodity groups.

Due to data limitations in the available databases, the study covers annual data for the period from 1995 to 2019. Lack of data is an important limitation for the time dimension. In this study, Türkiye and 11 selected European Union (EU) member countries (Germany, Austria, France, Netherlands, Spain, Hungary, Poland, Portugal, Finland, Lithuania, Latvia) were considered. Both the estimator method and data limitations have been effective in maintaining the number of countries at 12. Table 1 presents information on the variables used in this study.

Table 1. Information on the variables used in the study

Variable	Description of the Variable	Source of Variable
RCA	Values of RCA Coefficient Calculated By The Author	UNCOMTRADE
RD	R&D Expenditures (%GDP)	OECD
PGDP	Income Per Capita (USD)	World Bank
FDI	Foreign Direct Investments (Net Inflows-Current USD)	World Bank
ECI	Economic Complexity Index	Massachusetts Institute of Technology
LP	Labor Productivity	OECD
ER	Real Exchange Rate (National currency/USD)	Penn World Tables
HC	Human Capital Index	Penn World Tables
INF	Inflation (Consumer Prices-Annual %)	World Bank
CS	Capital Stock	Penn World Tables
TFP	Total Factor Productivity	Penn World Tables

Source: Prepared by the author.

Table 2. shows the determinants and proxy variables of the models used for the study.

Table 2. Determinants and proxy variables used in the models

Model	Determinants	Proxy Variables
Model 1 (Porter Approach)	Factor Conditions	Labor Productivity (LP), Capital Stock (CS)
	Demand Conditions	Income Per Capita (PGDP)
	Related and Supporting Industries	R&D Expenditures (RD)
	Firm Strategy, Structure and Rivalry	Economic Complexity Index (ECI)
	Government Regulations	Real Exchange Rate (ER), Inflation (INF)
Model 2 (Dunning Approach)	Factor Conditions	Foreign Direct Investments (FDI)
	Demand Conditions	Income Per Capita (PGDP)
	Related and Supporting Industries	R&D Expenditures (RD)
	Firm Strategy, Structure and Rivalry	Economic Complexity Index (ECI)
	Government Regulations	Real Exchange Rate (ER), Inflation (INF)
Model 3 (Alternative Approach)	Factor Conditions	Foreign Direct Investments (FDI), Human Capital Index (HC), Capital Stock (CS)
	Demand Conditions	Income Per Capita (PGDP)
	Related and Supporting Industries	R&D Expenditures (RD)
	Firm Strategy, Structure and Rivalry	Economic Complexity Index (ECI)
	Government Regulations	Real Exchange Rate (ER), Inflation (INF)
	Productivity Conditions	Total Factor Productivity (TFP)

Source: Prepared by the author.

The main hypotheses to be tested in the empirical application of this study are as follows:

Hypothesis 1

H_0: Factor conditions are the determinants of international competitiveness in export goods requiring advanced technology.

Hypothesis 2

H_0: Demand conditions are the determinants of international competitiveness in export goods requiring advanced technology.

Hypothesis 3

H_0: Related and supporting industries are the determinants of international competitiveness in export goods requiring advanced technology.

Hypothesis 4

H_0: Firm strategy, structure and rivalry are the determinants of international competitiveness in export goods requiring advanced technology.

Hypothesis 5

H_0: Government regulations are the determinants of international competitiveness in export goods requiring advanced technology.

Hypothesis 6

H_0: Productivity conditions are the determinants of international competitiveness in export goods requiring advanced technology

4.2. Method

Heterogeneous panels can be estimated in different ways, depending on whether the error terms in the models are correlated. The estimation method was chosen as follows: First, the homogeneity of parameters was tested. To test the homogeneity of the parameters, homogeneity tests such as the F, Wald, S, and Δ tests are frequently used in literature. Gündüz (2017) compared the parameter homogeneity test for many with Monte Carlo simulations and observed that Swamy S and Pasaran and Yamagata Δ tests gave better results (Tatoğlu, 2020). In this study, the Pesaran and Yamagata Δ test, which yielded the best results, was used. If all the parameters are heterogeneous, the next step is to test for the presence of an inter-unit correlation. This study employed the Breusch-Pagan LM test to identify cross-sectional dependence among units.

