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COMPARATIVE ADVANTAGE OF THE TURKISH AEROSPACE INDUSTRY IN THE CONTEXT OF INDUSTRIAL CLUSTERS[1]

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ABSTRACT

The study aims to investigate Turkey's aerospace industry's relative comparative advantage and specialization level of Turkey's aerospace industry under an industrial clustering context. To estimate the degree of industrial specialization; Balassa (1965), Balassa-Noland (1989), Vollrath (1991), and Laursen (2015) indices were used. The results revealed that Turkey's aerospace industry has not yet reached the specialization level to create any comparative advantage. In the light of concurrent data and reports presented by the World Trade Organization (2022), Defense Industry Manufacturers Association of Turkey (2022), and Turkish Exporters' Assembly (2022); it is seen that aerospace clusters' stakeholders are the principal actors who create the total industry outputs in Turkey. From this point of view, some policy recommendations are presented by synthesizing the research findings with the industrial cluster literature.

Keywords: *Competitiveness, Export, Industrial Cluster, Aerospace Industry, Innovation.*

JEL Codes: *F10, F14, O14.*

ENDÜSTRİYEL KÜMELENMELER BAĞLAMINDA TÜRKİYE'NİN HAVACILIK ve UZAY ENDÜSTRİSİNİN REKABET AVANTAJI

ÖZET

Bu çalışmanın amacı Türkiye'nin havacılık ve uzay endüstrisindeki mukayeseli üstünlük ve uzmanlaşma derecesini endüstriyel kümelenmeler bağlamında tespit etmektir. Endüstriyel uzmanlaşma derecesinin tespitinde Balassa (1965), Balassa-Noland (1989), Vollrath (1991) ve Laursen (2015) rekabet ve uzmanlaşma endBeksleri kullanılmıştır. Bulgular birbirleriyle tutarlı biçimde Türkiye'nin havacılık ve uzay endüstrisinin henüz mukayeseli üstünlük yaratacak olgunluğa erişemediğini göstermektedir. Dünya Ticaret Örgütü (2022), Savunma Sanayii İmalatçıları Derneği (2022) ve Türkiye

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İhracatçılar Meclisi (2022) verileri beraberce değerlendirildiğine, söz konusu endüstri çıktılarının neredeyse tamamen küme paydaşlarınca üretildiği görülmektedir. Bu doğrultuda analiz bulguları kümelenme alanyazını ile sentezlenerek sektör ve kümelenmeler bağlamında bazı politika önerileri sunulmuştur.

Anahtar Kelimeler: *Rekabet Gücü, İhracat, Kümelenme, Havacılık ve Uzay, İnovasyon.*

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1. INTRODUCTION

Efforts to identify the determinants of domestic value-added proportion and total composition of gross exports of a country are a subject of literature that spans approximately 250 years. However, classical foreign trade theories appear to need to be revised in explaining how international competitive advantages emerge in high-value-added technology-intensive industries (Storper, 1992: 66-68). While theories supporting the Ricardian tradition associate comparative advantages with the heterogeneity of the geographical distribution of production resources (Leamer, 1995: 1), they do this on the scale of countries. In recent years, some studies have focused on discussing the heterogeneity of resource distribution from the perspective of spatial economics and made regional inferences to address this theoretical gap (Venables and Limao, 2002). This new approach may be interpreted as a synthesis between the *Ricardian* tradition (Barney, 2001) and the *Marshallian* tradition (Bellandi, 1989). According to this synthesis, especially in technology-intensive industries, national competitive advantage is a direct outcome of *clusters* or similar *geographical agglomerations* that provide the most ideal environment for information spillovers, collective learning, and innovation (Porter, 1990: 19, 25, 29; Storper, 1992: 61, 84, 86).

Clusters create positive externalities through various mechanisms such as allowing access to raw materials and semi-manufactured goods at a more competitive price level thanks to specialized suppliers, facilitating access to qualified labor and specialized service inputs, establishing a healthy physical and cognitive infrastructure for formal information exchange between firms, paving the way for informal information spillovers between firms by making mobilization and the establishment of personal relationships more accessible, and reducing transaction costs (Porter, 1990; Baptista, 1996, Rosenfeld, 1997, Den Hertog and Maltha, 1999, Malmberg and Maskell, 2002, Doloreux and Parto, 2005). These characteristics of clusters provide essential clues as to why technology-intensive industries that take part in high-value-added production tend geographical agglomeration. However, by its inherent relatedness with defense industry (Vekeman, 2006: 1) which is considered even by Adam Smith as one of the three areas where state interventions are necessary (Coulomb, 1998: 299), the aerospace industry seems worth examining with its unique dynamics.

The recently observed exclusion of Turkey from some large-scale multinational defense industry projects since 2019 within the scope of the "*Countering America's Adversaries Through Sanctions Act (CAATSA)*" (Dilek and Oğuz, 2021: 198) brings the necessity of robust national self-sufficiency in this industry into question again. The achievement of this goal requires the high-level collaboration of large-scale firms that are in the position of prime contractors in the industry and SMEs, which usually act as suppliers. Such a collaboration that can be provided via industrial clustering has the potential to not only contribute to objectives concerning national security but also raise the foreign exchange earnings per-kilogram of exports.

2. THEORETICAL FRAMEWORK

2.1.Definition and Significance of Industrial Clustering

According to Porter (1998: 78), clusters refer to geographical agglomerations that involve firms that are connected; as well as the machinery, equipment, service, and standardized input suppliers of these firms. The European Commission (2008: 9) defines clustering as "a group of firms, related economic actors, and institutions that are located near each other and have reached a sufficient scale to develop specialised expertise, services, resources, suppliers and skills". Based on several unique definitions presented in the relevant literature (Martin and Sunley, 2003: 12), this phenomenon can be defined as a productive economic ecosystem that is created in a synergy between state institutions and different firms that are in a non-destructive competition and collaboration simultaneously with each other in a specific geographical area.

