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THE IMPACT OF INNOVATION ON THE COMPETITIVENESS OF THE AUTOMOTIVE SECTOR IN ASIAN COUNTRIES*

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Abstract

The study aims to identify which innovation variables are more effective in enhancing the competitiveness of the automotive sector. It investigates the impact of innovation variables on the revealed comparative advantage index of OICA member countries in Asia using panel data analysis covering the period from 1995 to 2021. The study finds that industrial value-added is a positive determinant of competitiveness across selected Asian countries. However, country-specific results indicate that education expenditures in China and Thailand, and oil consumption in South Korea, positively influence the competitiveness of the automotive sector. These findings suggest that innovation activities involving technological, human capital, and environmental indicators contribute to the sector's competitiveness.

Keywords: Automotive Industry, Asia, Competition, Innovation.
JEL Classification: E23, F02, O

ASYA ÜLKELERİNİN OTOMOTİV SEKTÖRÜ REKABET GÜCÜNDE İNOVASYONUN ETKİSİ

Öz

Çalışmada otomotiv sektörünün rekabet gücünde hangi inovasyan değişkenlerinin daha etkili olduğunu tespit etmek amaçlanmıştır. Çalışmanın amacı OICA üyesi Asya ülkelerinde inovasyon değişkenlerinin ülkelerin otomotiv sektörüne ait AKÜ endeksi üzerindeki etkisi panel veri analizi ile sınanmıştır. 1995-2021 yılını kapsayan çalışmada panelin genelinde seçilmiş Asya ülkelerinin rekabet gücünde sanayi katma değerinin pozitif bir belirleyici olduğu saptanırken, ülke bazlı sonuçlarda Çin ve Tayland'da eğitim harcamalarının, Güney Kore'de ise petrol tüketiminin otomotiv sektörü rekabet gücünü lehte etkilediği tespit edilmiştir. Ulaşılan bu sonuçlar ülkenin otomotiv sektörü rekabetçiliğinde teknoloji, beşeri sermaye ve çevresel göstergelerini içiren inovasyon faaliyetlerinin başarı getirdiğini göstermektedir.

Anahtar Kelimeler: Otomotiv Sanayi, Asya, Rekabet, İnovasyon.
JEL Sınıflandırması: E23, F02, O

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1. INTRODUCTION

The concept of competition is critically important in the conduct of economic activities, both strategically and practically. To increase their market share in global markets, countries and companies must carefully manage competition in terms of production, trade, and marketing. Innovation stands out as one of the most effective factors in enhancing competition through strategic management and fostering economic development. Each factor influencing the development of competition is closely tied to advancements in innovation, making innovation and competition an inseparable whole.

The automotive sector serves as a prime example of how innovation and competition are interconnected. Each additional innovative advancement enhances the sector's competitiveness. In particular, innovation initiatives related to technology and human capital significantly impact the sector's competitiveness, driving substantial differentiation and increasing its global reach. This leads to higher national income and sectoral profits compared to other countries. Given the significant influence of competition and innovation on the automotive sector, countries have begun to prioritize these elements in their strategies for sectoral development.

Asian countries are among those that place great importance on innovation and competition in the development of the automotive sector and are highly ambitious in the global automotive industry. Members of the International Organization of Motor Vehicle Manufacturers (OICA), including China, Japan, South Korea, India, Indonesia, and Thailand, exhibit strong competitive capabilities in the sector. Countries such as China, Japan, South Korea, and India, which have developed their own brands and driven global automotive sector growth, have advanced the industry through their investments in innovation. This reflects a dynamic development process in the sector, allowing these countries to establish a competitive identity.

As a high value-added industry, the automotive sector ranks first in industrial production and serves as a prime example of the fierce interplay between competition and innovation. In this context, the aim of the study is to determine the effects of innovation-related variables—including GDP, industrial value-added, education expenditures, government expenditures, oil consumption, and gross capital formation—on the Revealed Comparative Advantage (RCA) Index of the automotive sectors of selected Asian countries (China, Japan, South Korea, Thailand, Indonesia, and India). To achieve this, panel data analysis covering the years 1995–2021 was employed.

This study offers guidance on identifying the innovation priorities for the automotive sector as well as other high-tech and value-added industries. It also provides sector-specific insights for countries with similar economic structures. As one of the few studies focusing specifically on the automotive sector in terms of the literature, it contributes to research on the development of competition and innovation in national economies and industrial sectors. Overall, policymakers and the private sector can leverage the findings to make informed predictions regarding sectoral development, international trade dynamics, competition, and innovation strategies.

2. ECONOMIC DEVELOPMENT AND INNOVATIVE COMPETITION OF SELECTED ASIAN COUNTRIES

Countries must protect and enhance their economic power to maintain their current established order. This necessity has fostered a global competitive environment. Particularly with the transition of countries that once adhered to the concept of a closed economy to free-market economic management, competition has undergone a structural transformation driven by the motivation for greater profit and global power potential. China is one such country that previously adopted a closed economy model. However, by the late 1970s, China abandoned this model and implemented economic liberalization

policies. These policies were introduced cautiously, allowing China to increase its investments in human, financial, and physical capital, which are regarded as the three pillars of development (CRS, 2019:2). As a result of these investments, China has been able to boost productivity and effectively manage factor accumulation, enabling consistent annual growth. In addition to its production-focused policies, China has established international collaborations in the marketing of its manufactured products. These efforts have further strengthened China's position in the global competitive environment (ECB Economic Bulletin, 2017:32).

Unlike China, Japan adopted a modern economic management approach during the Meiji Restoration in 1868, based on the principles of Shokusan Kogyo (Encourage Industry) and Fukoku Kyohei (Enrich the Country, Strengthen the Army). However, Japan's negative political climate and the wars it faced hindered the success of this approach. The country was only able to enter a sustained economic growth process after the Second World War (Kimura, 2009:1). During this period, Japan implemented an export-oriented growth model, prioritizing the development of human capital and the industrial sector. Additionally, by increasing technology imports, Japan sought to internalize technology production, enhance competitiveness, and solidify its position as a global power in high-tech production (Toyoaki, 2022:4; Ohno, 2018:50–52). Similar to Japan, South Korea significantly increased its investments in human capital as a key driver of economic growth. Following the Korean War, South Korea adopted a stable economic approach by implementing structural reforms with support from the United States. Drawing upon Japan's policies as a role model, South Korea pursued strategies such as import substitution and prioritizing sectors with high development potential. Subsequently, it shifted to an export-oriented growth model (Keskin, 2021:2; Woo, 2015:8; Park, 2018:52).

In contrast to Japan and South Korea, Indonesia relied on an agricultural growth model until the 1960s, focusing on the export of agricultural products tailored to its demographic conditions. After 1960, Indonesia pivoted towards industrial development and adopted policies aimed at fostering industrial growth. By joining global integration networks for the marketing of manufactured goods, Indonesia accelerated its development process (Elias & Noone, 2011:33).

Thailand, unlike Indonesia, followed a path influenced by Japan's and South Korea's import substitution policies. With this approach, Thailand experienced rapid growth until 1970, supported by tariff protections and investment incentives. After 1970, it adopted an export-oriented growth model through economic liberalization policies. However, the desired outcomes were initially hindered by low productivity. Over time, investments and subsidies in the industrial sector began to amplify the positive effects of the export-driven growth model (Richter, 2006:7). India, on the other hand, struggled to establish a consistent economic development policy even after gaining independence in 1947. To this day, India has not achieved stable and effective economic management. Currently, it adopts an economic approach focused on efficiency and fiscal prudence, avoiding excessive debt in budget management. This strategy has enabled the creation of a cautious and self-sufficient economic system, free from financial and current account deficits. Recently, India has undertaken initiatives to encourage investments and boost capital formation through development incentive programs (Koswatta et al., 2019:9).