The presence of heterogeneity and inter-unit correlation in the panel, as well as the number of units being 12, necessitated the use of the panel SUR estimator developed and proposed by Zellner (1962) since it is a frequently used estimator in the literature. An important feature of SUR is that it captures unobservable unit-specific effects, thereby reducing heterogeneity and the simultaneous correlation of the residuals (Mao, 2016). In addition, SUR is an appropriate estimation method in the presence of inter-unit correlation and allows efficient forecasting (Ghimire et al., 2013). Another advantage of the SUR estimator is that it can also provide parameter estimation results for the analyzed countries.

4.3. Empirical Results

In this section, we present the pre-test results and the parameter estimation results to arrive at the final estimator.

4.3.1. Pre-test Results for Estimation Method

The Breusch-Pagan LM test was conducted to see whether there is horizontal cross-section dependence or, in other words, whether there is an interaction between the countries. In addition, the Pesaran & Yamagata (2008) Δ test was applied to observe the reflections of the characteristics of the countries under study in the models. Both preliminary tests indicate that the SUR estimator method can be used for all the three models in the two commodity groups.

Table 3. SUR pre-test results for all models

	Model-1		**Model-2**		**Model-3**	
	16.Group	**17.Group**	**16.Group**	**17.Group**	**16.Group**	**17.Group**
Homogeneity	7.989 (0.000)*	8.881 (0.000)*	6.980 (0.000)*	7.836 (0.000)*	6.297 (0.000)*	6.549 (0.000)*
Inter-Unit Correlation	169.549 (0.0000)*	108.075 (0.0008)*	174.506 (0.0000)*	124.846 (0.0000)*	156.166 (0.0000)*	87.747 (0.0380)**

Note: * and ** = Significant at 1% and 5%.

4.3.2. Pre-test Results for Estimation Method

The parameter estimation results for the 16th and 17th commodity groups in Table 4. were evaluated by considering the models separately for the overall panel. The country-specific parameter results given in Appendix 1 and Appendix 2 are then analyzed.

Table 4. SUR parameter estimation results

Variables	Model.1		Model.2		Model.3	
	16.Group	17.Group	16.Group	17.Group	16.Group	17.Group
Total Factor Productivity					-0.1012	2.1703a
Foreign Direct Investments			0.0026	-0.0011	0.0007	-0.0072c
R&D Expenditures	-0.0711b	-0.0735	-0.0202	0.1735a	-0.0538	0.1524
Economic Complexity Index	0.0578	0.0242	0.2938a	-0.0630	0.1141a	-0.2302a
Labor Productivity	-0.2449a	1.2654a				
Capital Stock	0.3778a	0.0623			0.3251a	0.0661
Real Exchange Rate	-0.0354	-0.0483	-0.0966b	-0.0272	-0.0075	-0.0837
Income Per Capita	-0.0735b	0.0056	-0.0318	0.2165a	-0.0836	0.0574
Inflation	0.0055b	0.0039	-0.0005	0.0067	0.0025	0.0074
Human Capital					-0.1424	0.6738b
Number of Countries	12	12	12	12	12	12
Number of Observation	84	84	72	72	108	108

Note: a, b and c = Significant at 1%, 5% and 10%.

In the 16th commodity group, the parameter estimation results of Model 1 show that R&D expenditure, labor productivity, and per capita income reduce competitiveness. In addition, capital stock and inflation increase competitiveness. In Model 2, it is observed that only the economic complexity index increases the competitiveness, while the real exchange rate decreases the competitiveness. In Model 3, it was determined that the economic complexity index and capital stock gave significant results and increased competitiveness.

