JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

Research Article
Online: www.drarch.org
Volume 5, Issue 3, (426-440), 2024
DOI: 10.47818/DRArch.2024.v5i3141

The effects of COVID-19 on the agglomeration of high-tech knowledge-intensive business services in Ankara, Istanbul, and Izmir

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Abstract

This study investigates the effect of COVID-19 on the concentration and agglomeration of jobs related to high-tech knowledge-intensive services (HKIS). The main objective of the study is to determine how COVID-19 measures have changed the HKIS agglomeration in three major metropolitan cities of Türkiye—Ankara, Istanbul, and Izmir. Data from 2019 were used as the pre-COVID-19 period, from 2020 as the COVID-19 period, and from 2021 as the post-COVID-19 period, and the agglomeration was calculated using the location quotient. Of the number of HKIS employees in Türkiye, 71.65% worked in Ankara, Istanbul, and Izmir in 2019, but during the COVID-19 period (2020) when the pandemic measures were implemented, the proportion increased to 79%. During the post-COVID-19 period (2021), the percentage of HKIS workers in Türkiye was 78.68%. The observations suggest that the agglomeration of HKIS activities in these three cities continued to increase after the COVID-19 pandemic measures were implemented and removed.

Keywords: COVID-19, high-tech knowledge-intensive business services, sectorial agglomeration

1. Introduction

1.1. KIS and HKIS

Knowledge-intensive services (KIS) refer to services that create, accumulate, or disseminate knowledge (Miles et al., 1995; Muller & Doloreux, 2009; Skorska, 2018). KIS has a broad scope that includes activities such as consulting, advertising, communication and computer services, financial and insurance activities, legal and accounting activities, and security and investigation activities. It can also be defined as a specific, technical, or functional area associated with professional knowledge or expertise (Windrum & Tomlinson, 1999). In another definition, KISs provide specialized knowledge to companies and are a vital source of information, advice, and expertise for other industries (Toivonen, 2004; Aslesen & Isaksen, 2007). Numerous cities aim to compete through knowledge creation and innovation (Benneworth & Ratinho, 2014). In knowledge-based societies, knowledge has taken the place of major capital and KIS industries have emerged as one of the main mechanisms of the contemporary economy (Yum, 2019). KISs offer a competitive advantage with cost and scale advantages (Aslesen & Isaksen, 2007; Vaillant et al., 2012; Mejri et al., 2018).

The Organization for Economic Co-operation and Development (OECD) classifies industries into four categories according to the level of research & development: 1) high-technology industries, 2) medium-high-technology industries, 3) medium-low-technology industries, and 4) low-technology industries (Vaillant et al., 2012). Similarly, in a study titled "EUROSTAT indicators on High-tech industry and Knowledge-intensive services Annex 3 - High-tech aggregation by NACE Rev.2," the European Statistical Office (EUROSTAT) categorizes KIS under the following headings: 1) Knowledge-intensive market services (excluding high-tech and financial services) 2) High-tech knowledge-intensive services (HKIS) 3) Knowledge-intensive financial services 4) Other knowledge-

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Article history: Received 08 December 2023, Accepted 26 November 2024, Published 29 December 2024

intensive services 5) Less knowledge-intensive services (LKIS) 6) Less knowledge-intensive market services 7) Other LKIS. This study focuses on HKIS (EUROSTAT, 2008).

1.2. KIS and Agglomeration

In general, KIS concentrates in big cities (Shearmur & Doloreux, 2008; Wood, 2002; Ženka et al., 2017; Santiago, 2020; Muller & Doloreux, 2009). Urban agglomeration theory suggests that economies of scale, especially economies of scope, competition, diversification, and promotion of specialization will benefit from the quality of services in and around cities more than elsewhere (Wood, 2002). Since its positive externalities can lower businesses' unit production costs and have a major impact on effects related to economies of scale, spatial agglomeration can enhance the growth of the economy (Fan & Scott, 2003; Peng et al., 2022). Although advances in communication technologies have significantly reduced communication costs, spatial agglomeration remains important as it facilitates face-to-face interaction in high-tech innovative activities because of the uncertainties associated with new technologies (Hu et al., 2006). Agglomeration has a positive impact on KIS firms in terms of innovation, development, and diffusion of technologies (Peng et al., 2022). The economic benefits and the benefits of face-to-face interaction have led KIS firms to favor spatial proximity, with spatial agglomeration and clustering often occurring in metropolitan areas, within proximity to their customers and labor pool (Aslesen & Jakobsen, 2007; Vissers & Dankbaar, 2013; Miles et al., 2021). Vaillant et al. (2012) argue that spatial proximity has a positive effect, and drawing on an OECD report (2006), emphasize that KIS firms are both sources and carriers of knowledge that influence and improve the performance of industry clusters in all sectors of the economy.

1.3. COVID-19 Precautions, Remote Working, and KIS

The COVID-19 coronavirus outbreak imposed negative impacts not only on humans but also on the global economy, including small and medium enterprises (Omar et al., 2020). Although KIS provided knowledge management, infrastructure, and services to companies, customers, and stakeholders (Zbuchea et al., 2023; Milasi et al., 2021) during the fight against COVID-19, they were impacted directly and indirectly by their customers who were affected by the health and safety measures. The innovation capabilities and the individual, organizational, and demographic attributes of KIS were impacted during COVID-19 (Kotsopoulos et al., 2022). Hrivnák et al. (2021) state that COVID-19 has had a relatively negative impact on the global economy and that the measures taken to prevent the spread of the virus can cause unemployment in many sectors. In addition, from an economic point of view, long-term effects may be observable in innovation activities for several years. In their study titled "OECD Productivity Working Papers," Milasi et al. (2021) report that working from home and teleworking in KIS in the European Union were also present before COVID-19. However, the measures taken to prevent the spread of COVID-19, such as stay-at-home calls, lockdowns, and social distancing practices, have led to increases in teleworking (Belzunegui-Eraso & Erro-Garcés, 2020; Vasic, 2020), remote work (Espitia et al., 2022; Kylili et al., 2020), and working from home (Bick et al., 2020; Birimoglu-Okuyan &Begen, 2022; Bolisani et al., 2020).

One of the most important changes from the COVID-19 pandemic is the attention to remote working methods. Practices such as remote working have brought up a very important question. Miles et al. (2021) state the question as follows: "If more professionals take opportunities to live and work outside of the major metropolitan areas that traditionally house them, as well as their firms, what happens to these cities?" This question constitutes the main problem addressed in this study. The main objective of the study is to determine how COVID-19 has affected HKIS agglomeration. Several important questions are addressed in this study: "Does the agglomeration of HKIS continue in metropolitan cities after practices such as telecommuting become ubiquitous?" "How has COVID-19 caused a change in HKIS sub-service sectors?"

2. Material

Annual statistical data from the Social Security Institution (SSI) were used in this study. Data on the distribution of insured and workplace statistics, workplaces within the scope of the SSI 4/a category, and compulsory insured persons by activity group and provinces were taken as the basis of this investigation. Agglomeration was calculated based on the number of HKIS employees according to the Nomenclature of Economic Activities (NACE) codes. Table 1 shows the NACE codes defined by EUROSTAT and the services corresponding to the codes.