Table 1. Global Innovation Index Values for Selected Asian Countries

Date	China	Japan	South Korea	Indonesia	India	Thailand
2011	46,4 (29)	50,32 (20)	53,7 (16)	27,78 (99)	34,5 (62)	37,6 (48)
2012	45,4 (34)	51,7 (25)	53,9 (21)	28,1 (100)	35,7 (64)	36,9 (57)
2013	44.7 (35)	52,23 (22)	53,3 (18)	31,95 (85)	36,2 (66)	37,6 (57)
2014	46,6 (29)	52,41 (21)	55,3 (16)	31,8 (87)	33,7 (76)	39,3 (48)

2015	47,5 (29)	53,97 (19)	56,3 (14)	29,8 (97)	31,7 (81)	38,1 (55)
2016	50,6 (25)	54,52 (16)	57,1 (11)	29,1 (88)	33,6 (66)	36,5 (52)
2017	52,5 (22)	54,72 (14)	57,7 (11)	30,1 (87)	35,5 (60)	37,6 (51)
2018	53,06 (17)	54,95 (13)	56,63 (12)	29,80 (85)	35,1 (57)	38,0 (44)
2019	54,82 (14)	54,68 (15)	56,55 (11)	29,72 (85)	36,5 (52)	38,6 (43)
2020	53,28 (14)	52,70 (16)	56,11 (10)	26,49 (85)	35,5 (48)	36,6 (44)
2021	54,8 (12)	54,5 (12)	59,3 (5)	27,1 (87)	36,4 (46)	37,2 (43)
2022	55,3 (11)	53,6 (12)	57,8 (6)	27,9 (75)	36,6 (40)	34,9 (43)
2023	55,3 (12)	54,6 (13)	58,6 (10)	30,3 (60)	38,1 (40)	37,1 (43)

Note: Values in parentheses indicate country rankings.

Source: Cornell University, INSEAD and WIPO, Global Innovation Index (GII) 2011-2023 Reports.

When examining the Global Innovation Index values, which provide insights into the economic development and competitiveness of countries, it is evident that Indonesia has made significant progress compared to other nations. India, despite advancing 39 positions during the periods studied, currently holds an average ranking and cannot be considered to have achieved a competitive edge in this regard. Among Asian countries, South Korea, China, and Japan have attained considerable innovative competitive power. South Korea, in particular, has demonstrated strong global competitiveness during the periods analyzed. China, meanwhile, has shown consistent progress over time and is currently ranked 12th globally. Unfortunately, Thailand has not made substantial progress and has yet to reach the desired level of competitiveness.

Table 2. Global Competitiveness Index Values for Selected Asian Countries

Date	China	Japan	South Korea	Indonesia	India	Thailand
2006-07	4,25 (54)	5,60 (7)	5,13 (24)	4,26 (50)	4,44 (43)	4,58 (35)
2008-09	4,70 (30)	5,38 (9)	5,28 (13)	4,25 (55)	4,33 (50)	4,60 (34)
2009-10	4,74 (29)	5,37 (8)	5,00 (19)	4,26 (54)	4,30 (49)	4,56 (36)
2010-11	4,84 (27)	5,37 (6)	4,93 (22)	4,43 (44)	4,33 (51)	4,51 (38)
2011-12	4,90 (26)	5,40 (9)	5,02 (24)	4,38 (46)	4,30 (56)	4,52 (39)
2012-13	4,83 (29)	5,40(10)	5,12 (19)	4,40 (50)	4,32 (59)	4,52 (38)
2013-14	4,84 (29)	5,40 (9)	5,01 (25)	4,53 (38)	4,28 (60)	4,54 (37)
2014-15	4,89 (28)	5,47 (6)	4,96 (26)	4,57 (34)	4,21 (71)	4,66 (31)
2015-16	4,89 (28)	5,47 (6)	4,49 (26)	4,52 (27)	4,31 (55)	4,64 (32)
2016-17	4,95 (28)	5,48 (8)	5,03 (26)	4,52 (41)	4,52 (39)	4,64 (34)
2017-18	5,00 (27)	5,49 (9)	5,07 (26)	4,68 (36)	4,59 (40)	4,72 (32)
2018	72,6 (28)	82,5 (5)	78,8 (15)	64,9 (45)	62,0 (58)	67,5 (38)
2019	73,9(28)	82,3 (6)	79,6 (13)	64,6 (50)	61,4 (61)	68,1 (40)

Note: GCI values were rated between 1 and 7 until the period 2006-2018. After 2018, GCI started to be calculated on a 100-point scale with new determinants within the scope of 4.0 efficiency level. Values in parentheses show country ranking.

Source: WEF 2006-2019 Reports

When the table is examined, Japan emerges as the Asian country with the highest global competitive power, followed by South Korea, China, Thailand, Indonesia, and India. Japan has exhibited strong performance across various areas influencing competitiveness, including institutional frameworks, innovation, business development, infrastructure, and collaborations. China, on the other hand, has been the fastest and most significantly developing country among Asian nations in its quest to establish a competitive identity. However, apart from Japan, China, and South Korea, other countries

have yet to attain the desired level of competitiveness. Notably, India has dropped 18 places, while Thailand has fallen by 5 places.

3. DEVELOPMENT AND SUSTAINABILITY OF THE AUTOMOTIVE INDUSTRY IN SELECTED ASIAN COUNTRIES

The automotive sector, one of the highest value-added industries globally, is a sector that countries strive to develop and retain for its competitive advantages. The growth of this sector, which offers substantial returns, significantly contributes to national income while also providing opportunities to enhance development levels and foster high-tech production. In this regard, it can be argued that the competitive power of the automotive sector is directly proportional to the development rates of countries. With this understanding, countries are prioritizing their investments and support in the sector to ensure its sustainability and to enhance its efficiency.

Table 3 presents the production volumes in the automotive sector of the Asian countries included in the study from 2000 to 2023.

Table 3. Automotive Production Quantities in Selected Asian Countries After 2000 (Unit)

Country	2000	2005	2010	2015	2020	2021	2022	2023
China	2.069.069	5.717.619	18.264.761	24.503.326	25.225.242	26.082.220	27.020.615	30.160.966
Japan	10.140.796	10.799.659	9.628.920	9.278.238	8.067.557	7.846.955	7.835.519	8.997.440
India	801.360	1.638.674	3.557.073	4.125.744	3.394.446	4.399.112	5.456.857	5.851.507
South Korea	3.114.998	3.699.350	4.271.741	4.555.957	3.506.774	3.462.404	3.757.049	4.243.597
Thailand	411.721	1.122.712	1.644.513	1.915.420	1.427.074	1.685.705	1.883.515	1.841.663
Indonesia	292.710	500.710	702.508	1.098.780	691.286	1.121.967	1.470.146	1.395.717

Source: OICA, 2023.