Akoorie (2011: 452) states that the concept of *clustering* was introduced to the literature by Czamanski (1971) and Czamanski and Ablas (1979). Nevertheless, the concept of *industrial districts* coined by Marshall (1890) is accepted today as a standard reference in the literature on industry clusters (Vorley, 2008: 790). In his pioneering studies leading to the emergence of the term, Marshall defines an industrial district as "a geographic area containing a number of firms producing similar products, including firms operating at different stages of a production process that gain advantages through co-location" (Marshall, 1890: cited in Menzel, Henn, and Fornahl, 2010: 142). It is seen that the perspective of Marshall on the concept is built upon 3 main components. According to this view, firms that share a common geographical area and take part in the same sector have the opportunity to reach to external economies of scale through *(i) information spillovers, (ii) labor pooling,* and *(iii) specialist suppliers* (Pinch and Henry, 1999: 818). This way, the external economies of scale forming initially on a regional scale in the context of an industry will have the potential to create positive effects spreading to every aspect of the national economy through industrial connections in time (Krugman, 1991). This, in turn, makes clusters ideal instruments for growth and development policies.

It should not be assumed that clusters are instruments that are unique to controlled economies in terms of economic growth and development. Porter (1990: 69-129), who excludes the government from the 4 main factors that facilitate sustainable competitive advantage in his seminal *diamond model* with a neoliberal point of view, interprets clusters as organic structures that should emerge by themselves in a free competition environment (ibid, xvii). Porter (1998: 86) describes clusters as structures that constantly pave the way for innovation, increase productivity, create new fields of business, and support these fields. Similarly, Rosenfeld (1997: 20-21) argues that in free market economies, various responsibilities fall upon policymakers, including raising awareness for the strategic significance displayed by clusters, making investments in the development of human capital and social infrastructures, supporting collaboration among clusters, and developing and organizing supply chain institutions.[2]

2.2. Industry Clusters and Innovation

A firm-level approach for innovation will be inadequate in understanding the role of other stakeholders - such as other firms, public institutions, universities, institutes, and independent research organizations - that participate in value creation process within a cluster (Porter, 1990: 151; Den Hertog and Maltha, 1999: 193). Considering innovation as a system along with its spatial aspects requires an approach that covers clusters in addition to industrial districts, spatial networks, and other environmental elements. The advantage brought about by this comprehensive point of view stems from the understanding of technological innovation and organizational innovation simultaneously (Mitra, 2000: 228). At this point, albeit not applicable to all clusters of today, one can think about an ideal modern cluster as a component of a regional innovation system (Doloreux and Parto, 2005: 134-135; Niosi and Zhegu 2010).

The triple helix model, which is frequently utilized in the explanation of the effectiveness and benefits of academia-industry-government collaborations in regional innovation systems (Leydesdorff and Etzkowitz, 1998; Etzkowitz and Leydesdorff, 2000) categorizes interactions among these actors in the context of chronology and policy. According to Etzkowitz and Leydesdorff (2000), this triple helix, in the most basic manner, is characterized in the form of the government adopting the role of a sponsor for the industry and academia, guiding them, and inspecting them, as usually seen in socialist regimes. This model, which failed because of its strict restrictions, has eventually been replaced with the *laissez-faire* approach, and the government has become an equivalent partner of the system by diverging from its guiding and inspecting roles. Today, the awareness that effectiveness in innovation could only emerge as a function of an intensive interaction among these three actors has provided the grounds for the

[2] In a study that was conducted by Roelandt and Den Hertog (1999) in this context, problems related to clusters in 13 OECD member countries and national policies adopted for the solutions to these problems were reviewed.

emergence of clusters and similar hybrid structures that gather firms on all scales that operate in different fields, research institutions under the state, and the academia.

The view that clusters create a suitable climate for innovation is based on the idea that information spillovers will emerge more effectively in a geographically limited area (Porter, 1990: 151; Den Hertog and Maltha, 1999: 193). These spillovers can also come from other stakeholders of clusters such as universities and research institutions (Baptista, 1996: 62). "In such an environment, chances are greater that an individual firm will get in touch with actors that have developed or been early adopters of new technology", according to Malmberg and Maskell (2002: 433). Hence, clustering not only provides firms with the opportunity for competitive skills, higher productivity, profitability, and growth but also increases innovation (Simmie, 2004: 1101).

It can be argued that knowledge sharing, which constitutes the basis of modern definitions of clustering, no longer appears to be a function of geographical proximity, which is another important element of these definitions, in the age of information and communication. Here, the concept of *tacit knowledge* can take on a facilitating role in the comprehension of the ongoing critical role of geographical proximity in the creation and sharing of knowledge, especially in SME clusters. Tacit knowledge, as stated by Polanyi (1966: 8), is the inexpressible part of what is known. Therefore, as tacit knowledge becomes an inseparable part of personality and is integrated with the talent to a certain extent, it is seen as natural by the person holding it, and it becomes that much difficult to transfer (Ambrosini and Bowman, 2001: 816). Such knowledge can usually be transferred through metaphors and storification (ibid). Therefore, tacit knowledge makes direct personal communication between the provider and the recipient crucial, and it primarily appears within structures involving geographical proximities such as clusters (Preissl and Solimene, 2003: 107). Studies on aerospace clusters have confirmed the view that spatial proximity increases the quantity and quality of knowledge sharing among firms (Bönte, 2004: 275-276; Biggiero and Samarra, 2010: 298-301).