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Table 1 High-Tech Knowledge-Intensive Services (Source: EUROSTAT, 2008)

NACE Rev. 2 codes	2-Digit Level High-Tech Knowledge-Intensive Services
59	Motion picture, video, and television program production, sound recording, and music publishing activities
60	Programming and broadcasting activities
61	Telecommunications
62	Computer programming, consultancy, and related activities
63	Information service activities
72	Scientific research and development

3. Method

Haig (1926) emphasized that location was effective for describing agglomeration in terms of consumption and production and explained the relationship between location and the labor force. In addition, Haig (1926) presented the relationship between employment data and location and regional specialization as the basic analysis of urban economics (Crawley et al., 2013; Cummings & Epley, 2014; Morrissey, 2016). Specifically, the location quotient (LQ) has been employed in urban and regional economic development studies since the 1940s (Miller et al., 1991; Oka, 2023). Mattila and Thompson (1955) used the LQ to calculate specialization at the local and national levels. In the 1970s, Leigh (1970), Mayer and Pleeter (1975), and Isserman (1977) used LQ for discussing regional specialization in their studies. More recently, LQ has been used in the study of regional clustering (Azhari et al., 2017; Carroll et al., 2008). LQ is effective for determining the concentration of sectors (Chiang, 2009) and is one of the fundamental parameters used in economic analyses (Cummings & Epley, 2014).

In practice, there are some disadvantages of using LQ. First, evaluating sectors that have very close LQ values is difficult (Azhari et al., 2017). Second, in the calculation made with LQ, different analysis methods are needed for competitiveness, inter-sectoral connections, and export characteristics (Carroll et al., 2008; Hill & Brennan, 2000). Third, LQ data cannot be accepted at face value, for example, additional research and data are needed regarding the potential for further expansion of a sector (Miller et al., 1991). The last negative aspect of LQ is that it is insufficient especially for input-output analysis; in addition, LQ value data are not sufficient for providing clustering (Crawley et al., 2013).

In a study conducted by Chiang (2009), it is stated that the LQ is effective in identifying agglomeration economies in regional economic development. As a geographical indicator and a tool for spatial analysis (Miller et al., 1991; Cromley & Hanink, 2012), LQ has been used predominantly to identify and compare local characteristics (Moineddin et al., 2003), industrial specialization, clustering, and economic aggregation in a geographic location or region, as well as promote regional growth (Glaeser et al., 1992; Porter, 2000; Henderson, 2003; Crawley et al., 2013; Tian, 2013). In the present study, agglomeration was calculated using the LQ, which defines the prominence of an industry in a given region (Crawley et al., 2013).

The LQ can be expressed as follows:

$$LQ_i = \frac{e_i / E_i}{e / E}$$

If the result of the above ratio is $LQ_i < 1$ then the concentration of employees in HKIS firms in this selected region is relatively low. In other words, $LQ_i < 1$ implies fewer concentration of employees work in a given sector (HKIS in this paper) compared with other regions (Morrissey, 2016; Çelik et al., 2019). If the result of the above ratio is $LQ_i = 1$, then there is an equal concentration of people working in HKIS activities among the regions. If the result of the above ratio is $LQ_i > 1$, then the concentration of HKIS employees in this region is relatively high (Cromley & Hanink, 2012; Karakayacı, 2010; Munandar et al., 2017; Seçkin, 2015; Środa-Murawska, 2013).

An LQ value of 1.25 is generally accepted as the threshold for local or regional specialization (Mans et al., 2008; Tian, 2013; Nowakowska-Grunt et al., 2014). If $LQ_1 > 1.25$, then regional specialization is considered, based on the number of HKIS employees (Środa-Murawska, 2013; Morrissey, 2016; Çelik et al., 2019). To investigate the agglomeration of HKIS firms and regional specialization, $LQ_i > 1$ (agglomeration) and (specialization) were used in this study for the concentration value and cut-off value for the regional specialization level, respectively.

Before applying the LQ method, the Chi-square test was used to examine the degree of correlation between the spatial location of different sectors and employment power. The Chi-square test is widely used to analyze whether there is a relationship between two or more groups of variables (Akyol & Akbulut, 2017) and/or whether two or more independently selected samples originate from the same group (Duran, 2016). In addition, continuous (numerical) variables specified using measurements can be turned into categorical variables by characterizing them as lower or higher than some reference, to a certain degree (Ak, 2019).

Herein, this study aimed to determine whether there was a significant relationship between years and changes in urban employment. Accordingly, two hypotheses were proposed:

1. Null Hypothesis (H0): There is no association between the spatial location (city or region) and the employment strength of different sectors.
2. Alternative Hypothesis (H1): There is an association between the spatial location and the employment strength of different sectors.

Table 2 was prepared to test these hypotheses, showing the spatial location of HKIS sectors and their relationship with employment.

Table 2 The Relationship Between Spatial Location of Sectors and Employment (The table was prepared based on (Mprotsis et al., 2022))

	NACE 59	NACE 60	NACE 61	NACE 62	NACE 63	NACE 72	TOTAL
ANK-2019	1,570	950	3,691	16,257	5,780	3,384	31,632
IST-2019	18,880	7,202	1,1761	60,057	11,841	2,535	112,276
IZM-2019	524	100	1,723	5,565	2,802	1,308	12,022
ANK-2020	1,191	1,025	4,694	17,994	2,927	4,123	31,954
IST-2020	16,944	7,867	13,424	68,911	11,082	3,112	121,340
IZM-2020	667	94	2,084	6,674	828	1,311	11,658
ANK-2021	1,232	1,069	5,912	20,398	3,150	4,359	36,120
IST-2021	15,187	8,894	13,194	84,556	13,229	2,947	138,007
IZM-2021	390	183	2,252	8,181	778	1,362	13,146
TOTAL	56,585	27,384	58,735	288,593	52,417	24,441	508,155

The numbers of employees in HKIS sectors in Ankara, Istanbul, and Izmir in 2019, 2020, and 2021 obtained using the Chi-square test are presented in Table 2.

From the analyses, the Chi-square value was 39862.168, the degrees of freedom were 40, the p-value was 0, and Yates' Chi-square value was 39862.168. Overall, the result was significant at $p < .05$. $X^2(40, N = 508155) = 39862.168$, $p = 0$. Based on this, hypothesis 0 was rejected and hypothesis 1 was accepted. Therefore, there was a relationship between the spatial location of different sectors and employment power.

4. Study Area

The COVID-19 pandemic started to spread across the world in November 2019. The first COVID-19 case in Türkiye emerged in March 2020. The data of this study were evaluated over three years using the data published by the SSI between 2019 and 2021. The data for 2019 show the agglomeration before COVID-19. Since the data for 2019 indicate the conditions before the COVID-19 outbreak, they were analyzed as control data for comparison. Then, the data for 2020 contain the period between March and June, when full lockdowns and curfews were imposed, and the period after June, when the effects of the controlled social life and renormalization on the HKIS agglomeration were investigated. Finally, 2021 was examined as the period after COVID-19.

