# Benchmarking competitiveness and innovation performances in two information technology clusters from Finland and Turkey

Murat Akpinar, corresponding author*, JAMK University of Applied Sciences, School of Business, Rajakatu 35, 40200, Jyväskylä, Finland, murat.akpinar (at) jamk.fi
Melike Mermercioglu, Koc University, Graduate School of Business, Rumelifeneri Yolu, Sarıyer, 34450, Istanbul, Turkey, mmermercioglu (at) ku.edu.tr
* The authors are listed in alphabetical order. They contributed equally to the development of this paper.

**Abstract**

Although clusters have been identified as influential mechanisms to drive knowledge-based innovations, there have not been many attempts to evaluate their competitiveness and explore the link between competitiveness and innovation performance. This study takes a novel approach and develops an assessment scheme to operationalize the emerald model for benchmarking competitiveness of two information technology (IT) clusters from Finland and Turkey. Despite that the cluster in Finland is more competitive in the dimensions of R&D and innovation attractiveness, ownership attractiveness, and environmental attractiveness, the innovation performances of the two clusters are surprisingly equal. This preliminary exploratory study suggests that environmental attractiveness is not a significant dimension of competitiveness for promoting innovation performance. Further research is needed to understand which of the other dimensions of competitiveness are more influential in driving innovation performance in clusters.

*Keywords:* Cluster, competitiveness, emerald model, innovation, information technology, benchmarking, Finland, Turkey.

## 1. Introduction

Clusters are geographic concentrations of organizations linked by commonalities and complementarities in providing a related group of products or services (Porter 1998). It is argued that the presence of strong clusters has positive impacts on new business formation, start-up employment, start-up firm survival, employment growth, growth of salaries and patenting rates (Porter 2003; Delgado et al. 2010; Delgado et al. 2012). Firms can access more specialized assets and suppliers faster in close proximity of the cluster (Porter 1998; Sölvell et al. 2008). Close interactions of firms, users, suppliers, and research institutes through face-to-face meetings, labour mobility, and informal social networks in the cluster create relationships based on trust and stimulate creation of new ideas, transfer of tacit knowledge, and knowledge spill overs (Giuliani 2005; Acs et al. 2009). Knowledge stocks and absorptive capacities of firms in clusters play key roles in driving innovations and new business formation (see Giuliani 2005; McCann and Folta 2011; Huber 2012). New business formation and start-up activity are easier because it is relatively easier to find network partners in the value chain in close proximity and access required resources to start and grow the business (e.g., availability of venture capital), and the negative consequences of failure are reduced as entrepreneurs can move back to other employment possibilities in the cluster (Porter 1998; Sölvell et al. 2008). Acknowledgment of these benefits has led to increasing cluster initiatives both in advanced economies and in emerging economies during the last twenty years (Sölvell et al. 2003; Ketels et al. 2006). For example, the European Cluster Policy Group was established on October 22, 2008 to strengthen the quality of cluster programmes in Europe as a viable solution to drive growth and employment in response to the economic crisis. Furthermore, in many countries governments developed Science Parks in order to establish mature clusters to improve competitive advantages especially for technology-based industries.

However, some contradictory research suggests that clustering may not be advantageous in all contexts. One study argues that clustering leads to employment growth in manufacturing industries but not necessarily to international export success (McDonald et al. 2007). Moreover, market positioning and firm positioning are identified as more important factors in driving firm competitiveness than purely spatial proximity and co-location (Hendry and Brown 2006; Eriksson and Lindgren 2009). Further research suggests that it is the type of co-located firms and not just clustering or cluster size per se that matters for innovativeness and knowledge spillovers (Beaudry and Breschi 2003; Folta et al. 2006; Huber 2012). Namely, while innovative performance improves when innovative firms co-locate with other innovative firms in the same industry, co-location of non-innovative firms will produce negative consequences. Furthermore, clustering is found to benefit more those firms with higher knowledge stocks and younger firms with higher uncertainty (McCann and Folta 2011). Hence, a positive relationship between clustering and innovation and entrepreneurship is difficult to generalize (Rocha 2004), and there is yet room for research to understand differences in performance between different clusters (Malmberg and Maskell 2002).