The parameter estimation results of Model.1 in the 17th commodity group show that only labor productivity gives significant results and increases competitiveness. In Model 2, significant results were obtained for R&D expenditure and per capita income, and it was observed that they have an increasing effect on competitiveness. In Model 3, it is observed that total factor productivity and human capital have a positive effect on competitiveness, while FDI and economic complexity index have a negative effect on competitiveness.

Considering the tables in Appendix 1 and Appendix 2, the parameter estimation results show variability in terms of both commodity groups and models within the framework of the variables. Therefore, it was decided to conduct an assessment for Turkey. In the 16th commodity group, the Porter model is not considered to be very advantageous for Turkey. Because although labor productivity, the main competitive factor, is effective, R&D expenditures and economic complexity do not have a strong impact in this sector. The fact that foreign direct investments are ineffective in this commodity group, but R&D expenditures are positively significant, indicates that the Dunning Model is partially acceptable for Türkiye. Turkey's advantage in this commodity group may depend on human capital and the economic complexity index, which indicates structural transformation. For this reason, it is believed that the Alternative Approach is more suitable for Türkiye. Again, the fact that R&D expenditures and economic complexity are determinants in the assessment made for the 17th commodity group, considering the relevant tables, shows that the Porter Model may be partially advantageous in this commodity group. The fact that FDI does not contribute to competitive advantage reduces the likelihood of acceptability of the Dunning Model in this commodity group. The insignificant results in most of the parameters for this commodity group indicate that the Alternative Approach is not advantageous. Which approach is advantageous for other countries is left to the judgment of decision makers and policymakers.

5. Discussion and Conclusions

The conclusion reached in this study is that all approaches based on modern theories to explain international competitiveness can be used when the empirical test results are considered. The general results for the commodity groups and empirical test results obtained on a country basis indicate the acceptability of the established models. Since the macroeconomic conditions and cyclical structures of the countries are different, this situation is considered an indicator of heterogeneity. As it is not expected that a model will be significant across all countries and commodity groups, models with sufficient significance were accepted as correct. In summary, it was decided that all three models compared could be valid models and were sufficient for research specific to each commodity group and country. For example, for Türkiye, the alternative approach is more advantageous than other approaches in the 16th commodity group, and the Porter Approach is partially advantageous in the 17th commodity group, but needs to be improved. However, it has been concluded that appropriate economic policies and investments should be implemented to eliminate the inefficiency and weakness of other models. Türkiye should invest more in R&D, innovation, and human capital to increase its competitiveness in export goods that require advanced technology. In addition, it should also boost structural transformation, improve labor productivity, and support sustainable production strategies.

It is concluded that the effect of all variables on international competitiveness differs from country to country in the countries subject to the study.

Comparative analysis of the findings obtained within the framework of Model 1, Model 2 and Model 3 reveals that the determinants of international competitiveness differ significantly according to both the theoretical approach and the commodity group characteristics.

In Model 1 based on Porter's Diamond Model, the positive and significant effects of capital stock (CS) and inflation (INF) on the competitiveness of the 16th group of goods are noteworthy. These results partially overlap with the literature emphasizing the impact of capital accumulation on structural strengthening. However, the positive effect of inflation contradicts traditional expectations and points to the importance of context and period differences. In the same model, the negative impact of variables such as R&D expenditures (RD) and labor productivity (LP) presents findings opposite to the expected direction. This suggests that the situation can be explained by conditional effects such as expenditure composition and time lags, which are frequently emphasized in the literature (Bojnec & Fertö, 2009; Narayan & Bhattacharya, 2018). In this context, in Model 1, while firm strategy, structure and rivalry as well as government regulations are determinants of competitive advantage in the 16th commodity group, in the 17th commodity group, related and supporting industries and demand conditions are determinants of competitive power. Overall, our findings confirm the significance of the determinants predicted by Porter's Diamond Model, but also show that the direction and magnitude of the effects differ significantly across commodity groups, exhibiting a heterogeneity parallel to the co-occurrence of positive and negative insignificant results for different commodity groups in the literature. This indicates that capital accumulation and macro price environment in the 16th group and productivity dynamics in the 17th group are the key determinants of competitiveness.