2.3. Role of Clusters in the Competitive Power of the Aerospace Industry

The fact that the aerospace industry is integrated with the defense industry by its nature is not the sole factor that leads to its consideration as strategic. This sector has intensive technological complexity, and this technological complexity requires an exceptionally high fixed capital and R&D investment to a scale on which its economic returns can only be gained in the long run (Alberti and Pizzurno, 2015: 265). The aerospace industry, which is categorized as one of the 3 main high-technology industries by Eurostat (2021), is the sector with the highest intensity of R&D (Galindo-Rueda and Verger, 2016: 14), whereas, in terms of patenting, it remains behind its competitors: automotive and biotechnology (OECD, 2014: 86-87). Its protection with an intensively import-substituting approach in several countries despite these disadvantages, even today (McGuire, 2014: 619-620), may be explained by that it has a backward linkage effect beyond its meaning for national security (Whealan-George, 2015). In other words, the stimulation of this sector that uses the production outputs of numerous related and supporting industries as inputs has the power to rejuvenate production and employment in many sectors. Therefore, the aerospace industry is described as "an assembly industry" by Vekeman (2006: 3). This comment is also supported by Beelaerts, Santema, and Curran (2010: 1), and the most prominent aerospace firms of today are named system "integrators" rather than manufacturers.

A high backward linkage effect means that the competitive power of the industry is substantially influenced by the performance of its suppliers. Such that, according to Fan, Russell, and Lunn (2000: 14-15), the supplier-producer relationships of the industry have recently had a trend of transition from a vertical organizational structure to a horizontally embedded integration. The responsibilities of suppliers regarding the inputs they provide no longer end at delivery, but these responsibilities are assumed directly by the suppliers throughout the economic life of the product. According to Rossetti and Choi (2005: 1), the reason for this transformation is that every subsystem in the aerospace industry requires a particular specialty and know-how. Thus, firms tend to establish long-term close relationships with their suppliers.

Long-term collaborations between suppliers and producers result in clusters in the aerospace industry without the need for political incentives. In terms of their styles of formation, it may be argued that aerospace clusters display the characteristics of hub-spoke clusters in general, as described by Markusen (1996: 298). In such clusters, one large-scale firm or a few such firms constitute a sort of hub, and these firms are usually supplied by multiple small-scale firms that have low revenues. An abundance of standardized financial and technical resources emerges around these clusters under the supervision of large-scale firms, and the effect of the public sector is seen in the provision of infrastructural resources. The study that was conducted by Niosi and Zhegu (2005: 24-25) in Montreal, Seattle, Toulouse, and Toronto, which host significant manufacturing centers of the most prominent aviation firms of the world, namely Boeing, Airbus, Bombardier, and Embraer, confirms this view.

2.4. Current State of the Aerospace Industry in Turkey

According to the 2021 performance report of the Defense and Aerospace Industry Manufacturers Association [SaSaD] regarding the current state of the Turkish aerospace industry, the total revenue of the Turkish aerospace industry increased by 14.72% compared to the number in 2020 and reached a total of $10 billion 159 million 297 thousand (SaSaD, 2022: 7). Within the scale of the civil aviation industry that is worth $1 billion 643 million in total, the contribution of SMEs is only around $2 million. The sectoral scale of military aviation is about $1 billion 652 million, and the contribution of SMEs in this field is $14 million. The scale of the Turkish space industry is approximately $3.83 million (ibid: 8, 24-25), and this subsector is currently in the form of an infant industry. In 2021, the total technology development spending of the national defense and aerospace industries was $215 million, while its total product development spending was $1 billion 425 million. While 28% of this spending was funded by the equities of the firms, 72% was covered by project grants. It is seen that the share of firm equities in the total product and technology development spending sum has an increasing trend compared to previous years (ibid: 18-19). In 2021, 19279 people, corresponding to 25% of the 75660 personnel in total employed in the defense and aerospace industries, were working in R&D operations. The total number of engineers employed in the sector was 21828. The employment of labor in the sector is localized in Ankara at a rate of 52%, in Istanbul at 18%, and in İzmir at 3% (İbid: 20-23).

According to the World Trade Organization [WTO] (2022) data, in the foreign trade division no 88 on "aircraft, spacecraft, and parts thereof", Turkey had an import volume of $2 billion 832 million 409 thousand and an export volume of $1 billion 407 million 656 thousand in total in 2021.[3] Therefore, in this division of foreign trade, the trade deficit in 2021 was $1 billion 424 million 753 thousand, and the export/import coverage ratio was approximately 50%, excluding foreign currency earning services with mutual attachment. The share of Turkey in the world's total exports, constituting a sum of $140 billion 380 million 963 thousand, was about 1% in the same year. In the exports of Turkey, its largest trade partner was the US, with a trade volume of approximately $305 million 592 thousand. The US was followed respectively by Germany, Azerbaijan, Morocco, and Ukraine. In 2021, Turkey increased its exports of products subject to this foreign trade division to Ukraine by 107% in comparison to the previous year.