The first aim of this research is to develop and operationalize a suitable framework to assess the competitiveness of clusters through benchmarking. The second aim is to benchmark the competitiveness and innovation performances of two clusters. Achievement of this aim will serve as an example of the operationalization of the developed framework and also be an initial step to explore the connections between dimensions of competitiveness and innovation performances. Accordingly, the research questions are:

1) How can competitiveness of clusters be measured?
2) What can be inferred from benchmarking of clusters on the relationship between competitiveness and innovation performance?

Two information technology (IT) clusters from Finland and Turkey were selected for the benchmarking. IT clusters were selected because they are largely knowledge-driven and have a high potential to drive innovations and entrepreneurial activities based on the application of new technological knowledge. The IT cluster is defined to include the sub-clusters of software publishers, electronic equipment, semiconductors, computers and peripherals, software reproducing, audio and video equipment, and related services (US Cluster Mapping 2014). This definition was adopted according to the categorization of sectors in statistics databases in Finland and Turkey and accordingly in this paper the IT cluster encompasses sectors of computer hardware, software, internet, telecom equipment, e-commerce and computer maintenance services. Being one of the fastest-growing global sectors and having influences on the productivity of all other industries, IT has become a key driver of global economic growth. Worldwide IT spending is expected to exceed 2.1 trillion USD in 2013 (International Data Corporation 2012). The market is forecast to grow on average by 5% per annum during 2012–2017 with increasing IT expenditures in the healthcare, retail, and transportation sectors (Lucintel 2012). As such, development of the IT sector is recognized by policy makers around the world as strategically important in the creation of knowledge-based societies.

The first cluster is the Istanbul Technical University (ITU) Arı Technopark located in the Sarıyer municipality of Istanbul in Turkey. It is a constructed cluster situated in the ITU campus, with the explicit aim to foster the development of new and innovative firms through joint R&D activities with the university. Istanbul is identified as the most competitive city in Turkey according to the City Competitiveness Index (Bulu 2011). The city's index point, calculated with 42 variables in four dimensions (human capital and life quality, branding skill and innovation, trade skill and production potential and accessibility), is much higher than any other city in the country. The district of Sarıyer is located on the European side of Istanbul. It is spread over an area of 151 km$^2$ comprising of both urban and rural areas with a population estimated to be close to 400,000. IT sector is highly important for Turkey, and the country targets to boost its IT sector by achieving a turnover of 160 billion USD and exports of 10 billion USD in 2023 (Deloitte and Yased 2012).

Turkey's largest IT clusters were constructed as "technoparks" in the campuses of well-known universities in Istanbul and Ankara. Sölvell (2009) argues that clusters can evolve from both evolutionary and constructive forces and in the case of constructed clusters social, political, and business leaders come together in a conscious effort to promote clusters and the regional business environment. These formations are usually formed under the names of enterprise zones, business parks, technology parks, technopoles, research parks, innovation parks and science parks, although there exist some terminology differences among these types of infrastructures due to their distinctive features in relation to their concept (Almeida et al. 2008). According to Hansson et al. (2005), the UK Science Park Association defines a science park as a property-based activity with formal operational links with a university or other higher educational or research institution, aiming the formation and growth of knowledge-based business and other organizations normally resident on site with a management function actively engaged in the transfer of technology and business skills to the organizations on site. Although the concept emerged in 1950's with the first park established in Stanford (Why 2001), many urban and regional economies have attempted to create specific places within the recent years, in order to develop and embed R&D activities (Phillips and Yeung 2003), as a means to create clusters to accelerate economic growth and international competitiveness (Link and Scott 2011) through managing the knowledge flow between universities, R&D institutions, industry and government (Chan and Pretorius 2007). Nowadays they are employed as a vital strategy for developing high-tech industries in many countries including Western Europe and Asia (Yang et al. 2009) and constructed science parks leading to clusters were initiated as a government policy in Turkey in the 1990s. It is widely acknowledged that science parks established in the university campuses are aiming to facilitate technology transfer and the creation, growth, and development of high technology firms (Leyden et al. 2008), build technological capabilities through networking among the tenants (Chan and Pretorius 2007), lead to the creation of an 'innovative milieu' (Phillimore 1999), stimulate local economic development (Hu 2008), promote job creation and enhance the image of the location (Siegel et al. 2003). Correspondingly, the formation of technoparks in Turkey was a deliberate and state-driven attempt to encourage the development of R&D activities through financial incentives and collaboration opportunities with the universities or other scientific institutions. According to Koçak and Can (2013), who had carried out a research among 12 technoparks in Turkey, the aim is to facilitate networking among their tenants by both creating a favourable ecology for collaboration through selection of tenants and encouraging the formation of ties among these firms through events and introductions.