The developments of countries in the automotive sector are listed in the table based on 2023 production values. According to the 2023 data, the highest production growth among Asian countries was observed in China, Japan, India, South Korea, Thailand, and Indonesia, respectively. Among these, China and India achieved the largest production increases between 2020 and 2023, followed by Thailand and Indonesia. Japan, however, lost its leadership position from the 2000–2005 period, and its 2023 production level was 11% lower than its production in 2000. South Korea maintained a relatively stable production process throughout the analyzed periods and continued to increase production, albeit modestly.

China, India, South Korea, and Japan, which have developed their own automotive brands, have successfully gained international competitive power. This was achieved through innovation, investments in human capital, financial structuring, and government support, all of which have reshaped the sector during the period examined. On the other hand, the automotive sectors in Thailand and Indonesia, which have grown largely through foreign investments, have historically positioned themselves as key players in low-cost production and the Asian market. However, their lack of domestic brands has limited their international presence.

3.1. China

China has placed special emphasis on the automotive sector, one of the key high-value-added industries, recognizing that economic development is largely driven by industrial growth. In its

development plans, particularly the 12th and 13th Five-Year Plans, China has made strategic decisions to position the automotive sector as a significant player in global competition. These plans outlined a series of objectives, including increasing the sector's innovative efficiency, diversifying energy sources, and fostering brand development. Additionally, in 2017, the country introduced the Automotive Medium and Long-Term Development Plan to ensure the sector's sustainability and address specific needs. This plan aimed to establish China's global reputation in vehicle and parts production. Today, China continues to closely monitor and implement technological and digital transformations in the industry, focusing on areas such as autonomous vehicles, connected vehicle technology, electric vehicle production, fuel-efficient vehicles, and the adoption of alternative fuel sources (Petti et al., 2019:6–7).

China is currently the world's largest producer and consumer of vehicles. In line with its commitment to environmental sustainability, the country supported the production of New Energy Vehicles (NEVs) through the Energy Saving and New Energy Vehicle Industry Development Plan (2012–2020), which has significantly shaped the current development of its automotive sector. This plan included policies to promote the adoption of NEVs, establish necessary infrastructure, provide subsidies, incentives, and financial support, enhance market supervision, and ensure the safe use of NEVs (Bingfeng, 2022). Later, the New Energy Automobile Industry Development Plan (2021–2035) reaffirmed China's ambition to be a leader in the sustainable and high-tech automotive sector. The plan set specific goals for the future, including reducing the average power consumption of fully electric vehicles to 12.0 kWh per 100 kilometers by 2025 and increasing NEV sales to 20% of total vehicle sales (CAAM, 2020). As a result of effectively managing a stable implementation process and spearheading innovative developments through its strategic decisions and plans, China has achieved a dominant position in global vehicle production. As of 2022, China's share in global vehicle production surpasses the combined total production of Japan, the United States, and the European Union (Ma, 2022).

3.2. Japan

The automotive sector in Japan originated with the withdrawal of foreign investments due to financial and military circumstances. In response to this withdrawal, the Japanese government provided support to Toyota and Nissan to sustain the automotive industry (Mgaziner, 1981:79). Although Japan was unable to maintain stable development in the sector until 1990, it increased investments and production by 20% after 1994, reaching 23.3 million vehicles in 2008 (Schaede, 2009:7–8). Following this milestone, the country established a significant position in the global automotive sector. One of the key factors contributing to this development was Japan's substantial investments abroad. By efficiently managing production with low costs, Japan was able to accumulate the capital needed for innovative advancements. Additionally, the country enhanced the sector's competitiveness by addressing customer demands and satisfaction, diversifying vehicle models, improving quality, implementing price differentiation, and offering reliable post-production services (Yücel and Ergin, 2015:107).

Over time, Japan's automotive sector has gained an international dimension due to its successful and sustainable integration of technology and innovation activities. Today, Toyota, Honda, and Nissan are the leading brands in Japan's automotive production. Alongside these brands, small- and medium-sized companies specializing in vehicle and parts production have also played a vital role in developing the sector's infrastructure (Arba, 2023a). With Japan's commitment to technological advancement and its vision for innovative vehicle production, efforts toward electric vehicle (EV) production have accelerated. Japan began EV production before 1980 and expanded it under the "Low Emission Vehicle Production" regulation introduced by the California Air Resources Board in 1990 (Yarime et al., 2008:194–195). Leveraging advanced technology and digital manufacturing, Japan now produces electric vehicles in four distinct categories: hybrid electric vehicles (HEVs), battery electric vehicles

(BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs). The country has set a goal to transition all vehicle production to electric vehicles by 2035 (Arba, 2023b).

3.3. South Korea

The development of the automotive sector in South Korea began in 1944 with Kyungsung Precision (now Kia) and in 1954 with Ha Dong-Hwan Motor Workshops (now Ssangyong Motor). Later, with the establishment of Daewoo, significant production volumes were achieved. However, due to the financial crisis in 1997–1998, Daewoo was acquired by General Motors and continued its operations under the name GM-Daewoo. Despite the challenges posed by these crises, the establishment of Hyundai Motor Company in 1967 under the Hyundai Group Chaebol enabled the sector to attain an international presence (Ebert & Montoney, 2007:13–14). Hyundai's international initiatives and strong government support accelerated the development of other companies in South Korea, positioning the country among the top five in global production volume by 2010. Approximately 90% of this production was accounted for by Hyundai Motor Company, Kia Motors Corporation, and Daewoo Motor Corporation, respectively (Lee, 2011:428).

Through continued investment and infrastructure support, South Korea rose to the top four in global production volume in 2021, with contributions from 639 companies, showcasing a remarkable example of competitiveness (Yoon, 2022:2023). By 2022, the country had become the world's fifth-largest passenger car manufacturer, producing 3.76 million vehicles (Yoon, 2023:2023). South Korea has shown the same level of diligence and precision in electric vehicle (EV) production. Its development and future strategies focus on reducing carbon emissions, advancing Industry 4.0, and promoting digital manufacturing. Considering South Korea's performance in EV production, the country demonstrates the qualities of both a leader in fostering a competitive environment and a pioneer in innovation (The Government of the Republic of Korea, 2020).

3.4. Thailand

The automotive sector in Thailand began to develop in the 1980s, primarily driven by investments from Japan. Later, following the Asian financial crisis, other Asian and Western countries increased their investments in Thailand, attracted by its new market opportunities and low-cost production policies. The automotive sector, which flourished due to these foreign investments, quickly positioned Thailand as the country with the largest automotive market among ASEAN nations. Additionally, Thailand became a significant player in the global automotive industry, ranking fifteenth in the world for vehicle production and second for pickup truck production (Pollio, 2012:1). By 2021, Thailand was the largest vehicle producer in Southeast Asia. Toyota emerged as the most produced brand in the sector, and in 2022, it was also the most sold vehicle in the country (Statista Research Department, 2023). Thailand has also made strides in innovative electric vehicle (EV) production. By 2030, the country has set ambitious targets for production, aiming for 2,935,000 passenger and light trucks, 156,000 trucks and buses, and 3,133,000 motorcycles. To support the development of electric vehicles, the Automotive and Tire Testing, Research, and Innovation Center was established by the Thailand Automotive Institute in 2022 (Thailand Automotive Institute, 2021).