2.5. Aerospace Clusters in Turkey

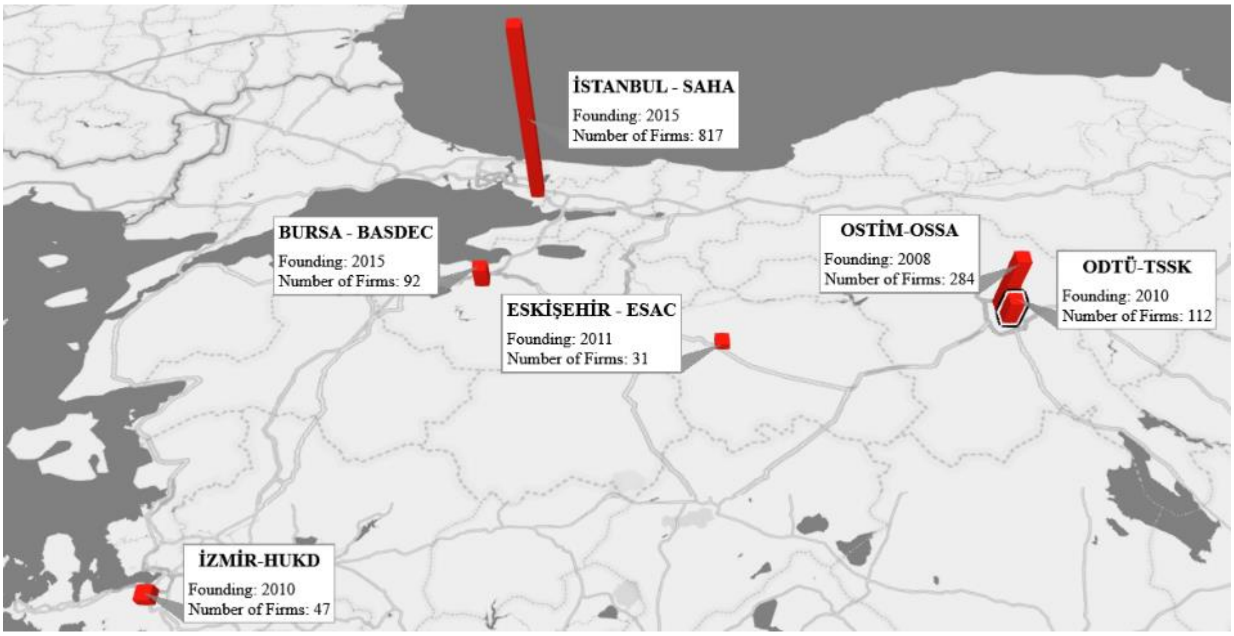
There are three comprehensive reports on the state and projections of the Turkish aerospace industry prepared by state institutions after 2000 (State Planning Organization [DPT], 2001; Ministry of Transportation, Maritime Affairs, and Communications [UDHB], 2013; Ministry of Development [TCKB], 2018). In these three separate reports, similarites in recommendations regarding sectoral human capital, institutional and legal infrastructure, financing opportunities, and raising the share of local manufacturing is worth noting. For eliminating these issues, in Turkey, aerospace clusters are supported as policy instruments (UDHB, 2013:156; TCKB, 2018: 51). By the year 2022, there are 6 aerospace clusters with legal entity status. These are the OSTİM Defense and Aerospace Cluster [OSSA], Teknokent Defense Industry Cluster [TSSK], İzmir Aerospace Cluster Association [HUKD], Eskişehir Aerospace Cluster [ESAC], Bursa Space, Aviation, and Defense Cluster [BASDEC], and

[3] According to the report published by SaSaD (2022: 26-27), the civil aviation exports of Turkey in the same year constituted a sum of $944 million, while its military aviation exports constituted a sum of $534 million, and its space industry exports constituted approximately $280 thousand. These exports collectively reflect a total sum of $1 billion 478 million. The difference of approximately 5% between the data provided by SaSaD (2022) and the WTO (2022) is considered to have originated from statistical errors, differences in the classification of products (HS-NACE), and differences in the form of delivery in the reporting of the data (FOB-CIF) (Fortanier, 2016). Almost all exports were conducted by large-scale firms.

Istanbul Defense and Aerospace Cluster [SAHA]. The geographical locations of these clusters, their establishment dates, and the numbers of their member firms are shown in Map 1.

OSSA, which is the oldest aerospace cluster in Turkey, was established in 2008 under the Ankara Middle East Industry and Trade Center [OSTİM]. ByOctober 2022, the cluster, which has missions such as supplying the needs of the Turkish Armed Forces (TSK) by domestic production, increasing the international competitive power of SMEs operating in the industry by improving their skill inventories, meeting the requirements of industrial certifications such as AS9100, and establishing infrastructure for information sharing between universities and SMEs (OSSA, 2022a), includes 284 member firms most of which are SMEs (OSSA, 2022b). The member firms supply for very strategic defense industry organizations and firms such as Roketsan, TUSAŞ, TÜBİTAK SAGE, HAVELSAN, FNSS, and BMC. In addition to multiple international platforms, the cluster is also a member of the European Aerospace Cluster Partnership [EACP]. Its projects are carried out in collaboration with several state institutions, ministries, universities, development agencies, military departments, the Directorate General of Security, and the General Directorate of State Airports Authority (OSSA, 2022a).

Map 1. Defense and Aerospace Clusters with Legal Entity Status in Turkey: Geographical Locations, Establishment Years, and Numbers of Member Firms[4]



Source: Created by the authors utilizing the cluster websites.

Another aerospace and defense industry cluster located in Ankara is TSSK, which gained legal entity status in 2010 under the Middle East Technical University [ODTÜ] Teknokent. The cluster, which prioritizes collective R&D operations, aims to achieve national self-sufficiency in the fields of defense,

[4] The number of member firms is displayed for October 1, 2022.

aerospace, and cybersecurity (TSSK, 2022a). By August 2022, the cluster hosts 112 firms most of which are SMEs. The cluster also includes research and coordination centers of significant organizations and institutions such as ASELSAN, FNSS, METEKSAN, and Vestel (TSSK, 2022b).