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In this study, calculations were made considering NUTS-3 regions. Ankara, Istanbul, and Izmir are Türkiye's three largest metropolises, and their provincial borders include both NUTS-2 and NUTS-3 regions. Figure 1 shows the locations of Ankara, Istanbul, and Izmir in Türkiye.

Figure 1 Locations of Ankara, Istanbul, and Izmir in Türkiye

According to data from the Turkish Statistical Institute (TURKSTAT), Türkiye's population in 2022 was 79,613,279, with 5,782,285 people living in Ankara, 15,907,951 in Istanbul, and 4,462,056 in Izmir. Of Türkiye's population in 2022, 32.84% lived in Ankara, Istanbul, and Izmir. According to the data on the distribution of SSI 4/a workplaces and compulsory insured persons by activity group and province, there were 1,239,615 actively insured persons in Ankara, 4,485,393 in Istanbul, and 1,010,798 in Izmir. Considering that there were 16,169,679 active insured persons in Türkiye in 2021, the share of active insured persons in the three metropolitan cities was 41.65%. Ankara, Istanbul, and Izmir were selected as the sample areas because approximately one out of every three people live in Ankara, Istanbul, and Izmir and approximately 4 out of every 10 actively insured people live in these three metropolitan cities.

In the context of the data published by TURKSTAT, the shares of Istanbul, Ankara, and Izmir in the gross domestic product from information and communication services were 87.26% in 2019, 87.46% in 2020, and 87.81% in 2021.

5. Results and Discussion

Table 3 shows that a total of 217,616 people were working in HKIS sectors in Türkiye before the COVID-19 pandemic. There were 112,276 people working in HKIS companies in Istanbul, 31,632 in Ankara, and 12,022 in Izmir. Of the total HKIS employees in Türkiye, 71.65% were working in Ankara, Istanbul, and Izmir. Computer programming and consultancy accounted for the majority of the employment activities. Of the HKIS employees employed in Ankara, Istanbul, and Izmir, 89.46% worked in motion picture, video, and television program production, sound recording, and music publishing, 84.61% in programming and broadcasting, 81.3% in computer programming, consultancy, and related activities, 64.71% in telecommunications, 52.59% in scientific research and development activities, and 47.04% in information service activities.

Table 3 Number of Employees in HKIS in Ankara, Istanbul, and Izmir (2019)

NACE CODE	HIGH-TECH KNOWLEDGE- INTENSIVE SERVICES	ANKARA	ISTANBUL	IZMIR	TÜRKİYE TOTAL	HKIS employment rate of the three cities in Türkiye (%)
59	Motion picture, video, and television program production, sound recording and music publishing, Video and television program production activities	1,570	18,880	524	23,444	89.46
60	Programming and broadcasting activities	950	7,202	100	9,753	84.61
61	Telecommunications	3,691	11,761	1,723	26,541	64.71
62	Computer programming, consultancy, and related activities	16,257	60,057	5,565	100,718	81.30
63	Information service activities	5,780	11,841	2,802	43,419	47.04
72	Scientific research and development	3,384	2,535	1,308	13,741	52.59
Total		31,632	112,276	12,022	217,616	71.65

Table 4 shows the HKIS LQ results in Ankara, Istanbul, and Izmir. In 2019, there was a concentration in the computer programming and consultancy sector in Ankara, and agglomeration at the regional specialization level in scientific research and development activities. In Istanbul, there was agglomeration at the regional specialization level in motion picture, video, and television program production, sound recording, music publishing, video and television program production sector and programming and broadcasting activities and concentration in the programming and broadcasting sector. In Izmir, there was a concentration in telecommunications, computer programming, consulting, and information service activities and an agglomeration at the regional specialization level in scientific research and development activities.

Table 4 LQ Value of High-Tech Knowledge-Intensive Services in 2019

NACE CODE	HIGH-TECH KNOWLEDGE-INTENSIVE SERVICES	ANKARA	ISTANBUL	IZMİR
59	Motion picture, video, and television program production, sound recording, and music publishing Video and television program production activities	0.46	1.56	0.40
60	Programming and broadcasting activities	0.67	1.43	0.19
61	Telecommunications	0.96	0.86	1.18
62	Computer programming, consultancy, and related activities	1.11	1.16	1.00
63	Information service activities	0.92	0.53	1.17
72	Scientific research and development	1.69	0.36	1.72

The 2019 LQ data are illustrated in Figure 2. The dominance of Istanbul in motion picture, video, and television program production, sound recording, and music publishing activities, and programming and broadcasting activities, and the dominance of Ankara and Izmir in scientific research and development activities are observed. The three cities were almost equal in computer programming, consultancy, and related activities.

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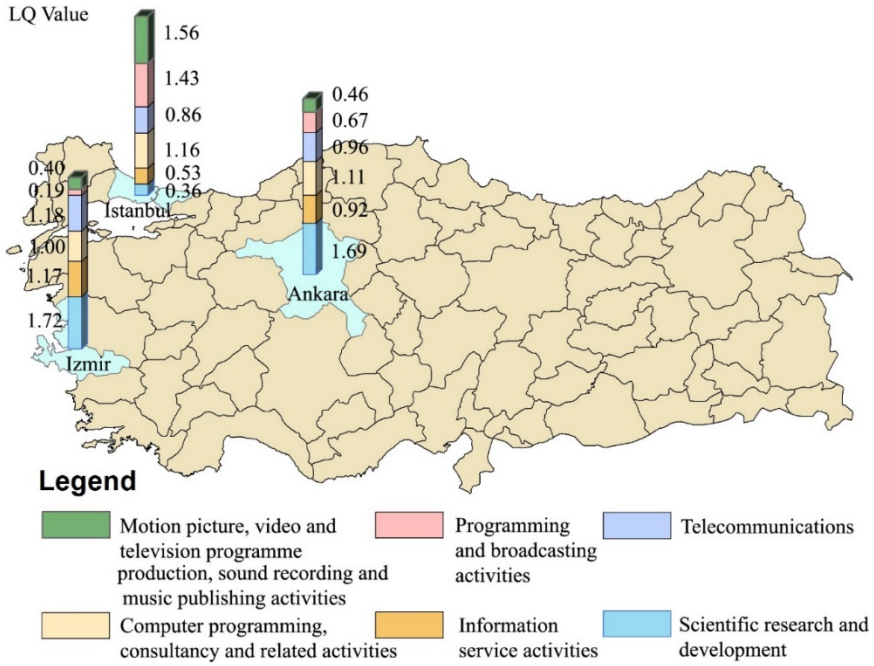

Figure 2 LQ map of HKIS activities in Ankara, Istanbul, and Izmir (2019)

After COVID-19 was defined as a pandemic by the World Health Organization in March 2020, measures to prevent it from spreading began to be implemented in many countries. The measures implemented in Türkiye, such as stay-at-home calls, distance education and work, and curfews, affected all sectors, including HKIS. HKIS activities have been directly and indirectly negatively affected by these restrictions while working to ensure that its customers adapt to pandemic conditions. According to SSI data on the distribution of workplaces covered by the 4/a category and compulsory insured persons by activity group and provinces, while 217,616 people were working in HKIS activities in 2019, the number of employees in HKIS activities decreased to 208,800 by the end of 2020 (Table 5), a 4.05% decrease in HKIS employment compared with the previous year. Although there was a decrease in total employment in Türkiye in 2020 during which COVID-19 measures were implemented, there was an increase of 1.02% in Ankara and 8.07% in Istanbul. In Izmir, a decrease of 3.01% in HKIS employment was recorded. However, when the combined proportions of the three provinces in Türkiye are examined, there was an increase of 1.6% in motion picture, video, and television program production, sound recording, and music publishing, video and television program production services, 1.67% in programming and broadcasting activities, 4.78% in telecommunication services, 0.81% in computer programming and consultancy activities, 31.56% in information service activities, and 1.44% in scientific research and development activities. After the COVID-19 pandemic, HKIS firms' desire to be located in metropolitan areas, agglomeration, and clustering has increased.