The selected ITU Arı Technopark is a science park, affiliated with Istanbul Technical University. Following the law regarding Technology Development Zones and relevant regulations in Turkey, ITU Arı Technopark IT cluster was founded in 2002 within the campus of ITU. The technopark was declared as a Technology Development Zone in 2003. According to the records of the technopark management, it is founded on an area of 1,850,000 m$^2$, and there were 125 firms in the area as of year 2011, of which 86 are specialized in the IT sector. The number of employees working in these 86 firms was 3,832 and the revenue generated in year 2011 was equal to approximately 86 million Euros. Employment in the ITU Arı Technopark is reported to be high compared to other IT firms in Turkey because the personnel employed in the R&D and support functions of the firms operating in a technopark zone are exempt from all taxes. The ITU Arı Technopark cluster was selected because it is a good example for a constructed cluster from an emerging country that has decided to invest in the IT sector to capture growth opportunities.

The second cluster is the IT cluster in Central Finland located around the city of Jyväskylä in an area of 1,171 km$^2$ (City of Jyväskylä 2014). IT is also a highly important sector for Finland with ca. 48,000 people employed in the sector and a turnover of 7 billion Euros (Federation of Finnish Technology Industries 2013). It is a vital part of Finland’s technology industries, which altogether account for 60% of Finnish exports and 80% of R&D expenditures. Software is among the three top priority future sectors in Finland together with the bio sector and the nano sector (Research and Innovation Council of Finland 2010). Tekes, the Finnish Funding Agency for Technology and Innovation, Sitra, the Finnish Innovation Fund, and the Academy of Finland, an expert organization on research funding, provide necessary financing for firms and universities involved in research activities in the IT sector. VTT, the Technical Research Centre of Finland promotes technology transfer by producing a great deal of public research knowledge. In addition, science parks of Finland with direct links to the education and research centers in their own regions provide supportive platforms for the application of state-of-the-art technology (Finnish Science Park Association 2013). The IT cluster in Central Finland included 410 enterprises with total employment of 2,913 people and turnover of ca. 527 million Euro as of year 2011 (Statistics Finland 2014a). Most of the enterprises are small firms with less than 10 employees. Software programming is the core area of the cluster with 243 enterprises and employment of 1,794 people (ibid.). Other areas include telecommunications (14 enterprises with total employment of 511 people), hardware and electronic equipment production (37 enterprises with total employment of 367 people), repair and maintenance of electronic equipment (84 enterprises with total employment of 127 people), and data services (32 enterprises with total employment of 114 people) (ibid.). The cluster suffered a hit during the last five years when Nokia, the anchor firm in the Finnish IT sector, started to downsize its operations in Finland. Back in 2007, the IT cluster in Central Finland used to employ 3,391 people and had a turnover of ca. 773 million Euros (ibid.). In this study the IT cluster in Central Finland was selected because it is a good example of an evolutionary cluster from an advanced economy with a highly developed IT sector.

A study benchmarking the competitiveness and innovation performances of a constructed cluster with an evolutionary one could also contribute to the ongoing discussion on the role of science parks as there have been several studies to identify the effects of the science parks on the innovativeness and competitiveness of firms located within them, especially those operating in high technology industries.

The rest of the paper is organized as follows. Following this introduction, the applied theoretical framework is outlined in the light of literature review. Later, the methodology is described in section 3, the results are shared in section 4, and the paper ends with a discussion in section 5.

## 2. Theoretical Framework

The first aim of this research is to develop a framework to assess competitiveness of clusters, and the second aim is to benchmark competitiveness and innovation performance of two IT clusters. Innovations have been recognized as the lifeblood of entrepreneurial activity and as a major source of generating economic growth (Schumpeter 1934). They are defined narrowly as technologically new products and processes or significant technological improvements in existing products and processes (Damanpour and Wischnevsky 2006). Empirical research shows that geographical proximity is important in the creation of knowledge and innovations (Arbonies and Moso 2002; Evers et al. 2010). The “learning-centered theory of clustering” argues that the “local buzz”, consisting of information flows, gossip and news, encourages interactive learning and problem solving within the cluster (Bathelt et al. 2004). Firms in the cluster get informed about the features, production factors, costs and quality of competitors’ products, and the new ideas generated by suppliers, customers or service providers combined with the firm’s own suggestions become the source of further ideas for innovation (ibid). Spillovers of knowledge contribute to innovations as they occur in clusters intentionally or unintentionally through monitoring and imitation of competitors, formation of spin-offs from existing organizations, or mobility of qualified labour between firms (Tödtling et al. 2009; Jankowska and Pietrzykowski 2013).