In Model 2 based on the Dunning approach, only the economic complexity index (ECI) and the real exchange rate (ER) were found to be significant in the 16th commodity group; the positive effect of the ECI and the negative effect of the ER highlight the context-sensitive competition elements. In the 17th commodity group, R&D expenditures (RD) and per capita income (PGDP) show positive and significant effects, revealing that demand conditions and technology investments are more decisive in this group. Although it is observed that the effects of the proxy variables differ in both commodity groups, it is consistent with the literature. These differentiations point to the impact of mechanisms such as the technology/complexity level of commodity groups, their position

in the value chain and exchange rate pass-through, as emphasized in the literature (Bojnec & Fertö, 2009; Narayan & Bhattacharya, 2018). While firm strategy, structure and rivalry as well as government regulations are determinants of competitive advantage in the 16th commodity group, in the 17th commodity group, related and supporting industries and demand conditions are determinants of competitive power.

Model 3, which integrates the Porter and Dunning approaches, offers a clearer distinction. In the 16th commodity group, the economic complexity index (ECI) and capital stock (CS), which are indicators of firm strategy, structure and rivalry and factor conditions, are in the foreground. In the 17th commodity group, productivity-based variables such as total factor productivity (TFP) and human capital (HC) stand out as the main factors that increase competitiveness. In this model, the negative effects of foreign direct investment and economic complexity in the 17th group are also noteworthy, and this shows that the nature of investment, the degree of localization and the structural response of complexity may differ at the sectoral level.

In general, the findings observed in all models show that the direction and magnitude of the factors affecting competitiveness vary not only according to the theoretical framework but also according to the production structure of the commodity group, its technological level and its position in the value chain, and in this context, policy recommendations should be customized at the sectoral level.

The parameter estimation results vary across panels and across countries. Based on the assumption that the models are adversely affected by the aggregation error, it is considered appropriate to conduct the final evaluation based on the country parameter results rather than the overall results. Policymakers are advised to make model choices and decisions based on the outcomes for their own countries. However, it is suggested that researchers test the models by keeping the time periods longer and considering unaggregated HS commodity groups or different commodity classification systems across countries.

The study covers annual data from the 1995-2019 period. The lack of export data required for the calculation of the RCA index and the independent variables on the basis of selected countries created limitations in terms of time and unit.

It was observed that the proxy variables determined as indicators of the main determinants in the study were also indicators of different main determinants. For example, there are studies that use per capita income as a proxy variable for the main determinants of factor conditions (Molendowski & Żmuda, 2014) and firm strategy, structure and rivalry (Tsiligiris, 2018). Likewise, R&D expenditures were used as proxy variables for the main determinants of factor conditions (Rodrigues & Khan, 2015) and related and supporting industries (Srivastava et al., 2006). This allows researchers to construct different models using these proxy variables as indicators of different main determinants and to retest the impact of these main determinants on competitiveness. This could lead to new and different policy recommendations.

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Appendix 1. SUR parameter estimation results for Group 16 goods

		RD	ECI	LP	CS	ER	PGDP	INF
Model 1	**General**	-0.07**	0.06	-0.25*	0.38*	-0.03	-0.07**	0.01**
	Germany	-0.01	-0.20*	-0.27	-0.06	-0.24*	-0.08	0.03*
	Austria	0.07**	-0.15	-1.05*	0.49**	-0.16***	-0.01	0.02*
	France	-0.34*	-0.33*	-0.91*	-0.10***	-0.03	-0.09*	0.01*
	Netherlands	-0.13***	4E-3	0.69*	-0.03	-0.22***	-0.18	-3E-3
	Spain	-0.01	-0.15*	-0.92*	-0.10*	-0.16*	-0.12*	0.01*
	Hungary	-0.89*	0.74**	-1.45**	1.05*	-3E-3**	0.08	-0.07*
	Poland	-0.42*	-0.15	1.16*	0.45*	-0.08*	-0.20*	-0.01*
	Portugal	0.08	0.08	-0.11	0.61*	0.08	0.05	0.03*
	Türkiye	0.06	0.05	0.21***	-0.01	-0.01	0.01	-2E-3*
	Finland	0.24*	0.73*	-0.78*	1.64*	0.18	0.16	0.02**
	Lithuanian	0.37*	-3E-3	0.18	3E-3	0.19*	0.03	2E-3*
	Latvia	0.27***	-0.05	0.80*	-0.17	0.10	-0.38*	0.01*