Table 5 Number of Employees in HKIS in Ankara, Istanbul, and Izmir (2020)

NACE CODE	HIGH-TECH KNOWLEDGE-INTENSIVE SERVICES	ANKARA	ISTANBUL	IZMIR	TÜRKİYE TOTAL	HKIS employment rate of the three cities in Türkiye (%)
59	Motion picture, video, and television program production, sound recording, and music publishing, Video and television program production activities	1,191	16,944	667	20,647	91.06
60	Programming and broadcasting activities	1,025	7,867	96	10,417	86.28
61	Telecommunications	4,694	13,424	2,084	29,071	69.49
62	Computer programming, consultancy, and related activities	17,994	68,911	6,674	113,970	82.11
63	Information service activities	2,927	11,082	828	18,877	78.60
72	Scientific research and development	4,123	3,112	1,311	15,818	54.03
Total		31,954	121,340	11,660	208,800	79.00

Table 6 shows the LQ values for the HKIS sub-sectors of Ankara, Istanbul, and Izmir in 2020. When the LQ data for 2020 are compared with the LQ data for 2019, unlike the previous year, concentration started in the telecommunications sector and information service activities in Ankara, in information service activities in Istanbul and Izmir, and there was concentration at the level of regional specialization in telecommunication services, while the concentration in information service activities decreased below the value of 1. It can be argued that the COVID-19 pandemic and measures to prevent the spread of the disease caused HKIS concentration and agglomeration in the metropolitan areas.

Table 6 LQ Value of High-Tech Knowledge-Intensive Services in 2020

NACE CODE	HIGH-TECH KNOWLEDGE-INTENSIVE SERVICES	ANKARA	ISTANBUL	IZMİR
59	Motion picture, video, and television program production, sound recording, and music publishing Video and television program production activities	0.38	1.41	0.58
60	Programming and broadcasting activities	0.64	1.30	0.17
61	Telecommunications	1.06	0.79	1.28
62	Computer programming, consultancy, and related activities	1.03	1.04	1.05
63	Information service activities	1.01	1.01	0.79
72	Scientific research and development	1.70	0.34	1.48

Figure 3 illustrates the LQ data for 2020. Istanbul continued to dominate in motion picture, video, and television program production, sound recording, music publishing, and programming and broadcasting activities, whereas Ankara and Izmir continued to dominate in scientific research and development activities. The three cities continued to have equivalent structures in computer programming, consultancy, and related activities. Comparing Figures 2 and 3, in 2020, when COVID-19 measures were implemented, information service activities started to be concentrated in Ankara and Istanbul compared with before the COVID-19 measures were applied.

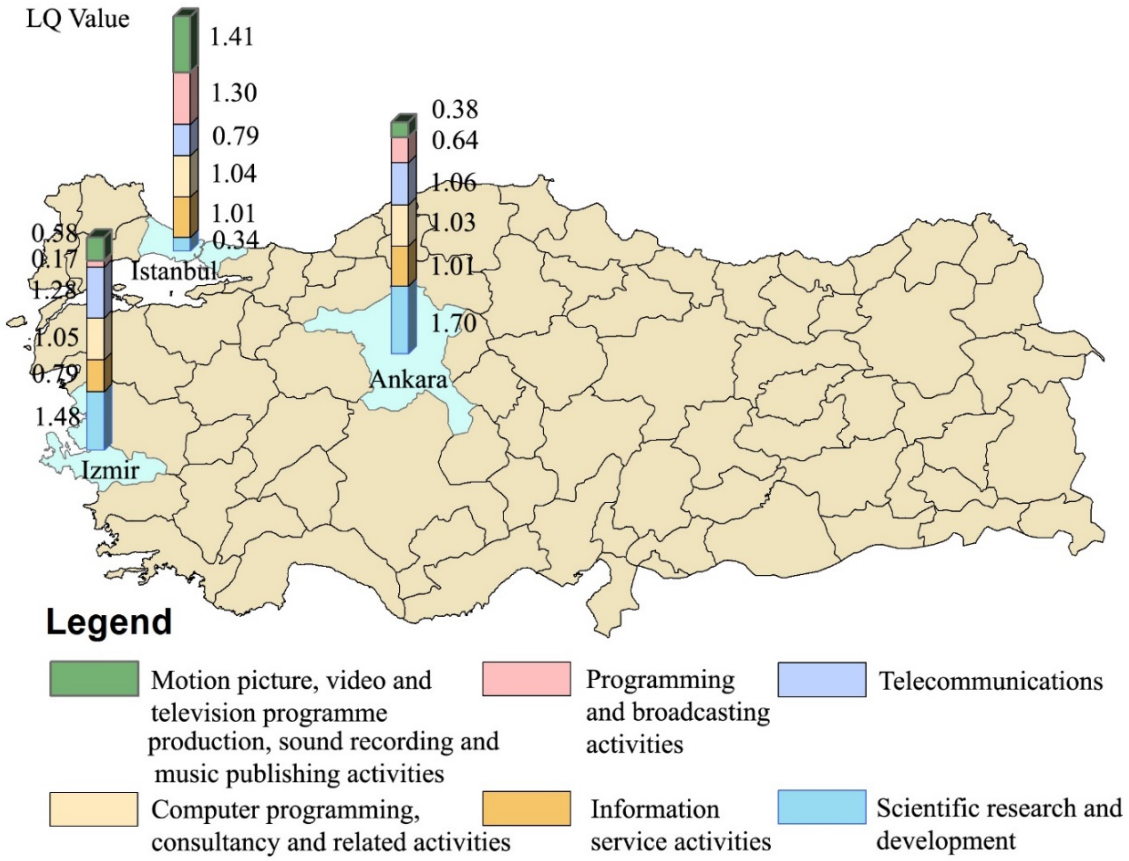

Figure 3 LQ map of HKIS activities in Ankara, Istanbul, and Izmir (2020)

The renormalization period caused a positive movement in terms of employment in 2021, owing to the lifting of bans and measures. There was a 14% increase in HKIS employment in 2021. Although there was a general decrease in employment in all HKIS sectors compared with 2020, the trend of agglomeration in metropolitan areas continued after 2020.