Accordingly, taking into account the advantages of clusters in generating knowledge and increasing innovativeness, some governments played important roles in their construction. According to Sölvell (2009) a central role of government is to stimulate dynamism and upgrading among firms within its territory. Along with some measures geared towards general macro and micro business environments, governments took active steps in the formation of clusters. This was the case in many countries, especially in Europe, and many science parks were formed during the 1980s and the 1990s (Bakouros et al. 2002). However results of studies related to the achievements of firms located within science parks compared to those located off park reveal contradictory results (Westhead 1997; Löfsten and Lindelöf 2002; Hansson et al. 2005). Some of these studies point to the benefits generated (Löfsten and Lindelöf 2002; Link and Scott 2006; Fukugawa 2006; Almeida et al. 2008; Hu 2008; Yang et al. 2009; Koçak and Can 2013). Others reveal no significant differences regarding growth (sales) and profitability (profit margin) between the on-park and off-park firms (Löfsten and Lindelöf 2005), limited synergies (Bakouros et al. 2002), or successful results obtained in only some of the science parks (Bengtsson 2003).

In order to understand competitiveness and explore its link to innovation performance, existing models of competitiveness are examined next. The diamond model by Porter (1990), the framework of the Global Competitiveness Report by the World Economic Forum, the IT Industry Competitiveness Index by Business Software Alliance (2013), the IT cluster benchmarking model by Meier Zu Köcker (2009), the IT cluster competitiveness methodology by Van Dijk (2003), and the emerald model by Sasson and Reve (2012) are reviewed respectively in terms of their potential for operationalization.

The diamond model (Porter 1990) has been used widely in studying the competitive advantage of regions. In this model, a region has competitive advantage based on its factor conditions, demand conditions, existence of strong related and supporting industries, and firm strategy, structure and rivalry. Factor conditions include inherited physical resources, capital resources, human resources and knowledge resources (ibid.). Demand conditions reflect the character of the region's buyers and their needs including segment structure and sophistication level of buyers, anticipatory buyer needs, size and growth rate of demand, as well as early demand and early saturation (ibid.). The determinant of related and supporting industries implies the cluster concept. Finally, firm strategy, structure, and rivalry are factors related to the nature of competition. One can argue that while demand conditions and rivalry pull for innovations, factor conditions and related and supporting industries enable them. As such, the diamond model is a useful model for assessing a region's sources of competitive advantage, and it was used in several studies including the assessment of IT clusters in India (Khomiakova 2007) and in Turkey (Bulu et al. 2004). However, despite its high recognition, the model is not perfectly suitable for the purposes of this study for two reasons. Firstly, the unit of analysis in this study is the cluster, which is one of the four determinants (i.e. related and supporting industries) in the model. Secondly, some of the variables in the model (especially regarding demand conditions and firm strategy, structure and rivalry) are not easy to operationalize given the nature of available secondary cluster data. For example, the measurement of demand sophistication requires an extensive field study on its own. Similarly, a detailed study would be needed for understanding differences (if any) in firm strategy and structure. Furthermore, rivalry, a key element in the model, is more and more borderless in the 21st century.

An alternative model of assessment is the framework used in the Global Competitiveness Report developed by the World Economic Forum where competitiveness is measured in 12 pillars including institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labour market efficiency, financial market development, technological readiness, market size, business sophistication, and innovation (Sala-I-Martin et al. 2013). In this framework it is argued that a region's competitiveness has substantial impacts on the productivity of firms operating in the region that in turn affects the region's growth (ibid). This is a very comprehensive framework for understanding competitiveness at the country level, but it is too general and at the same time difficult to operationalize at cluster level.