İzmir HUKD, which gained legal entity status in 2010 with the support of the Undersecretariat of Defense Industries [SSM] (HUKD, 2022a), hosts 47 member firms and state institution representatives by October 2022. Prominent aerospace firms such as HAVELSAN, Kale Havacılık, and Kale-Pratt and Whitney are among the stakeholders of the cluster (HUKD, 2022b).

ESAC, which was established in 2011 with the initiatives of the Eskişehir Chamber of Industry, aims to achieve collaboration between state and private sector stakeholders, promote sectoral entrepreneurship and innovation, facilitate the access of members to the financial and physical inputs that they need, and conduct market research (ESAC, 2022a). By October 2022, the cluster includes 31 firms and institutions most of which are SMEs (ESAC, 2022b).

BASDEC, which gained legal entity status as an association in 2015 with the support of the Bursa Chamber of Commerce and Industry, conducts operations such as supplying the needs of the defense and aerospace industries with domestic resources, facilitating the access of members to Supporting the Development of International Competitiveness (UR-GE) projects, meeting the requirements of certifications such as AS9100, and consulting (BASDEC, 2022a). By October 2022, the cluster includes 92 member firms most of which are SMEs (BASDEC, 2022b).

As of October 2022, SAHA, which gained legal entity status as an association in 2015 in Istanbul with 27 founding firms (SAHA, 2022a), is the largest aerospace cluster in Turkey and the EACP, with 817 member firms most of which are SMEs (SAHA, 2022b). SAHA has adopted missions such as reducing dependency on imports in the aerospace and defense industries, providing infrastructure for firms and public stakeholders on every scale for R&D operations, facilitating the commercialization of the knowledge bases of universities and research organizations, developing human capital, developing and inspecting sectoral standards and certifications, and facilitating the access of members to state support and grants within the scope of the Industrial Competence Assessment and Support Program [EYDEP] and UR-GE programs. The association also aims to assess and follow the operations of the SMEs working under it with a success index. Moreover, the association operates in collaboration with various ministries, universities, development agencies, the General Directorate of Civil Aviation, and the Scientific and Technological Research Council of Turkey (TÜBİTAK). SAHA supports start-ups that aim to operate in the aerospace industry within the scope of the SAHA Istanbul Entrepreneurship Project (SAHA, 2022a).

Considering the data of the WTO (2022), SaSaD (2022), and the Turkish Exporters Assembly [TİM] (2022) together, it is seen that almost the entirety of the total revenue and exports of the Turkish aerospace industry belongs to firms that are the founding members or stakeholders of clusters that have legal entity status in this field such as TUSAŞ, TEİ, ASELSAN, Alp Havacılık, ROKETSAN, and Pratt and Whitney. In agreement with the arguments of Markusen (1996: 298), the aerospace clusters in Turkey mostly include SMEs that are located in the same region to supply for these firms. It is observed that this exceptionally high-value-added industry is almost entirely composed of stakeholders of clusters in Turkey. In other words, the thesis that the performance of clusters is the main factor determining national competitive advantage in high-value-added industries (Storper, 1992) is validated in particular for the aerospace industry of Turkey.

The common conclusions of studies focusing on defense and aerospace clusters in Turkey (Yalçınkaya and Adiloğlu, 2014; Demir, Caymaz, and Erenel, 2016; Eceral, 2017) have suggested that clusters have found their place as an effective policy instrument in the achievement of national self-sufficiency since the 2010s, but despite the significant incentives and support of supervisory state institutions, factors such as hastiness, lack of coordination, and lack of planning have created some difficulties in the functional realization of the potential of these clusters. These studies have also shown that the defense and aerospace industry clusters in Turkey show similarities to their counterparts in the rest of the world (Markusen, 1996) in terms of not only the form of their emergence but also their low profitability for firms (Gebeş and Battal, 2014).

3. EMPIRICAL LITERATURE

The empirical literature on industrial specialization and competition analysis can be examined under 4 categories. The first category covers studies representing the Ricardian tradition that aim to identify comparative advantage by comparing the specialization degrees of certain countries or groups of countries in various industries without regard to the spatial aspect. In the determination of comparative advantage, mostly the Balassa (1965) index, Vollrath (1991) index, and other indices that are derivatives of these are utilized. There are numerous studies conducted in this field. In one of the studies with the highest number of citations, Kösekahyaoğlu (2003) examined the comparative advantages of Turkey against EU countries from a historical perspective. Accordingly, Turkey started to lose its comparative advantages in labor-intensive industries during the commercial deregulation period after 1980. The author explains this finding by the effect of the increased demand for labor on real wages. In a similar study, Utkulu and Seymen (2004) made the same comparison for the period between 1990 and 2003. According to their findings, Turkey had a comparative advantage over EU member countries in 7 industries associated with agriculture, rubber, and textile. Topçu and Kılavuz (2012) examined the effects of the Custom Union Agreement [CUA] between the EU and Turkey, which has been in force since 1996, on the comparative advantage of the Turkish Manufacturing sector in terms of the expected shifts stemming from the prospective intensification of international competition. The findings present no change in the competitiveness of the Turkish manufacturing sector after the advent of the CUA in terms of technological intensity. The authors attribute the lack of a technological shift in national exports to the domestic supply conditions (ibid. 27). In a more recent study that was performed by Leromain and Orefice (2014: 48-63), the comparative advantages of 20 OECD countries in 70 industries in the period of 1995-2010 were investigated. As a consequence, Turkey was found to be the country with the greatest comparative advantage in the textile, minerals, and glassworking industries.