3.5. India

The automotive sector in India began in the 1940s with the establishment of Hindustan Motors and Premier Automobiles Limited, while the sub-industry of the sector started developing in the 1950s. Significant progress in the country's automotive sector was achieved after 1980. During this period, increasing income levels and production led to an expansion in production scale, adapting to varying income and demand conditions. Additionally, a state-owned company, Maruti Udyog Limited (MUL),

was established to expand the sector and enhance its competitiveness. In collaboration with Suzuki Motor Corporation, the company produced the first domestically manufactured vehicle, Maruti, featuring fully modern technology. India also strengthened its international trade and cooperation by forming joint ventures with Japanese automotive brands (Miglani, 2019:442–443).

One of the key factors behind the development of India's automotive sector has been the government's investments. The establishment of research and testing centers, alongside R&D-focused investments, has fostered sectoral competition (Tiftikçigil and Öztürk, 2021:957–959). Through strategic planning and substantial investments, India has become the world's largest tractor manufacturer and ranks second and third globally in the production of buses and heavy vehicles, respectively. As a result of these advancements, India became the third-largest automotive market in the Asia-Pacific region in 2021, considering the production of two-wheelers, three-wheelers, passenger vehicles, and commercial vehicles. In 2022, Maruti Suzuki led the sector by accounting for 46% of the country's total passenger vehicle production, while TATA Motors was the leader in commercial vehicle production. The Indian automotive sector has also performed remarkably well in the production of electric vehicles (EVs) on an international scale. In 2021, India sold 329,190 EVs, marking a 168% increase compared to the previous year. The Indian government has prioritized integrating low-carbon footprint solutions, urban transport reform, and high-capacity passenger transport through EV production. In line with these goals, India launched its first double-decker electric bus in Mumbai (IBEF, 2022; Sun, 2023a; Sun, 2022a; Sun, 2022b; Sun, 2023b).

3.6. Indonesia

In Indonesia, the automotive sector began to develop with investments made by General Motors in 1927, followed by Kramayuda and Djakarta Motor companies, which were affiliated with the Hasjim Ning group, in the 1960s. To further advance the sector, the Indonesian government adopted import substitution policies during this period, banning imports and implementing tariff and non-tariff barriers. However, by 1995, it became evident that protectionist measures were insufficient for the sector's growth, prompting the government to shift toward liberalization policies (Hale, 2001:630–631).

Despite these efforts, the sector experienced limited growth until 2008 due to economic crises and political instability. However, with the establishment of economic and political stability, Indonesia's automotive sector emerged as a leader in the ASEAN region by 2011. Unfortunately, this success was short-lived, as economic challenges such as currency depreciation and rising inflation hindered further progress. Although the government continued to provide support and incentives to boost the sector, successive economic stagnation and the economic crisis triggered by the COVID-19 pandemic in 2019 led to significant setbacks. In 2019, the sector contracted by 10%, with production decreasing by 46% and sales dropping by 48% (JICA, 2021:8).

Currently, Indonesia has the highest vehicle sales in the ASEAN region and ranks second in vehicle production. This position is attributed to factors such as low motorization rates, low labor costs, and increased investments from major companies like Toyota, Nissan, and General Motors. During this period, the most sold vehicle brands in Indonesia were Toyota, Audi, and BMW, respectively. The country also aims to increase its electric vehicle (EV) production by 25% by 2030 (Statista Research Department, 2022).

4. LITERATURE

Competition is a strategic and dynamic element that drives opportunities for countries, companies, and individuals to achieve greater economic gains. At the same time, it is essential for ensuring comparative advantage. With these characteristics, competition has a direct impact on the

economy and fosters the emergence of new structures, structural transformations, shifts in demand, changes in professions, new skill requirements, and technological advancements, all of which can be considered reformative. Thus, the shaping nature of competition remains a dynamic and relevant topic in economics. Economists and policymakers closely monitor the global evolution of competition and actively seek and implement strategies to enhance competitiveness.

The topic of competition has been widely studied in the literature, as outlined in the table below. In general, studies focusing on the industrial sector and national economies have identified a positive relationship between innovation indicators and competitiveness.

Table 4. Literature Research

Author	Country / Period	Method	Result
Zhang et al. (2024)	China / Construction Industry /2022	Survey Study	It has been observed that the competitiveness of innovation activities carried out together with environmental regulations has increased further.
Çetin & Erkişi (2023)	EU (15) and EU (13) / 1997-2019	Parks-Kmenta Panel Data Analysis	In the study comparing European countries, the effects of innovation, income inequality, unemployment and labor's share in income on competition were examined. According to the results, it was determined that EU (15) countries are more competitive.
Aktaş (2023)	BRICS-T / 2011-2021	Panel Data Analysis	The study investigated the impact of innovation and GDP on competition. It was determined that GDP has a greater impact on competition across the panel. On the other hand, it was determined that the increases in innovation affected the competition of Russia and China more and the competition of Africa and Turkey less.
Hakhverdyan & Shahinyan (2022)	52 Countries / 2001-2020	Panel Data Analysis	In general, it has been concluded that innovation and productivity have a positive effect on competition. However, it has been determined that labor productivity, R&D, FDI and imports have a significant effect on competition. However, it has been determined that weak institutions and complexities in export organization in developing countries have a negative effect on competition.
Kuzmenko et al. (2022)	Czech Republic and EU (27) / Agricultural Sector	RCA, LFI and GL Indices, Logistic Regression Analysis.	While it was concluded that competitiveness is high in the determined index values in the agricultural sector, it was determined in the regression analysis that capital is the only variable with a significant

			statistical value affecting competition.
Kang (2021)	USA / 1818 Firm / 1975-2016	Difference-in-Difference Method, Regression Analysis.	It has been determined that there is an inverse relationship between price competition and innovation. It has also been emphasized that competition based on agreement suppresses innovation.
Altıntaş (2020)	G20 /2018-2019	Pearson Correlation Coefficient, Somers' d Effect Coefficient, Canonical Correlation Coefficient and DEMATEL Numerical Method	As a result of the research, it was found that innovative dimensions should be developed to strengthen competition with innovation.
Çelik (2020)	OECD (18) /1994-2017	Panel Data Analysis	It is concluded that GDP, exchange rate, openness, FDI, capital stock, human capital and patent variables have significant effects on competition.
Zuhal (2020)	18 Developing and 31 Developed Countries / 1996-2016	Panel Data Analysis	It has been observed that technological and infrastructure factors have a very little effect on the innovation capacity of developing countries. On the other hand, it has been determined that developing countries are dependent on the technological activities of developed countries in their innovation developments.
Uslu & Kapkara (2020)	Turkey / NACE Rev 2 / 2008- 2016	Panel Data Analysis	It was concluded that openness to the outside world, the ratio of R&D workforce to the total workforce of the sector, R&D expenditures and the Globalization index increase competition, while the price index and R&D intensity affect competition negatively.
Lui & Xie (2020)	China / Manufacturing Industry, 21 Sub-Sectors / 2000-2014	Panel Regression Analysis	It has been determined that FDI, environmental variables, human sector indicators and technological progress positively affect the manufacturing industry battery values.
Distanont & Khongmalai (2020)	Thailand / Frozen Food Sector - Selected 155 SMEs / 2017	Explanatory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), Structural Equation Modeling (SEM)	In the analysis conducted with the survey, it was observed that innovation positively affects competitiveness through external factors.
Karakaya et al. (2018)	Turkey / Manufacturing Industry, /2008-2013	Panel Data Analysis	Innovation is found to increase competition, while it decreases it in one-lagged estimation results.
Manyaza (2016)	Northern Cyprus / BMW-Mercedes Benz	Survey Study	It was concluded that innovative brands, marketing knowledge, and credit opportunities positively affect competitiveness in the researched car brand.