		FDI	RD	ECI	ER	PGDP	INF
Model 2	**General**	3E-3	-0.02	0.29*	-0.10**	-0.03	-5E-4
	Germany	-0.01*	-4E-3	-0.12**	-0.26*	-0.08	0.02*
	Austria	1E-3**	0.04***	0.03	-0.21*	-0.10	0.02**
	France	-0.01*	-0.19*	0.09***	-0.06	-0.17**	3E-3
	Netherlands	3E-3	-0.01	-0.20**	-0.15	-0.12	-0.01
	Spain	2E-3	-0.01	0.05***	-0.16*	-0.03	5E-3***
	Hungary	0.02*	-1.45*	0.82*	-5E-4	-0.09	-0.06*
	Poland	4E-3***	0.09	0.300**	-0.17*	-0.09	-0.02*
	Portugal	3E-3***	0.08**	0.22*	0.07	0.23***	0.02**
	Türkiye	0.01	0.23*	0.02	-0.01	0.07**	-3E-3*
	Finland	-4E-3	0.30*	1.06*	-0.11	0.24	0.03**
	Lithuanian	-2E-3	0.39*	0.09***	0.13***	0.09***	1E-3
	Latvia	0.01	0.34***	0.59*	-0.04	-0.27**	2E-3

		TFP	FDI	RD	ECI	ER	PGDP	INF	HC	CS
Model 3	**General**	-0.10	7E-4	-0.05	0.11*	-8E-3	-0.08	3E-3	-0.14	0.33*
	Germany	-1.44*	-0.01*	0.09***	-0.11***	-0.16**	-0.04	0.04*	0.28	0.25
	Austria	-1.39**	-8E-4	0.40*	-0.02	-0.15***	0.08	0.03*	-1.69*	0.45**
	France	-0.04	-2E-3***	-0.18*	-0.25*	-0.06	-0.08**	0.01**	-0.39*	-0.19*
	Netherlands	2.18**	-9E-5	0.06	2E-3	-0.36**	-0.22***	-0.01	-0.31	-0.18
	Spain	-0.52**	-3E-5	0.04	-0.09**	-0.12*	-0.06**	0.01*	-0.38*	-0.04
	Hungary	-0.67	0.02*	-1.10*	1.60*	4E-5	-0.20	-0.07*	-1.67*	0.91*
	Poland	0.89**	2E-3	-0.57*	-0.21***	-0.05**	-0.21*	-0.01**	0.99*	0.42*
	Portugal	-0.49	2E-5	0.07	0.14	0.14	0.04	0.03*	-0.11	0.75*
	Türkiye	-0.14	0.01	-0.17	0.13**	-0.03**	0.05	-2E-3*	0.55**	-0.05
	Finland	1.67*	3E-5	0.11*	-0.15	0.06	-0.20***	-4E-3	-1.33*	1.25*
	Lithuanian	0.57***	-0.01	0.38*	5E-3	0.24*	0.01	2E-3*	-0.19	-0.14
	Latvia	-1.65*	-3E-3	0.32*	0.09	0.41**	0.01	0.01*	2.84*	-0.20**