It should be emphasized that Turkey is not the sole developing economy in which Balassa (1965) and Vollrath (1991) indexes are still widely utilized among researchers in order to guide policy making. Although it is not exempt from critiques (Das, 2009); as a first and relatively simple instrument, comparative advantage indexes enable academics and policymakers to gain more insight into the complex nature of international trade. For instance, a multi-layered long-term analysis by Boonzaaier and Van Rooyen (2016) conducted on the South African stone fruit sector revealed how numerous the factors that impact competitive advantage may be even in a so-called traditional sector. The authors detected 84 factors that impact competitiveness in the industry and suggested industry-level strategies in 11 fields, including technological innovation and climate change for policymakers. Some other studies show how policymaking can change the comparative advantage observably even in short term. Tapsin and Alitoska (2018) utilized these indexes to calculate the revealed comparative advantage in 150 product groups in Macedonia for the period 2013-2016. The findings of the study revealed that the comparative advantage of the country shows signs of a shift towards capital-intensive products, possibly thanks to policies that support investment in the trade sector (ibid. 253).

The second category includes the micro-level observations of the Marshallian tradition. From the point of view of the existence of a positive relationship between innovation performance and export performance, these studies (Love and Roper, 2015: 42) have made inferences on the relationship between clusters and export performance. The study that was carried out by Niosi and Zhegu (2005) with this approach confirms this relationship in aerospace industry. Nevertheless, the mediating role of innovation performance between the geographical propensity of clustering and export performance appears to be controversial in different regions and industries. Kesidou and Szirmai (2008) detected a positive significant relationship between local knowledge spillovers and innovative performance of firms that located in Montevideo software clustering, Uruguay. The absence of a statistically significant relationship between the innovation performance and export intensity was attributed to tacit nature of the disseminated knowledge by the authors (ibid. 24). Likewise, a structural equation model tested by Prim, Amal and Carvalho (2016) on 100 manufacturing companies located in the State of Santa Catarina- Brazil, could not confirm this mediation while confirming the relationship between clustering and export performance.

The third category of studies that also represent the Marshallian tradition includes macro-scale studies that focus on the effects of industry clusters on national export performance. The number of these studies is relatively low. One of the most noteworthy studies in this field was conducted by Storper (1992). The author concludes that approximately 25% of the high technology exports of the US are carried out by industry clusters (Storper, 1992: 76). Similarly, Haunkes (1999: 65) found that 6 mega-cluster networks containing firms that operate in 104 different sectors in Norway conducted 76.8% of the national exports. A more recent macroanalysis was carried out by Hollander and Merkelbach (2020). The study shows that 2950 clusters operating in 51 exporting industries in the EU increased productivity in exporting sectors by approximately 15%. This difference increased to 140% in the 198 highest-performing exporting clusters. In a study conducted specifically on aerospace clusters in this context revealed that 80% of the exports of the French national aerospace industry were conducted by a single cluster located in the city of Toulouse (Porter and Takeuchi; 2013: 11). In India, the share of Bangalore Aerospace Cluster is estimated at two-thirds in total aerospace exports (Paone, 2016: 49) Likewise, aerospace manufacturing in Mexico, which is hugely export-oriented, is primarily consists of the production of 5 sub-clusters (Luna, Addepalli, Salonitis and Makatsoris, 2018: 31). While it seems that different reasons gave rise to form of clusters in the Mexican and Indian cases; including R&D institutions, incentives, proximity to customers, and low operation costs (Paone, 2016; Romero, 2011; Ketels, Ramirez and Porter, 2015); occasionally, foreign direct investments fueled by diaspora relations appear as a unique way to determine the destiny of a national industry via industrial clusters. According to Freund and Moran (2017), the commissioning of a Morrocan national as Boeing’s Executive President for Worldwide Sales in Seattle had led to the form of an aerospace cluster in Casablanca around a multinational joint venture in the 2000s. After all these developments, “Moroccan aerospace exports reached almost a billion dollars ($961 million) in 2013, up from zero in 1999” (ibid. 11).

The fourth category, which may be described as a synthesis of the Ricardian and Marshallian traditions, uses the Balassa (1965) and Vollrath (1991) indices in the testing of models that directly associate comparative advantages with clusters. However, due to statistical limitations, datasets have been narrowed down in terms of time or regions (De Benedicts, 2007: 216), and the number of empirical studies in this field has remained highly limited. In such as study, Figiel, Kuberska, and Kufel (2012: 11-17), who investigated the relationship between the presence of agricultural food clusters in 27 EU member countries and the competitive power levels of countries in this industry using these indices, explained their finding that this relationship was not at an expected level by that the statistics of the European Cluster Observatory are not methodologically qualified sufficiently.

4. METHOD and DATA SOURCES

This study adopts the approach that theoretically associates the role of clusters in industrial specialization with comparative advantages on the national scale. Accordingly, the study utilized data obtained from the Comtrade database of the WTO (2022) in the calculation of the Balassa (1965), Vollrath (1991), and Laursen (2015) competition/specialization indices in the foreign trade division no 88 on "aircraft, spacecraft, and parts of thereof". These data covered the period of 2002-2021. The Microsoft Excel program was used to calculate these indices.