Table 7 shows the number of employees in HKIS activities in Ankara, Istanbul, and Izmir in 2021. HKIS employment in Ankara, Istanbul, and Izmir decreased by 0.32% compared with 2020 and accounted for 78.68% of the total HKIS employment in Türkiye. In 2021, compared with 2020, Ankara, Istanbul, and Izmir experienced a decrease of 1.58% in motion picture, video, and television program production, sound recording, and music publishing, video and television program production activities, 0.64% in programming and broadcasting activities, 1.02% in telecommunication activities, 0.05% in computer programming and consultancy activities, and 1.67% in information service activities. Compared with 2020, there was an increase of 0.03% in scientific research and development activities in Ankara, Istanbul, and Izmir in 2021.

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Table 7 Number of Employees in HKIS in Ankara, Istanbul, and Izmir (2021)

NACE CODE	HIGH-TECH KNOWLEDGE-INTENSIVE SERVICES	ANKARA	ISTANBUL	IZMIR	TÜRKİYE TOTAL	HKIS employment rate of the three cities in Türkiye (%)
59	Motion picture, video, and television program production, sound recording, and music publishing, Video and television program production activities	1,232	15,187	390	18,786	89.48
60	Programming and broadcasting activities	1,069	8,894	183	11,847	85.64
61	Telecommunications	5,912	13,194	2,252	31,192	68.47
62	Computer programming, consultancy, and related activities	20,398	84,556	8,181	137,868	82.06
63	Information service activities	3,150	13,229	778	22,303	76.93
72	Scientific research and development	4,359	2,947	1,362	16,034	54.06
Total		36,120	138,007	13,146	238,030	78.68

Table 8 shows the HKIS LQ values of Ankara, Istanbul, and Izmir in 2021. Compared with 2020, the HKIS trends continued in Ankara, Istanbul, and Izmir in 2021. Comparing Tables 8 and 6, there was agglomeration at the regional specialization level in telecommunication services in Ankara, but the level of concentration in computer programming, consulting, and information service activities decreased and fell below the concentration limit. Compared with 2020, there was no change in Istanbul and Izmir, and the agglomeration and clustering trend continued in the same way.

Table 8 LQ Value of High-Tech Knowledge-Intensive Services in 2021

NACE CODE	HIGH-TECH KNOWLEDGE-INTENSIVE SERVICES	ANKARA	ISTANBUL	IZMIR
59	Motion picture, video, and television program production, sound recording, and music publishing Video and television program production activities	0.43	1.39	0.38
60	Programming and broadcasting activities	0.59	1.29	0.28
61	Telecommunications	1.25	0.73	1.31
62	Computer programming, consultancy, and related activities	0.98	1.06	1.07
63	Information service activities	0.93	1.02	0.63
72	Scientific research and development	1.79	0.32	1.54

Figure 4 illustrates the 2021 LQ data. Istanbul's dominance continued in motion picture, video, and television program production, sound recording, music publishing, and programming and broadcasting activities, and Ankara and Izmir's dominance continued in scientific research and development activities. In the telecommunications sector, the agglomeration was maintained in Ankara and Izmir before COVID-19 and after COVID-19 measures. Istanbul and Izmir continued to

be concentrated on computer programming, consultancy, and related activities. Comparing Figures 4 and 3, information service activities continued to be concentrated in Istanbul after 2020.

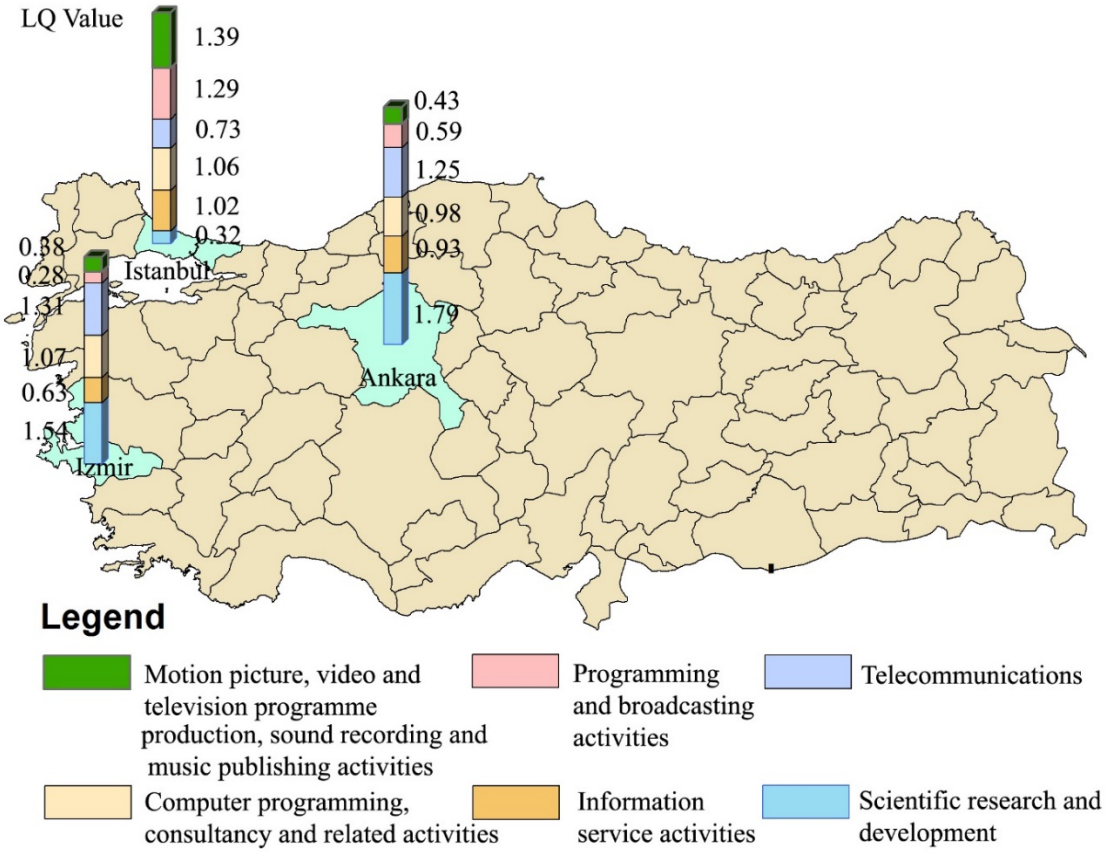

Figure 4 LQ map of HKIS activities in Ankara, Istanbul, and Izmir (2021)

6. Conclusion

This study investigated the changes in the spatial agglomeration of HKIS before the COVID-19 pandemic, during the implementation of measures to prevent its spread, and after the COVID-19 pandemic, specifically in Ankara, Istanbul, and Izmir.