Appendix 2. SUR parameter estimation results for Group 17 goods

		RD	ECI	LP	CS	ER	PGDP	INF
Model 1	**General**	-0.07	0.02	1.27*	0.06	-0.05	0.01	4E-3
	Germany	0.21***	-0.65*	0.51	1.87**	0.78*	0.05	0.03
	Austria	-0.25*	0.59***	5.75*	-1.77*	-0.23	-0.15	-0.03
	France	0.30***	-0.28***	2.22*	0.51***	0.25**	0.01	0.06*
	Netherlands	0.16*	0.14*	-0.13	-0.29*	-0.09	0.03	1E-3
	Spain	-0.05	0.24	-2.13*	0.54**	0.05	0.35***	-0.01
	Hungary	1.47*	-0.76***	1.29***	0.62	1E-3	-0.21	0.01
	Poland	-1.39*	0.06	2.18*	0.54	-0.06	-0.24	3E-3
	Portugal	-0.18	0.81*	0.96	-1.54*	0.25	-0.09	-0.01
	Türkiye	-0.92*	0.44*	0.59	-0.12	0.06***	-0.19	-0.01*
	Finland	-0.21*	-0.11	0.98**	0.41	0.01	-0.12	-0.02
	Lithuanian	-0.13	-0.40***	-0.18	-0.29	-0.71**	0.93*	-0.01*
	Latvia	0.24	0.17	0.62*	0.14	-0.81*	-0.31*	0.02*

		FDI	RD	ECI	ER	PGDP	INF
Model 2	**General**	-1E-3	0.17*	-0.06	-0.03	0.22*	0.01
	Germany	3E-3	0.33*	-0.61*	0.41**	0.15	0.04***
	Austria	-4E-3*	-0.02	-0.80**	-0.08	0.62**	0.01
	France	0.03*	-0.09	-1.24*	0.23	0.25	0.09*
	Netherlands	-2E-3	0.16*	0.16*	-0.03	0.01	3E-3
	Spain	0.01	-0.17	0.92*	-0.28	0.65*	-0.02
	Hungary	-0.02*	1.46*	-0.22	-8E-5	-0.29	-0.01
	Poland	9E-4	-0.30**	0.67***	-0.22*	0.16	-0.03*
	Portugal	0.01**	0.10	0.58*	0.56*	-0.18	-0.01
	Türkiye	0.01	-0.47**	0.51*	0.07**	-0.09	-0.01*
	Finland	-0.01	-0.11***	-0.42**	0.03	-0.04	-0.01
	Lithuanian	-0.05*	0.25	-0.76*	-0.40	1.02*	-0.01**
	Latvia	4E-3	0.60*	0.58*	-0.56**	-0.09	0.02*

		TFP	FDI	RD	ECI	ER	PGDP	INF	HC	CS
Model 3	**General**	2.17*	-0.01***	0.15	-0.23*	-0.08	0.06	0.01	0.67**	0.07
	Germany	-1.87***	0.01	0.18	-0.25	0.61*	0.13	0.05***	2.70*	1.50***
	Austria	3.85	-1E-3	-0.52***	-0.67	-0.12	0.10	0.01	1.77	-0.44
	France	4.18*	-3E-3	0.81*	-0.16	-0.08	-0.32**	0.06*	0.56*	0.17
	Netherlands	0.04	-9E-4	0.19*	0.17*	-0.12	0.01	4E-3	-0.10	-0.27**
	Spain	1.63	-0.01	0.33	0.17	0.16	0.43**	-0.01	-0.96**	0.69*
	Hungary	1.35**	-0.01*	1.05*	-1.80*	-3E-4	0.17	0.01*	2.69*	0.71*
	Poland	3.55**	4E-3	-1.28*	-0.05	-0.03	-0.37***	-1E-3	0.15	0.68
	Portugal	6.50*	0.02*	-0.10	0.80*	-0.04	-0.36**	-0.02**	0.94*	-1.63*
	Türkiye	0.77	0.01	0.40	0.21	0.13*	-0.06	-0.01*	-1.37	0.01
	Finland	1.69***	-0.01	-0.25*	-0.38	-0.04	-0.16	-0.02	-0.05	-0.12
	Lithuanian	0.54	-0.06*	0.46	-0.57**	-0.58***	1.05*	-0.01*	-1.08	-0.69
	Latvia	-0.52	-0.01	0.27	0.22	-0.72*	-0.05	0.02*	1.49*	0.06