The Revealed Comparative Advantage [RCA] Index, which has become a tradition in the measurement of the degree of specialization and international competitive power in certain industries, was developed by Balassa (1965). The index mainly measures the share of the ratio of the exports in a certain industry to the gross exports of that country in the ratio of the total exports in that industry in the world to the world's gross in all industries. This way, the presence of national specialization in the examined industry is measured. The index is expressed mathematically as follows, such that X is exports, j is the industry, i is the country, and w is the world (Balassa, 1965: 116; De Benedictis and Tamberi 2004: 325):

$$RCA = (Xij/Xi)/(Xwj/Xw) > 1 \tag{1}$$

In the RCA Index, the critical threshold is 1.[5] While a value higher than 1 represents a specialization in the industry in question, a value lower than 1 represents the absence of such specialization. The index, which is criticized in the literature based on the claim that it neglects import data and basic foreign trade theories (Bowen, 1983), has led to new efforts including both export and import operations of foreign trade. In light of these efforts, the index was revised by Balassa and Noland (1989) in such a way as to also include imports, and the Net Export Index [NEI] was developed. The index is calculated as follows, where M represents imports (Balassa and Noland, 1989: 9):

$$NEI = (Xij-Mij)/(Xij+Mij) > 0 \tag{2}$$

NEI expresses the ratio of the net exports of a country in a certain industry to the country's total foreign trade volume in the same industry. In this case, the |NEI| value expresses the share of inter-industry trade in the total trade volume, whereas 1-|NEI| expresses the share of intra-industry trade in the trade volume of the industry in question (Vixathep, 2011: 6; Erkan and Sarıçoban, 2014:120).

The competition indices that are used more frequently today are the Vollrath (1991) indices that eliminate the shortcomings of especially the RCA Index developed by Balassa (1965). These are the

[5] Hinloopen and van Marrewijk (2001: 18) recommend different threshold values that may allow a more accurate interpretation of the index. Accordingly, values in the range of [0,1] would indicate a competitive disadvantage, those in the range of (1,2] would indicate a weak competitive advantage, those in the range of (2,4] would indicate a moderate competitive advantage, and those greater than 4 would refer to a strong competitive advantage.

Relative Export Advantage [RXA] Index, the Natural Logarithm of the Relative Export Advantage [lnRXA], the Relative Import Penetration Index [RMA], the Relative Trade Advantage [RTA] Index, and the Revealed Competitiveness [RC] Index. The main difference between RXA and RCA is that the former prevents duplicate calculations by neglecting the exports of the industry and country in question in the national and total world exports. RMA, on the other hand, makes the same calculation over import data.[6] When X is exports, M is imports, j is the industry, t is all industries other than the aforementioned industry j, i is the country, and n is all countries other aforementioned country i, these indices are mathematically expressed as follows (Vollrath, 1991, Fertö and Hubbard, 2003: 249-250; Altay and Gürpınar, 2008: 262-268):

$$RXA=(Xij/Xit)/(Xnj/Xnt) >1 \tag{3}$$

$$\ln RXA >1 \tag{4}$$

$$RMA=(Mij/Mit)/(Mnj/Mnt) <1 \tag{5}$$

$$RTA=RXA–RMA >0 \tag{6}$$

$$RC=\ln(RXA)-\ln(RMA) >0 \tag{7}$$

Laursen (2015: 104-105) recommends the usage of the Revealed Symmetric Comparative Advantage [RSCA] Index in interpretations to be made over trends due to the fact that the RCA Index provides asymmetric outputs in the ranges of 0 - 1- ∞. RSCA is calculated as follows (Laursen, 2015: 101):

$$RSCA= (RCA-1)/(RCA+1) \tag{8}$$

In this case, the index takes values between -1 and 1, and values deviating from 0 indicate low or high specialization respectively in the industry in question.

5. RESULTS and DISCUSSION

Eight competition index values that were calculated for the foreign trade division no 88 on “aircraft, spacecraft, and parts of thereof” for Turkey are presented collectively in Table 1.

Table 1. Degree of Specialization in the Foreign Trade Division No 88 on “Aircraft, Spacecraft, and Parts of Thereof” in Turkey (2002-2021)

YIL	RCA	NEI	RXA	lnRXA	RMA	RTA	RC	RSCA
2002	0,192	-0,368	0,189	-1,669	0,354	-0,165	-0,630	-0,677
2003	0,586	0,487	0,581	-0,543	0,165	0,416	1,257	-0,261
2004	0,490	-0,423	0,485	-0,724	1,000	-0,515	-0,724	-0,342

[6] The total exports and imports of the world, which are expected to be equal, usually do not exactly fit each other due to reasons such as differences in the reporting of data (FOB-CIF), customs regimes, and differences in the countries of origin that are taken as a basis in the declaration of imports and exports (Fortanier, 2016).

2005	0,233	-0,104	0,230	-1,472	0,225	0,005	0,020	-0,621
2006	0,326	-0,573	0,321	-1,136	0,843	-0,522	-0,966	-0,509
2007	0,372	-0,367	0,367	-1,001	0,650	-0,282	-0,570	-0,457
2008	0,149	-0,719	0,146	-1,925	0,681	-0,535	-1,541	-0,741
2009	0,164	-0,572	0,160	-1,832	0,552	-0,392	-1,238	-0,719
2010	0,175	-0,829	0,172	-1,762	1,423	-1,252	-2,115	-0,702
2011	0,183	-0,839	0,180	-1,716	1,554	-1,374	-2,157	-0,691
2012	0,209	-0,726	0,205	-1,583	1,121	-0,916	-1,697	-0,654
2013	0,289	-0,518	0,283	-1,261	0,750	-0,466	-0,973	-0,552
2014	0,272	-0,600	0,267	-1,320	0,920	-0,653	-1,237	-0,572
2015	0,238	-0,695	0,233	-1,458	1,265	-1,033	-1,693	-0,615
2016	0,239	-0,715	0,233	-1,456	1,429	-1,195	-1,812	-0,615
2017	0,520	-0,271	0,513	-0,668	0,853	-0,340	-0,508	-0,316
2018	0,313	-0,476	0,307	-1,180	0,920	-0,613	-1,097	-0,523
2019	0,369	-0,493	0,362	-1,015	1,343	-0,980	-1,310	-0,461
2020	0,425	-0,614	0,419	-0,869	1,941	-1,522	-1,533	-0,404
2021	0,623	-0,336	0,619	-0,480	1,407	-0,788	-0,822	-0,232

Source: Calculated by the authors.