There was agglomeration at the concentration level LQ > 1 in Izmir in the telecommunications sector in 2019. In 2020, COVID-19 pandemic measures caused agglomeration at the regional specialization level LQ > 1.25 in Izmir and agglomeration at the concentration level in Ankara. After the COVID-19 measures were implemented, Ankara and Izmir experienced agglomeration at the regional specialization level in the telecommunications sector. During and after the COVID-19 measures period, the telecommunications sector agglomerated at the regional specialization level in Ankara and Izmir. Owing to the COVID-19 measures, in 2020, unlike in 2019, the concentration in Izmir fell below LQ < 1 in the information service activities sector; in Ankara and Istanbul NUTS-3 regions, it exceeded LQ > 1, showing a change in agglomeration at the concentration level. In 2021, only information service activities resulted in an agglomeration at the concentration level in Istanbul, with the value of LQ > 1. The agglomeration in information service activities in Izmir before COVID-19 tended to concentrate in Istanbul after COVID-19 measures were implemented. Although all three cities experienced a concentration level of agglomeration in computer programming and consulting activities before the COVID-19 measures were implemented, in 2020, there was no change during the period of COVID-19 measures and the concentration level of agglomeration was maintained in these cities. However, in 2020, when COVID-19 measures were implemented, there was a decrease in the concentration levels of agglomeration in Ankara and Istanbul and an increase in Izmir compared with the period before COVID-19 measures were implemented. It can be argued

that COVID-19 measures caused a change in the trend of agglomeration in computer programming and consultancy activities toward Istanbul and Izmir.

After the COVID-19 measures were removed, the LQ level in Ankara fell below 1 in 2021, and the agglomeration trend in Istanbul and Izmir, which was caused by the impact of COVID-19, continued. The trend of agglomeration at the regional specialization level in motion picture production, sound recording, music publishing, and programming and broadcasting activities before COVID-19 measures continued during the COVID-19 measures period (2020) and the renormalization period (2021). COVID-19 measures did not change the agglomeration of these two sectors at the regional specialization level in Istanbul but caused a decrease in their LQ levels. The agglomeration of scientific research and development activities was at the level of regional specialization in Ankara and Izmir in 2019 before the COVID-19 pandemic; however, in 2020, when COVID-19 measures were implemented, this led to an increase in the LQ value in Ankara and a decrease in Izmir, but agglomeration at the regional specialization level was found to continue in both cities. With the renormalization period in 2021, there was an increase in the LQ value in scientific research and development activities in Ankara and an increase in Izmir compared with 2020, while the LQ value was lower than that in 2019. Moreover, COVID-19 further increased the agglomeration in scientific research and development activities in Ankara and decreased the agglomeration in Izmir compared with 2019 but caused the agglomeration trend to continue at the regional specialization level in both cities.

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The proportion of HKIS employees in Ankara, Istanbul, and Izmir compared with all of Türkiye was 71.65% in 2019; however, this rate increased to 79% in 2020, the period when the COVID-19 measures were implemented. COVID-19 measures may have caused less labor force loss in metropolitan cities where clustering is observed, especially in Ankara, Istanbul, and Izmir, compared with other cities. In 2021, the post-measures period, the share of HKIS employees in Türkiye for the three cities was 78.68%, decreasing by 0.32% because of HKIS investments in other cities. In addition, it was concluded that the HKIS agglomeration trend increased in Ankara, Istanbul, and Izmir compared with before the COVID-19 pandemic.

The literature review discussed in this study reports that HKIS activities mainly tend to agglomerate in metropolitan cities. The study showed that HKIS continued to agglomerate in the three metropolitan cities during and after the COVID-19 pandemic period. At this point, it can be argued that positive externalities are effective in reducing production costs through the agglomeration of HKIS in a city. In addition, economies of scope and scale may continue to agglomerate in cities because of competitiveness, variety, and improvement of specialization.

The literature review in this study also emphasizes that LQ provides only statistical data, not information about spatial differences besides issues such as the quality of firms and employees or sectoral connections and competition. The concentration information of HKIS in Istanbul, Izmir, and Ankara was obtained in this study that investigated the effect of COVID-19 on the concentration of HKIS sub-sectors. According to the results of this study, detailed future research is required on the competitiveness levels of firms, production, market, and sectoral relations. Future studies should also examine why HKIS activities are concentrated in these regions to develop strategies for HKIS sub-sectors. The literature review revealed that HKIS were directly and indirectly affected by COVID-19. However, it can be argued that the ability of HKIS companies to use technological infrastructure and have the qualified labor force potential reduced the level of impact resulting from the COVID-19 pandemic.

The COVID-19 pandemic and safety measures implemented to mitigate it have affected HKIS agglomeration. However, it was observed that the pandemic did not cause a major change in the concentration level of HKIS in the short term. In addition, the pandemic shifted the locations where HKIS activities were located. COVID-19 also caused changes in the sectoral agglomeration among HKIS sub-sectors. Trends for the 2020 and 2021 data indicate that the economic environment after the COVID-19 pandemic may continue to have an impact on service activities in the future. HKIS

activities are prone to be located mostly in big cities for various reasons such as spatial proximity with customers, production, industrial units, and infrastructure. This study, which also examined the changes in HKIS spatial agglomeration before, during, and after the COVID-19 measures concluded that they did not affect agglomeration trends in Ankara, Istanbul, and Izmir. The literature review emphasizes the tendency to work outside of the major metropolitan areas during and after the COVID-19 pandemic. Based on the findings of this study, HKIS concentration may continue in metropolitan areas. HKIS firms which were also affected by the pandemic and its measures can most likely choose places in metropolitan areas in the future and use the positive effects of agglomeration.

References

Ak, D. (2019). Taşra sakinliğinde sakin şehir olmak: Yenipazar. *Uluslararası Ekonomi ve Yenilik Dergisi*, *5*(1), 1-26. doi:https://doi.org/10.20979/ueyd.513025

Akyol, A., & Akbulut, E. (2017). Korunan alanların planlanması ve etkin yönetiminde ziyaretçi özellikleri ve algılarının önemi: Kurşunlu Şelalesi Tabiat Parkı örneği. *Turkish Journal of Forestry*, *18*(3), 197-206. doi:https://doi.org/10.18182/tjf.306364

Aslesen, H. W., & Isaksen, A. (2007). New perspectives on knowledge-intensive services and innovation. *Geografiska Annaler: Series B, Human Geography*, *89*(1), 45-58. doi:https://doi.org/10.1111/j.1468-0467.2007.00259.x

Aslesen, H. W., & Jakobsen, S. E. (2007). The role of proximity and knowledge interaction between head offices and KIBS. *Tijdschrift Voor Economische en Sociale Geografie*, *98*(2), 188-201. doi:https://doi.org/10.1111/j.1467-9663.2007.00391.x

Azhari, T. A., Musdholifah, A., & Arsyad, L. (2017). Modified agglomerative clustering with location quotient for identification of regional potential sector. *Journal of Theoretical and Applied Information Technology*, *95*(5), 1191-1199.

Belzunegui-Eraso, A., & Erro-Garcés, A. (2020). Teleworking in the context of the Covid-19 crisis. *Sustainability*, *12*(9), 3662.