Lotfi & Karim (2016)	Morocco / Selected 10 Sectors / 1998-2014	Regression Analysis	According to the analysis, it was determined that Morocco gained competitive power in the selected sectors with its largest trade partner, the EU, and the development of companies in this sector is of great importance in Moroccan competition.
Saray & Hark (2015)	OECD / High Technology Products / 2004-2013	Panel Data Analysis	It has been determined that productivity affects the competition of high technology products the most. No statistical significance has been determined between competition, FDI and technological change.
Cordes et al. (2015)	European Region / 3 different regions / 22 Manufacturing Industry Sectors / 2000 - 2011	Statistical and Regression Analysis	It was concluded that low and medium-low technology products determine the competitive power in the researched regions. At the same time, it was observed that SMEs' increasing innovation with R&D studies has a positive effect on competition.
Ustaoğlu (2013)	Turkey / Automotive Sector / 1996:M1-2012:M12	Hatemi-J Cointegration Analysis, Hacker and Hatemi-J Causality Analysis	It has been observed that there is a positive relationship between the real effective exchange rate and competition in the automotive sector.
Gülmez (2012)	EU (27)-Turkey / Automotive Sector / 1996-2011	Statistical Analysis	It was stated that although the decrease in the battery index in Turkey's automotive sector is observed, competition still continues. It was emphasized that competition will increase further with R&D and technology-intensive production.
Yapraklı (2011)	Turkey / Manufacturing Industry / 1980-2010	Multiple Cointegration Analysis, Error Correction Model	It was determined that openness and GDP values positively affected manufacturing industry competition, while exchange rate and labor costs were observed to have negative effects.

5. ECONOMETRIC ANALYSIS

5.1. Data And Method

The study investigated the effects of innovation on the automotive sector competitiveness of Asian countries (China, Japan, India, South Korea, Thailand and Indonesia) between 1995 and 2021, which includes the period after the 1980 global trade liberalization. The research was tested with panel data analysis. The variables used in the analysis were selected as appropriate for the automotive sector, taking into account the studies of Şen and Pehlivan (2021), Uslu and Kapkara (2020), Çelik (2020), Lui and Xie (2020), Gamariel and Hove (2019), Antoniadis (2017), Doğan and Türkekul (2016), Cordes et al. (2015), Yapraklı (2011), Vergil and Yıldırır (2006).

The equational representation of the analysis is shown in equation 1, and information about the variables is shown in Table 5.

$$AK\ddot{U}_t{:}\beta_0+\beta_1 GSY\dot{I}H_t+\beta_2 DH_t+\beta_3 BSO_t+\beta_4 PT_t+\beta_5 EH_t+\beta_6 SKD_t+\varepsilon_t \quad (1)$$

Table 5. Information on Variables and Attributes Used in Variables

Variables	Variables Qualifications	Source
Revealed Comparative Advantage Index (RCAI)	Competitiveness	UNCTADSTAT
Gross Domestic Product (GDP) (Dollar)	Innovation (Economic Indicator)	The World Bank World Development Indicators
Government Expenditure (GE) (Dollar)	Innovation (Institutional Indicator)	The World Bank World Development Indicators
Gross Capital Formation (GCF) (Dollar)	Innovation (Financial Indicator)	The World Bank World Development Indicators
Oil Consumption (OC) (Barrel)	Innovation (Environmental Indicator)	Bp-Statistical Review of World Energy
Education Expenditure (EE) (Dollar)	Innovation (Human Capital Indicator)	The World Bank World Development Indicators
Industrial Value Added (IVA) (Dollar)	Innovation (Technological Indicator)	The World Bank World Development Indicators

5.2. Cross-Section Dependency and Homogeneity Test

The cross-sectional dependency test guides the selection of tests to be used in the analysis, depending on the correlation relationship between the sections used in the model in panel data analysis (Kar & Kar, 2019:997). According to the cross-sectional dependency result, if appropriate tests are not used, the estimation results will have incorrect and deviant values and will lead to misleading inferences (Türkay, 2020:696). In order to avoid such problems in the analysis, it is very important to determine the cross-sectional dependency. In the analysis, the cross-sectional dependency of the model was tested with LM (Breusch and Pagan (1980)), LM adj (Pesaran, Ullah and Yamagata (2008)) and LM CD (Pesaran (2004)) tests.

LM test equation (Breusch and Pagan, 1980:251);

$$CD_{LM}:\mathrm{T}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\alpha_{ij}^{2} \qquad (2)$$

LM CD test equation (Pesaran, 2004);

$$\mathrm{CD}=\sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\alpha_{ij}^{2}\right) \qquad (3)$$

LM adj test equation (Özcan and Özmen, 2018:42);

$$LM_{adj}=\sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\alpha_{ij}^{2}\right)\frac{(T-k)\alpha_{ij}^{2}-\mu_{Tij}}{v_{Tij}} \qquad (4)$$

Another test used to determine appropriate tests is the homogeneity test. This test takes into account the slope coefficients of the model in panel data analysis. In this context, the homogeneity test of Pesaran and Yamagata (2008), which was developed based on the slope homogeneity test developed by Swamy (1970), was used in the study (Kocaman, 2019:295). The Δ and Δ_{adj} tests derived by Pesaran and Yamagata are as follows (Pesaran and Yamagata, 2008: 62).

$$\Delta=\sqrt{N}\left(\frac{N^{-1}\hat{\mathrm{S}}-1}{\sqrt{2}}\right) \qquad (5)$$

$$\Delta_{adj}=\sqrt{\frac{N(T+1)}{T-k-1}}\left(\frac{N^{-1}\hat{\mathrm{S}}-k}{2k}\right) \qquad (6)$$

N: Number of cross-sections

Ŝ: Swamy test statistics

The cross-section dependency and homogeneity test results of the study are shown in the table below.

Table 6. Cross-Section Dependency and Homogeneity Test Results

Cross-Section Dependency		
Test	Test İstatistiği	Olasılık Değeri
LM (Breusch and Pagan (1980)	19,22	0,1998
LM adj (Pesaran vd. (2008)	-0,2283	0,8194
LM CD (Pesaran (2004)	1,521	0,1282
Homogeneity Test		
Test	Test İstatistiği	Olasılık Değeri
Delta_tilde	6,324	0,000*
Delta_tilde_adj	7,538	0,000*

Note: * sign indicates 1% significance level.

According to the cross-sectional dependency test results, the probability values in all three tests of the model were found to be greater than the 1%, 5%, and 10% significance levels. Based on these results, it was determined that the model did not exhibit cross-sectional dependency. Regarding the homogeneity test results, it was observed that the slope coefficients of the variables in the model were heterogeneous at the 1% significance level in both tests.

Since the model did not display cross-sectional dependency, the analysis proceeded with first-generation panel data tests. Additionally, tests that accounted for heterogeneity were considered in the selected analyses.

5.3. Im, Pesaran and Shin (IPS) Unit Root Test

According to the cross-section and homogeneity test results, since the model does not contain cross-section dependency and the slope coefficients have a heterogeneous structure, the unit root test of the variables was tested with the IPS unit root test developed by Im, Pesaran and Shin (2003).