Considering the results on the RCA Index, it is seen that the index values in the examined period were all smaller than 1 without any exception. This result showed that Turkey did not have any comparative advantage or specialization in the industry in question in that period. In other words, Turkey contributed to the world's exports in the industry in question to a lower extent than its general export performance did. Because annual changes in degrees of specialization are reflected on the RCA Index values, which are disproportionally asymmetric, it is not possible to comment on a trend here.

According to the results on NEI, which also includes imports in the equation, without an exception, Turkey was in the position of a net importer from 2002 to 2021. This is why the index value, which measures the share of the net trade deficit or surplus for the industry in question in the national trade volume, remained under the critical threshold of 0. It is seen that the index values peaked in the period between 2010 and 2016.

As the share of the industry in question in not only the total world export volume but also the national export volume in Turkey for the period between 2002 and 2021 was low, the values of the RXA and RCA Indices, which prevent duplicate calculations, were close to each other. Likewise, the RXA value that was smaller than 1 showed that Turkey did not have a comparative export advantage in this industry. The value of the lnRXA Index, which makes the RXA Index value symmetric about the origin and shows more precise measurements, that was smaller than 1 also confirmed this finding.

RTA, which expresses the difference between RXA and RMA values, was positive only in the years 2003 and 2005. For this reason, the RC Index value, which expresses the difference between the natural logarithms of the RXA and RMA values, was also positive in these years. This finding may be interpreted as Turkey had a small comparative trade advantage or competitive advantage in this industry in 2003 and 2005.

Finally, the RSCA Index, which makes the RCA Index symmetric for a similar purpose to the purposes of the logarithmic Vollrath indices, showed that in the examined period, Turkey did not have specialization in this industry. The index indicates reduction in the inadequacy degree of specialization after 2010, or in other words, a positive development.

6. CONCLUSION and RECOMMENDATIONS

The aerospace industry; which has an intensive backward linkage effect, a far break-even point, and a high degree of technological complexity; creates clusters deterministically in Turkey, without the need for political incentives, in a similar way to most of its counterparts in the rest of the world. However, since its bidirectional relatedness to the defense industry by its nature, aerospace clusters have rapidly gained legal entity status in the 2010s as a consequence of the significant increase in awareness of the self-sufficiency necessity in light of contemporary sociopolitical developments. Literature shows that these clusters show some similarities to their counterparts in the rest of the world in terms of not only their forms of emergence but also the problems that are observed in these clusters. Studies and official reports have confirmed the foundation of aerospace clusters takes root around large-scale, state-affiliated prime contractor firms, and SMEs within these clusters supply these large-scale prime contractors with low revenue and profitability.

The number of empirical studies examining clusters' role in terms of raising export income, which is especially crucial for underdeveloped and developing countries with limited foreign currency resources, is very low. This situation is associated with difficulties of paired data extraction on different levels of unit, namely firm scale, cluster scale, and industrial scale. Nevertheless, it is seen that the economic output of the Turkish aerospace industry is created almost entirely by the stakeholders of clusters. This allows us to interpret the findings of this study from two different perspectives. Considering the industrial perspective, it may be argued that the Turkish aerospace industry does not have a comparative advantage or specialization yet. This is related to the chronic trade deficit in this division of foreign trade that involves fighter aircraft, airliners, and similar products that have immensely high costs per unit.

Combining the findings with the literature implications on industrial clusters owing to the fact that the aerospace industry is almost entirely embodied by the cluster members in Turkey, the results of this study allow us to offer some policy recommendations on clusters as well. As it was stated earlier, two primary motivations can be detected in the national policymaking pertains to the aerospace industry. Policies determined by economic motivation seem to prioritize the integration of the national industry within the global value chain. In this way, foreign direct investments and cross-border knowledge spillovers are highly encouraged. On the other hand, national security motivation priorities self-sufficiency which is understandable even for the most free-market economies. Few empirical studies conducted in developing countries enable us to gain some insights into the determinants of the success of economic goals. For instance, in Moroccan and Mexican cases, empirical studies confirm the theory. Human capital, geographical concentration, proximity to the customer, existence of anchor-tenants, and even diaspora seem determinative for the fate of the clusters and of the whole national industry. Since self-sufficiency motivation appears to be the prominent factor in the Turkish case, findings should be evaluated accordingly.

The common findings and conclusions of the few academic studies and official reports by state institutions clearly demonstrate that despite their disadvantages, SME clusters are the key to the achievement of national self-sufficiency in this sector. The main advantage of clusters is their potential to mobilize firms and stakeholders of any scale that are unable to achieve the necessary R&D and fixed capital investments with their own equities by creating a synergy in high-value-added technology-intensive industries. In policy recommendations, it should be kept in mind that profitability should be a long-term goal due to the high technological complexity of the sector, and the long-term gains provided by the collective accumulation of knowledge emerging within clusters in the creation of human capital, as well as the high industrial backward linkage effect of the sector, should not be overlooked.

In conclusion, although competition and specialization indices allow for calculations regarding industrial specialization, it is believed that examining this sector, which is frequently subject to governmental protectionism and trade barriers worldwide, by multivariate analysis techniques that also account for these variables will provide more precise outputs. Furthermore, incidental factors such as the reflections of international political developments on the sector, which is currently the case for Turkey, should also be kept in consideration. In this sense, it is believed that enabling public-access cluster databases that integrate different level statistical data from different public institutions, similar to the practices in the EU and the US, will contribute to studies.

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