Benneworth, P., & Ratinho, T. (2014). Reframing the role of knowledge parks and science cities in knowledge-based urban development. *Environment and Planning C: Government and Policy*, *32*, 784-808. doi:https://doi.org/10.1068/c1266r

Bick, A., Blandin, A., & Mertens, K. (2020). *Work from home after the COVID-19 outbreak*. Working papers from the Federal Reserve Bank of Dallas. Retrieved from https://doi.org/10.24149/wp2017

Birimoglu-Okuyan, C., & Begen, M. A. (2022). Working from home during the COVID-19 pandemic, its effects on health, and recommendations: The pandemic and beyond. *Perspect Psychiatr Care*, *58*, 173-179. doi:https://doi.org/10.1111/ppc.12847

Bolisani, E., Scarso, E., Ipsen, C., Kirchner, K., & Hansen, J. P. (2020). Working from home during COVID-19 pandemic: lessons learned and issues. *Management & Marketing*, *15*(1), 458-476. doi:https://doi.org/10.2478/mmcks-2020-0027

Carroll, M. C., Reid, N., & Smith, B. W. (2008). Location quotients versus spatial autocorrelation in identifying potential cluster regions. *The Annals of Regional Science*, *42*(2), 449 463. doi:https://doi.org/10.1007%2Fs00168-007-0163-1

Chiang, S. (2009). Location quotient and trade. *The Annals of Regional Science*, *43*(2), 399-414. doi:https://doi.org/10.1007/s00168-008-0218-y

Crawley, A., Beynon, M., & Munday, M. (2013). Making location quotients more relevant as a policy aid in regional spatial analysis. *Urban Studies*, *50*(9), 1854-1869. doi:https://doi.org/10.1177/0042098012466601

Cromley, R. G., & Hanink, D. M. (2012). Focal location quotients: Specification and applications. *Geographical Analysis*, *44*(4), 398-410.

Cummings, J. R., & Epley, D. R. (2014). A total requirements view of a tourism and hospitality market is more accurate than traditional location quotients. *Tourism Economics*, *20*(3), 473-492. doi:https://doi.org/10.5367/te.2013.0285

Çelik, N., Akgüngör, S., & Kumral, N. (2019). An assessment of the technology level and knowledge intensity of regions in Turkey. *European Planning Studies*, *27*(5), 952 973. doi:https://doi.org/10.1080/09654313.2019.1579301

Duran, G. (2016). Kümelenme düzeyi üzerine bir araştırma: Bucak ilçesi mermer sektörü örneği. *Mehmet Akif Ersoy Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *8*(15), 147-163.

Espitia, A., Mattoo, A., Rocha, N., Ruta, M., & Winkler, D. (2022). Pandemic trade: COVID-19, remote work and global value chains. *World Econ*, *45*, 561-589. doi:https://doi.org/10.1111/twec.13117

EUROSTAT. (2008). *Statistical classification of economic activities in the European Community, methodologies and working papers.* Luxembourg: Office for Official Publications of the European Communities. Retrieved from https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF

Fan, C. C., & Scott, A. J. (2003). Industrial agglomeration and development: A survey of spatial economic issues in east Asia and a statistical analysis of Chinese regions. *Economic Geography*, *79*(3), 295-319. doi:https://doi.org/10.1111/j.1944-8287.2003.tb00213.x

Glaeser, E. L., Kallal, H. D., Scheinkman, J. A., & Shleifer, A. (1992). Growth in cities. *Journal of Political Economy*, *100*(6), 1126-1152.

Haig, R. M. (1926). Toward an understanding of the metropolis. *The Quarterly Journal of Economics*, *40*(2), 178-208. doi:https://doi.org/10.2307/1884617

Henderson, J. V. (2003). Marshall's scale economies. *Journal of Urban Economics*, *53*(1), 1-28. doi:https://doi.org/10.1016/S0094-1190(02)00505-3

Hill, E., & Brennan, J. (2000). A methodology for identifying the drivers of industrial clusters: The foundation of regional competitive advantage. *Economic Development Quarterly*, *14*(1), 65-96. doi:https://doi.org/10.1177/089124240001400109

Hrivnák, M., Moritz, P., & Chreneková, M. (2021). What kept the boat afloat? Sustainability of employment in knowledge-intensive sectors due to government measures during COVID-19 Pandemic. *Sustainability, 13*, 8441. doi:https://doi.org/10.3390/su13158441

Hu, T. S., Chang, S. L., Lin, C. Y., & Chien, H. T. (2006). Evolution of knowledge intensive services in a high-tech region: The case of Hsinchu, Taiwan. *European Planning Studies*, *14*(10), 1363-1385. doi:https://doi.org/10.1080/09654310600852530

Isserman, A. M. (1977). The location quotient approach to estimating regional economic impacts. *Journal of the American Institute of Planners*, *43*(1), 33-41. doi:https://doi.org/10.1080/01944367708977758

Karakayacı, Ö. (2010). Ekonomik büyüme ve girişimcilik aktivitelerinde kümeleşmenin rolü: Bursa ve Konya sanayi kümeleri örneğinde karşılaştırmalı bir araştırma. *Megaron*, *5*(3), 149-159.

Kotsopoulos, D., Karagianaki, A., & Baloutsos, S. (2022). The effect of human capital, innovation capacity, and Covid-19 crisis on knowledge-intensive enterprises' growth within a VC-driven innovation ecosystem. *Journal of Business Research*, *139*, 1177-1191. doi:https://doi.org/10.1016/j.jbusres.2021.10.055

Kylili, A., Afxentiou, N., Georgiou, L., Panteli, C., Morsink-Georgalli, P. Z., Panayidou, A., Papouis, C., & Fokaides, P. A. (2020). The role of remote working in smart cities: Lessons learnt from COVID-19 pandemic. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 1-16. doi:https://doi.org/10.1080/15567036.2020.1831108

Leigh, R. (1970). The use of location quotients in urban economic base studies. *Land Economics*, *46*(2), 202-205. doi:https://doi.org/10.2307/3145181

Mans, P., Alkemade, F., Valk, T., & Hekkert, M. P. (2008). Is cluster policy useful for the energy sector? Assessing self-declared hydrogen clusters in the Netherlands. *Energy Policy*, *36*, 1375-1385. doi:https://doi.org/10.1016/j.enpol.2007.12.004

Mattila, J. M., & Thompson, W. R. (1955). The measurement of the economic base of the metropolitan area. *Land Economics*, *31*(3), 215-228.

Mayer, W., & Pleeter, S. (1975). A theoretical justification for the use of location quotients. *Regional Science and Urban Economics*, *5*(3), 343-355. doi:https://doi.org/10.1016/0166-0462(75)90030-7

Mejri, k., MacVaugh, J. A., & Tsagdis, D. (2018). Knowledge configurations of small and medium-sized knowledge-intensive firms in a developing economy: A knowledge-based view of business-to business internationalization. *Industrial Marketing Management*, *71*, 160 170. doi:https://doi.org/10.1016/j.indmarman.2017.12.018

Milasi, S., González-Vázquez, I., & Fernández-Macías, E. (2021). *Telework before the COVID-19 pandemic: Trends and drivers of differences across the EU.* OECD Productivity Working Papers. Paris: OECD Publishing. Retrieved from https://www.sipotra.it/wp-content/uploads/2021/01/TELEWORK-BEFORE-THE-COVID-19-PANDEMIC-TRENDS-AND-DRIVERS-OF-DIFFERENCES-ACROSS-THE-EU.pdf

Miles, I. D., Belousova, V., Chichkanov, N., & Krayushkina, Z. (2021). Knowledge-intensive business services in time of crisis: The coronavirus pandemic. *Foresight*, *23*(2), 125-153. doi:https://doi.org/10.1108/FS-07-2020-0066

Miles, I., Kastrinos, N., Flanagan, K., Bilderbeek, R., den Hertog, P., Huntink, W., & Bouman, M. (1995). *Knowledge-Intensive Business Services - Users, Carriers, and Sources of Innovation*. European Innovation Monitoring System (EIMS) Reports. University of Manchester. Retrieved from https://pure.manchester.ac.uk/ws/portalfiles/portal/32800224/FULL_TEXT.PDF

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Miller, M., Gibson, J., & Wright, G. (1991). Location quotient: a basic tool for economic development analysis. *Economic Development Review*, *9*(2), 65-68.