Although the IPS test is a first-generation test, it allows the coefficients of the variables to show a heterogeneous quality. At the same time, it includes a different quality by taking the averages of individual unit root statistics. The IPS test suggests the average of the ADF test depending on the correlation relationship between different variables along the cross-section units (Baltagi, 2005:242). The IPS equation is as follows:

$$t_{IPS} = \sqrt{N}(\bar{t} - \frac{1}{N}\sum_{i=1}^{N} E[t_{iT}|^{p}{}_{i}=0]) \,/\, \sqrt{\frac{1}{N}\sum_{i=1}^{N} var\{t_{iT}|p_i = 0\}} \rightarrow N(0,1) \quad (7)$$

The values of $E[t_{iT}|^{p}{}_{i}=0]$ ve $var\{t_{iT}|p_i = 0\}$ were calculated by simulating the difference T and the values of the variables. Depending on the results of the test, the null hypothesis states that the variables in the panel contain a unit root, while the alternative hypothesis allows the existence of a unit root in some of the individual series (Baltagi, 2005:242).

$$H_0: p_i = 0$$

$$H_1: \begin{cases} p_i < 0, \; i = 1,2, \ldots . N_1 \\ p_i = 0 \, , i = N_1 + 1, \ldots . , N \end{cases}$$

The results of this test are given in Table 7.

Table 7. IPS Unit root Test results

Variables	Statistics I(0)	Probability	Adj-t-Statistics I(1)	Probability
RCAI	-0,2411	0,4047	-7,8020	0,0000*
GDP	4,8321	1,0000	-4,9138	0,0000*
OC	3,4696	0,9997	-5,7831	0,0000*
GCF	2,7993	0,9974	-5,9993	0,0000*
GE	4,7709	1,0000	-5,0015	0,0000*
EE	4,3032	1,0000	-4,1549	0,0028*
IVA	3,1808	0,9993	-5,8346	0,0000*

According to the IPS test results, it was determined that the differences in the probability values of all variables were stationary at the 5% statistical significance level.

5.4. Westerlund Cointegration Test

Westerlund (2007) developed four different new tests to test the null hypothesis, which states that there is no cointegration without requiring any factor restriction with long-term structural dynamics between variables. This test is the panel-arranged version of the time series developed by Banerjee, Dolado and Mestre (1998). Accordingly, in an error correction model, the equality of the error term to zero is tested and if the null hypothesis is rejected in the error correction model, the null hypothesis, which states that there is no cointegration, is also rejected. At the same time, cointegration tests can be performed for models regarding the existence and absence of cross-sectional dependence with this test (Westerlund, 2007:709-710). The cointegration equation developed by Westerlund is as follows:

$$\Delta y_{it}=\delta_i^{'} d_t+\alpha_i y_{it-1}+\lambda_i^{'} x_{it-1}+\sum_{j=1}^{pi} \alpha_{ij} y_{it-j}+\sum_{j=0}^{pi} \gamma_{ij} \Delta x_{it-j}+e_{it} \qquad (8)$$

λ_i is unlimited and the cointegration vector is implicitly estimated under the alternative hypothesis. This estimate indicates that a test based on α_i with asymptotic similarity can be revealed. For this reason, four tests were developed within the scope of the t ratio included in α_i based on the least squares (LSA) estimate. The equations of the four tests are as follows (Westerlund, 2007:715-718).

Group mean statistics consist of three stages. In the first stage, the LSS estimate is made for each i in equation (8).

$$\Delta y_{it}=\delta_i^{'} d_t+\alpha_i y_{it-1}+\lambda_i^{'} x_{it-1}+\sum_{j=1}^{pi} \alpha_{ij} y_{it-j}+\sum_{j=0}^{pi} \gamma_{ij} \Delta x_{it-j}+e_{it} \qquad (9)$$

In the second stage, estimates are made and $\alpha_i(1)$ is estimated with a parametric approach.

$$\alpha_i(1)=1-\sum_{j=1}^{pi} \alpha_{ij} \qquad (10)$$

In the third stage, G_t and G_a test statistics are calculated.

$$G_t=\frac{1}{N}\sum_{i=1}^{N} \frac{\alpha_i}{SE(\alpha_i)} \text{ ve } G_a=\frac{1}{N}\sum_{i=1}^{N} \frac{T\alpha_i}{\alpha_i(1)} \qquad (11)$$

$SE(\alpha_i)$= Standard error of α_i

$\frac{T\alpha_i}{\alpha_i(1)}$= Individual quantities that make up G_a

Panel statistics allow the parameters and dimensions of equation (8) to change between cross-sectional units. Panel statistics also consist of three stages. The first stage is the same as the group mean statistics and includes the determination of p_i, which indicates the individual delay. The equation is as follows:

$$\Delta\tilde{y}_{it}=\Delta y_{it}-\delta_i^{'}d_t-\lambda_i^{'}x_{it-1}-\sum_{j=1}^{pi}\alpha_{ij}\Delta y_{it-j}-\sum_{j=0}^{pi}\tilde{y}_{ij}\,\Delta x_{it-j} \qquad (12)$$

The second stage involves using $\Delta\tilde{y}_{it}$ and $\tilde{y}_{it-1}$ to find the standard error term of the test and the common error correction term.

$$\alpha=\left(\sum_{i=1}^{N}\sum_{t=2}^{T}\tilde{y}_{it-1}^{2}\right)^{-1}\sum_{i=1}^{N}\sum_{t=2}^{T}\frac{1}{\alpha_i(1)}\tilde{y}_{it-1}\,\Delta\tilde{y}_{it} \qquad (13)$$

The standard error of α is:

$$SE(\alpha)=\left((\hat{S}_N^2)^{-1}\sum_{i=1}^{N}\sum_{t=2}^{T}\tilde{y}_{it-1}^{2}\right)^{-1/2} \quad , \quad \hat{S}_N^2=\frac{1}{N}\sum_{i=1}^{N}\hat{S}_i^2 \qquad (14)$$

The calculation of the statistics of the panel in the third stage is shown in the equation below.

$$P_t=\frac{\alpha}{SE(\alpha)} \quad \text{ve} \quad P_\alpha=T\alpha \qquad (15)$$

The results of the Westerlund cointegration analysis used in models without cross-sectional dependence are shown in Table 8.

Table 8. First Generation Westerlund Cointegration Test

RCAI	Statistics	Value	Z-Value	Probability Value
OC	Gt	-4,283	-6,859	0,000*
	Ga	-27,100	-8,994	0,000*
	Pt	-11,421	-7,709	0,000*
	Pa	-30,385	-13,895	0,000*
EE	Gt	-4,362	-7,078	0,000*
	Ga	-30,775	-10,655	0,000*
	Pt	-13,375	-9,638	0,000*
	Pa	-33,467	-15,541	0,000*
IVA	Gt	-3,791	-5,505	0,000*
	Ga	-29,248	-9,965	0,000*
	Pt	-8,840	-5,160	0,000*
	Pa	-26,378	-11,756	0,000*
GE	Gt	-3,561	-4,870	0,000*
	Ga	-24,808	-7,958	0,000*
	Pt	-9,606	-5,917	0,000*
	Pa	-27,563	-12,389	0,000*
GDP	Gt	-3,393	-4,409	0,000*
	Ga	-24,033	-7,608	0,000*
	Pt	-9,695	-6,004	0,000*
	Pa	-28,853	-13,077	0,000*
GCF	Gt	-3,345	-4,277	0,000*
	Ga	-24,837	-7,971	0,000*
	Pt	-8,874	-5,194	0,000*
	Pa	-25,747	-11,419	0,000*

Note: * sign indicates 1% significance level.

Since the slope coefficients of the variables in the model are heterogeneous, the Gt and Ga test statistics were utilized in the Westerlund cointegration test. According to the findings, a long-term relationship between the RCAI variable and all other variables was identified at a 1% significance level. In this context, the alternative hypothesis indicating the existence of a cointegration relationship was accepted.

5.5. Pesaran &Smith Average Group Estimator

In the study, after the cointegration relationship was tested with the Westerlund cointegration test, the long-term cointegration coefficients between the variables were determined with the Average Group Estimator developed by Pesaran and Smith (1995). This test is used as a first-generation test in models where there is no cross-sectional dependency, and it is also a test that takes heterogeneity into consideration.

Pesaran and Smith (1995) investigated the relationship between the data and heterogeneous units within the scope of poolability with the increase in the time dimension in panel data analysis. Pesaren and Smith estimated a dynamic panel data model in the case that the parameters have individual heterogeneity in their analysis (Baltagi, 2005:201-203)

In the analysis, long-term coefficients are calculated based on four basic methods: group averages, total time series, pooled and cross-section. Accordingly, long-term coefficients contain three stages (Pesaran and Smith, 1995:95).

- From the averages of coefficients belonging to the industry in the long term
- From the averages of coefficients belonging to the industry in the short term
- From the coefficients of the averages in cointegration regressions belonging to the industry

The model developed by Pesaran and Smith is as follows:

$$y_{it}=\lambda_i y_{i,t-1}+\beta_i x_{it}+u_{it}\ ,\ \text{i=1……N; t=1……..T} \qquad (16)$$

λ_i and β_i are independent variables. In this case, the aim of the analysis is to make a consistent estimate in the mean values of the independent variables. In this analysis, both N and T being large will not change the consistent estimate results (Baltagi, 2005:203).

Table 9. Pesaran and Smith Mean Group Estimator - Long-Term Cointegration Coefficient Estimates

Panel Long-Term Cointegration Coefficient Estimates					
RCAI	Coefficient	Standard Error	Z-Value	P > |z|	95% Confidence Interval Lower GS / Upper GS
OC	0,0001642	0,0001787	0,92	0,358	-0,00/0,00
EE	9,42e-12	6,33e-12	1,49	0,136	-2,98/2,18
IVA	1,77e-12	6,92e-13	2,56	0,011**	4,12/3,13
GE	1,34e-12	1,20e-12	1,11	0,265	-1,02/3,70
GDP	-1,95e-12	1,03e-12	-1,88	0,059***	-3,98/7,79
GCF	-1,27e-12	1,11e-12	-1,14	0,255	-3,45/9,15
Long-Term Cointegration Coefficient Estimates by Country					
RCAI	Coefficient	Standard Error	Z-Value	P > |z|	95% Confidence Interval Lower GS / Upper GS
			CHINA		
OC	-0,0000174	0,0000462	-0,38	0,706	-0,00/0,00
EE	2,33e-11	1,06e-11	2,20	0,028**	2,58/4,41
IVA	1,65e-13	2,25e13	0,73	0,463	-2,75/6,05
GE	-1,87e-13	2,46e-13	-0,76	0,448	-6,70/2,96
GDP	-3,82e-13	2,60e-13	-1,47	0,141	-8,92/1,27
GCF	2,08e-13	2,76e-13	0,75	0,452	-3,33/7,48
			JAPAN		
OC	-0,0001244	0,0002421	-0,51	0,609	-0,00/0,00
EE	1,10e-11	8,79e-12	1,25	0,211	-6,24/2,82

IVA	1,45e-12	1,70e-12	0,85	0,395	-1,89/4,78
GE	2,04e-12	1,52e-12	1,35	0,178	-9,32/5,02
GDP	-2,49e-12	1,60e-12	-1,56	0,120	-5,62/6,45
GCF	-1,60e-12	1,33e-12	-1,20	0,230	-4,20/1,01
		INDIA			
OC	0,0000612	0,0002973	0,21	0,837	-0,00/0,00
EE	3,75e-11	3,55e-11	0,77	0,439	-4,21/9,71
IVA	4,34e-12	4,97e-12	0,87	0,383	-5,41/1,41
GE	-1,42e-13	2,40e-12	-0,06	0,958	-4,84/4,55
GDP	-7,18e-13	3,01e-12	-0,24	0,812	-6,62/5,19
GCF	-2,02e-12	2,78e-12	-0,73	0,467	-7,47/3,43
		SOUTH KOREA			
OC	0,0010483	0,0003645	2,88	0,004*	0,00/0,00
EE	-1,35e-11	1,33e-11	-1,01	0,312	-3,96/1,26
IVA	3,36e-12	8,35e-12	0,40	0,687	-1,30/1,97
GE	7,05e-12	4,69e-12	1,50	0.133	-2,14/1,63
GDP	-6,85e-12	5,76e-12	-1,19	0,235	-1,81/4,45
GCF	-6,17e-12	5,14e-12	-1,20	0,230	-1,62/3,90
		THAILAND			
OC	0,0000323	0,0001116	0,29	0,772	-0,00/0,00
EE	1,11e-11	4,78e-12	2,31	0,021**	1,70/2,04
IVA	8,20e-13	2.02e-12	0,41	0,684	-3,13/4,77
GE	-2,21e-13	1,13e-12	-0,20	0,845	-2,44/1,99
GDP	-1,07e-12	1,11e-12	-0,97	0,333	-3,24/1,10
GCF	7,52e-13	1,49e-13	0,51	0,613	-2,17/3,67
		INDONESIA			
OC	-0,000015	0,0001552	-0,10	0,923	-0,00/0,00
EE	-2,89e-12	7,96e-12	-0,36	0,717	-1,85/1,27
IVA	4,81e-13	1,23e-12	0,39	0,695	-1,92/2,88
GE	-5,00e-13	9,59e-13	-0,52	0,602	-2,38/1,38
GDP	-1,90e-13	9,41e-13	-0,20	0,840	-2,04/1,65
GCF	1,22e-12	1,51e-13	0,81	0,416	-1,73/4,18

Note: *, ** and *** signs indicate 1%, 5% and 10% significance levels, respectively.

According to the long-term coefficient estimates, when the panel is examined as a whole, statistical significance was found in the effect of innovation indicators on competitiveness for the IVA and GDP variables. It was determined that a 1% increase in the IVA variable increased competitiveness by 1.77%, while a 1% increase in the GDP variable decreased competitiveness by 1.95%. When the test results for individual countries were analyzed, it was observed that a 1% increase in EE (Education Expenditures) in China, OC (Oil Consumption) in South Korea, and EE in Thailand increased competitiveness by 2.33%, 0.0010%, and 1.11%, respectively. No statistically significant results were found for Japan, India, and Indonesia.

CONCLUSION

Innovation, one of the fundamental determinants of competition, plays a dynamic role in high-tech production and value-added industrial sectors. Particularly in the automotive sector, which caters to both functional needs and luxury demands through advanced technology and knowledge, innovation initiatives create new competitive environments in real-time processes. In line with the critical importance of innovation in high-tech products and production, this study aims to identify which innovative developments are most efficient and effective in the six Asian countries with the highest competitive power in the automotive sector: China, Japan, South Korea, India, Indonesia, and Thailand.