Moineddin, R., Beyene, J., & Boyle, E. (2003). On the location quotient confidence interval. *Geographical Analysis*, *35*(3), 249-256. doi:https://doi.org/10.1111/j.1538-4632.2003.tb01112.x

Morrissey, K. (2016). A location quotient approach to producing regional production multipliers for the Irish economy. *Papers in Regional Science*, *95*(3), 491-506. doi:https://doi.org/10.1111/pirs.12143

Mprotsis, T., Doxani, C., & Zintzaras, E. (2022). *Chi-square test calculation: An interactive calculator for chi-square tests of independence*. Retrieved from https://biomath.med.uth.gr/statistics/chi_square.html

Muller, E., & Doloreux, D. (2009). What we should know about knowledge-intensive business services. *Technology in Society*, *31*, 64-72. doi:https://doi.org/10.1016/j.techsoc.2008.10.001

Munandar, T. B., Azhari, A., Musdholifah, A., & Arsyad, L. (2017). Modified agglomerative clustering with location quotient for identification of regional potential sector. *Journal of Theoretical and Applied Information Technology*. *95*(5), 1191-1199.

Nowakowska-Grunt, J., Jelonek, D., & Kościelniak, H. (2014). Logistics' clusters as a part of regional policy in Poland. *International Conference on Advanced Logistics and Transport*, (pp. 206-210). Hammamet, Tunisia. doi:http://dx.doi.org/10.1109/ICAdLT.2014.6866313

OECD. (2006). *Innovation and knowledge-intensive service activities.* Paris: OECD. doi:https://doi.org/10.1787/9789264022744-en

Oka, M. (2023). Conceptual and methodological arguments against the use of location quotient as an area-based measure of residential segregation: A measurement perspective. *Societies*, *13*, 256. doi:https://doi.org/10.3390/soc13120256

Omar, A. R., Ishak, S., & Jusoh, M. A. (2020). The impact of Covid-19 movement control order on SMEs' businesses and survival strategies. *Geografia-Malaysian Journal of Society and Space*, *16*(2), 139-150. doi:https://doi.org/10.17576/geo-2020-1602-11

Peng, D., Li, R., Shen, C., & Wong, Z. (2022). Industrial agglomeration, urban characteristics, and economic growth quality: The case of knowledge-intensive business services. *International Review of Economics and Finance*, *81*, 18-28. doi:https://doi.org/10.1016/j.iref.2022.05.001

Porter, M. E. (2000). Location, competition, and economic development: Local clusters in a global economy. *Economic Development Quarterly*, *14*(1), 15-34. doi:https://doi.org/10.1177/089124240001400105

Santiago, L. E. (2020). The industries of the future in Mexico: Local and non-local effects in the localization of "knowledgeintensive services". *Growth and Change*, *51*, 584 606. doi:https://doi.org/10.1111/grow.12368

Seçkin, E. (2015). Perakende sektöründeki yapısal dönüşümün Bursa'daki üretim piyasası ile tüketim piyasasına yansıması. *Megaron*, *10*(1), 70-79. doi:https://dx.doi.org/10.5505/megaron.2015.25238

Shearmur, R., & Doloreux, D. (2008). Urban hierarchy or local buzz? High-order producer service and (or) knowledge-intensive business service location in Canada, 1991-2001. *The Professional Geographer, 60*(3), 333-355. doi:https://doi.org/10.1080/00330120801985661

Skorska, A. (2018). Spatial diversity in development of knowledge intensive business services in the European Union. *35th International Scientific Conference on Economic and Social Development-"Sustainability from an Economic and Social Perspective"*, (pp. 15-16). Lisbon.

Środa-Murawska, S. (2013). Knowledge-intensive services in post-socialist cities from the perspective of 20 years of a free market economy-the Polish experience. *In Geografiâ Mirovogo Hozâjstva : Regionalizm v Usloviâh Globalizacii : Materialy IV Meždunа Meždunarodnoj Naučno-praktičeskoj Konferencii*, (pp. 140-149). Moskva.

Tian, Z. (2013). Measuring agglomeration using the standardized location quotient with a bootstrap method. *The Journal of Regional Analysis and Policy*, *43*(2), 186 197. doi:https://doi.org/10.22004/ag.econ.243958

Toivonen, M. (2004). *Expertise as Business: Long-term development and future prospects of knowledge-intensive business services (KIBS) (PhD Thesis).* Espoo: Department of Industrial Engineering and Management-Helsinki University of Technology.

Vaillant, Y., Lafuente, E., & Serarols, C. (2012). Location decisions of new 'knowledge intensive service activity' firms: The rural urban divide. *The Service Industries Journal*, *32*(16), 2543 2563. doi:https://doi.org/10.1080/02642069.2011.594880

Vasic, M. (2020). Challenges of teleworking during the COVID-19 pandemic. *The Annals of the Faculty of Economics in Subotica*, *56*(44), 63-79. doi:https://doi.org/10.5937/AnEkSub2044063V

Vissers, G., & Dankbaar, B. (2013). "Knowledge and proximity". *European Planning Studies*, *21*(5), 700-721. doi:https://doi.org/10.1080/09654313.2013.734459

Windrum, P., & Tomlinson, M. (1999). Knowledge-intensive services and international competitiveness: A four country comparison. *Technology Analysis & Strategic Management*, *11*(3), 391-408. doi:https://doi.org/10.1080/095373299107429

Wood, P. (2002). Knowledge-intensive services and urban innovativeness. *Urban Studies*, *39*(5-6), 993-1002. doi:https://doi.org/10.1080/00420980220128417

Yum, S. (2019). The interaction between knowledge-intensive business services and urban economy. *The Annals of Regional Science*, *63*, 53-83. doi:https://doi.org/10.1007/s00168-019-00920-3

Zbuchea, A., Dinu, E., Iliescu, A. N., Stăneiu, R. M., & Salageanu Şoldan, B. R. (2023). Managing knowledge in Romanian KIBS during the COVID19 pandemic. *Knowledge*, *3* 18 39. doi:https://doi.org/10.3390/knowledge3010002

Ženka, J., Novotný, J., Slach, O., & Ivan , I. (2017). Spatial distribution of knowledge-intensive business services in a small post-communist economy. *Journal of the Knowledge Economy*, *8*, 385-406. doi:https://doi.org/10.1007/s13132-015-0260-9

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Resume

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