Within the scope of the study, the impact of innovation determinants on the competitive power of the automotive sector in Asian countries was analyzed using panel data analysis. The findings revealed that developments in industrial value-added had a positive impact on the competitive power of the automotive sector in these countries overall. This result indicates that these countries have not yet

reached a saturation point in industrial development and that each additional innovative industrial advancement positively contributes to their competitiveness. Moreover, this positive effect highlights the efficient management of industrial initiatives. Conversely, increases in the GDP variable were found to negatively affect the competitiveness of the automotive sector. This negativity stems from the decrease in productivity due to the increase in GDP in terms of prices, and also from the fact that the revenues obtained from low value-added sectors do not affect the national competitiveness.

Beyond the panel analysis, it was observed that investments in human capital in China and Thailand have significantly transformed their respective automotive sectors, demonstrating that the sector and innovative developments are closely supported by human capital. Lastly, while oil consumption has a small but notable influence, it plays a decisive role in the development of the automotive sector in South Korea. However, the limited positive impact of oil consumption suggests that South Korea, as an industrialized nation with a highly competitive automotive sector, is transitioning from oil to alternative fuel sources. These findings align with prior studies, such as Çelik (2020) and Lui and Xie (2020), which identified a strong positive relationship between innovation and competitiveness, as well as Aktaş (2023), Hakverdyen and Shahinyan (2022), Kuzmenko et al. (2022), and Uslu and Kapkara (2020).

The research and analysis also revealed that China, Japan, South Korea, and India, as prominent brand owners, hold significant importance in the Asian region through both domestic production and investments. In contrast, Thailand and Indonesia serve complementary roles in the automotive sector by specializing in assembly and spare part production. However, the lack of a unified platform for sharing information, production resources, financial support, and innovative developments among these countries limits the sector's overall growth. Establishing an automotive industry union or economic trade bloc among these nations would strengthen Asian countries against their Western competitors. Additionally, the inclusion of an automotive trade agreement under China's One Belt One Road project could enhance sectoral innovation by facilitating greater financial and information exchange within the Asian region. From a macroeconomic perspective, countries' implementation of regulations that increase their productivity-related income and their increased investments in sectors with high added value will positively affect their competitiveness. Specifically, the sector's competitiveness can be managed correctly through cooperation and supportive national policies that will ensure global technological advances such as green transformation, charging infrastructure, software security, and battery-chip supply.

Ethical Statement

In the writing and publication processes of the study titled "The Impact of Innovation on the Competitiveness of the Automotive Sector in Asian Countries" research and publication ethics have been strictly adhered to, and no data manipulation has been conducted. Ethics committee approval was not required for this study.

Contribution Statement

The authors of the study has contributed to all stages of the study, from writing to drafting, and has approved the final version after reviewing it.

Conflict of Interest Statement

This study has not led to any individual or institutional/organizational conflict of interest.

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Extended Abstract

The Impact of Innovation on the Competitiveness of the Automotive Sector in Asian Countries

The concept of competition is critically important in the conduct of economic activities, both strategically and practically. Countries and companies must carefully manage competition in terms of production, trade, and marketing to increase their market share in global markets. Innovation is one of the most effective factors in enhancing competition through strategic management and in driving economic development. The factors influencing the development of competition often emerge in response to advances in innovation. This interdependence makes innovation and competition an inseparable whole.

The automotive sector exemplifies the inseparability of innovation and competition. Each incremental innovation in the sector enhances its competitiveness. Particularly, innovation initiatives related to technology and human capital significantly differentiate the sector on a large scale, thereby increasing its international presence. This, in turn, leads to higher national income and sectoral profits compared to other countries. Given the profound impact of competition and innovation on the automotive sector, countries have increasingly prioritized these elements in their strategies for sectoral development.

The automotive sector, recognized for its high added value, ranks first in industrial production and serves as a prime example of the intense transformation driven by competition and innovation. In this context, the purpose of this study is to determine the effects of various innovation-related variables—including GDP, industrial added value, education expenditures, government expenditures, oil consumption, and gross capital formation—on the Revealed Comparative Advantage (RCA) Index of the automotive sectors in selected Asian countries (China, Japan, Indonesia, India, Thailand, South Korea). To achieve this, a panel data analysis covering the years 1995-2021 will be employed.

This study will guide the prioritization of innovations that the automotive sector, as well as other high-tech and value-added sectors, should focus on. It will also provide sectoral insights relevant to countries with similar economic structures. From a literature perspective, this research will contribute not only as a specific study focused on the automotive sector but also as a valuable resource for understanding the development of competition and innovation within national economies and sectors. Overall, policymakers and the private sector will be able to draw informed conclusions about sectoral development, international trade awareness, and strategies for competition and innovation.

The study employed panel data analysis. To select the appropriate tests for this analysis, model cross-section dependency and heterogeneity tests were conducted. The results indicated that the model did not exhibit cross-section dependency, while the slope coefficients displayed a heterogeneous structure. Consequently, the panel data analysis proceeded with first-generation tests. The cointegration relationship between the variables was tested using the first-generation Westerlund test, which confirmed a long-term relationship among the variables. For long-term coefficient estimates, the Pesaran & Smith Average Group Estimator test was applied. The test results revealed statistically significant effects of innovation indicators on competitiveness, particularly in the SD and GDP variables. Specifically, a 1% increase in the SD variable led to a 1.77% increase in competitiveness, whereas a 1% increase in the GDP variable resulted in a 1.95% decrease in competitiveness. Examining the test results for individual countries, it was found that a 1% increase in the EH variable in China, PT in South Korea, and EH in Thailand increased competitiveness by 2.33%, 0.0010%, and 1.11%, respectively. No statistically significant results were found for Japan, India, and Indonesia.

This study tested the impact of innovation determinants on the competitiveness of the automotive sector in Asian countries using panel data analysis. It was observed that, in general, only improvements in industrial value added positively affected the competitiveness of the automotive sector in these countries. This finding suggests that these countries have not yet reached saturation in industrial development, and that each additional innovative industrial advancement further enhances their competitiveness. Additionally, this positive effect implies that industrial initiatives are being managed efficiently. However, increases in the GDP variable were found to have a negative impact on competitiveness in the automotive sector. Outside of the panel analysis, it was determined that investments in human capital in China and Thailand significantly benefited the competitiveness of their automotive sectors. This evidence underscores the role of human capital in driving sectoral and innovative developments. In South Korea, it was observed that oil consumption plays a critical role in the development of the automotive sector, albeit with a small impact. The low positive impact suggests a shift from oil consumption to alternative fuels in South Korea, which is one of the most competitive and industrialized countries in the global automotive sector. These findings align with other studies—such as those by Çelik (2020), Lui and Xie (2020), Aktaş (2023), Hakverdyan and Shahinyan (2022), Kuzmenko et al. (2022),

and Uslu and Kapkara (2020)—which have similarly identified a significant positive impact of innovation on competitiveness.

The research and analysis also highlight the strategic importance of China, Japan, South Korea, and India in the Asian automotive sector, both in terms of their own production and investments. Thailand and Indonesia complement this by focusing on assembly and spare parts production. However, the lack of a unified platform for sharing information, production factors, financial support, and innovative developments among these countries limits their potential. Establishing an automotive sector or economic trade union among these countries would strengthen their position against Western competitors. Additionally, including Asian countries in China's One Belt One Road initiative through an automotive trade agreement could foster a sectoral innovation initiative by facilitating greater financial and information flow within the region.