A more sector-specific assessment tool is the IT Industry Competitiveness Index, developed to compare countries on the extent to which they possess the conditions necessary to support a strong IT sector (Business Software Alliance 2013). This index uses 26 indicators grouped under the following six categories: business environment, IT infrastructure, human capital, R&D environment, legal environment, and support for IT sector development (ibid.). Finland ranks as the second most competitive country in IT in the world while Turkey ranks as the 41st. In Figure 1 the two countries' scores are compared in the index's six dimensions. The framework helps to understand competitiveness of a country regarding the IT sector. However, some of its dimensions (e.g., business environment) are too general and difficult to operationalize at the cluster level for the purposes of this study.

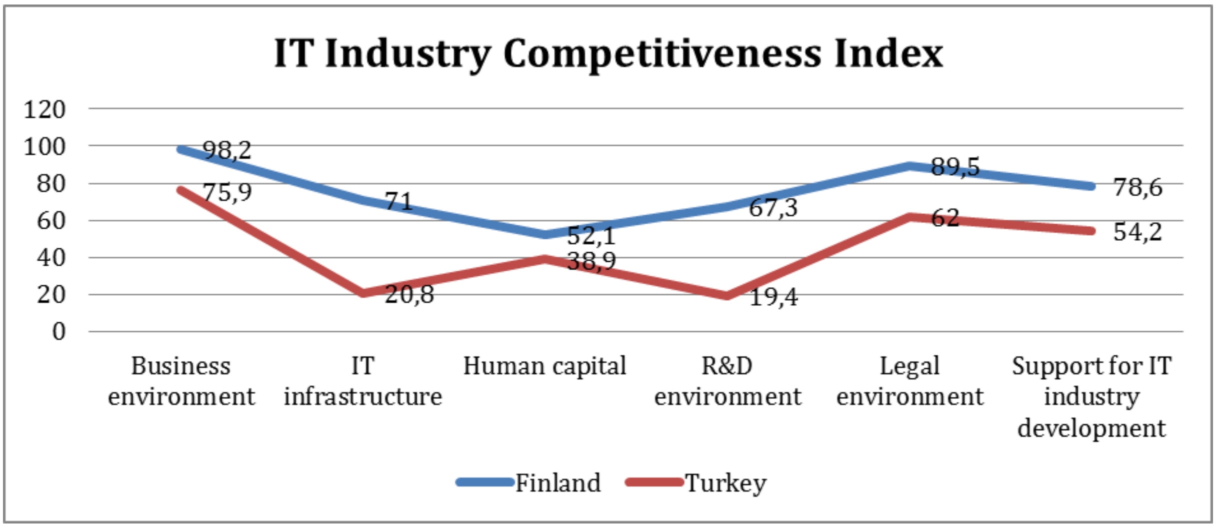


**Figure 1.** IT industry competitiveness index for Finland and Turkey adapted from Business Software Alliance (2013).

Another evaluation model is the benchmarking study of the Grenland IT cluster including 47 indicators categorized into dimensions of cluster structure, financing of cluster organisation, typology and governance of the cluster, spectrum of services implemented, output of services, internationalisation, achievements, and performance (Meier Zu Köcker 2009). Yet in another study about the Bangalore IT cluster, demand conditions, the role of large firms in the cluster, reliance on a network of universities and research institutions, and the quality of life in the city were taken into consideration as determinants of competitiveness (Van Dijk 2003). However, the variables applied in these studies differ and do not address our goals precisely.

Following the assessment of the above approaches, the emerald model (Sasson and Reve 2012) was selected as the appropriate theoretical framework to be utilized in this study. The model has been originally developed to evaluate the attractiveness of a location to attract foreign direct investments (FDI) and previously used in the assessment of oil and gas industry (Sasson and Blomgren 2011), health industry (Sasson 2011a), metals and materials industry (Sasson 2011b), telecom industry (Vinje and Nordkvelde 2011), and tourism industry (Akpinar and Mermercioglu, in press). The model is acknowledged to be easier to operationalize at cluster level than other models like the diamond model or the competitiveness framework by the World Economic Forum and especially useful in the identification of suggestions for policy makers (ibid.).

The model has six dimensions and one moderator. The dimensions in the model are educational attractiveness, talent attractiveness, R&D and innovation attractiveness, ownership attractiveness, environmental attractiveness, and cluster attractiveness. These dimensions are moderated by knowledge dynamics, the degree of flow of knowledge in the cluster (see Figure 2).

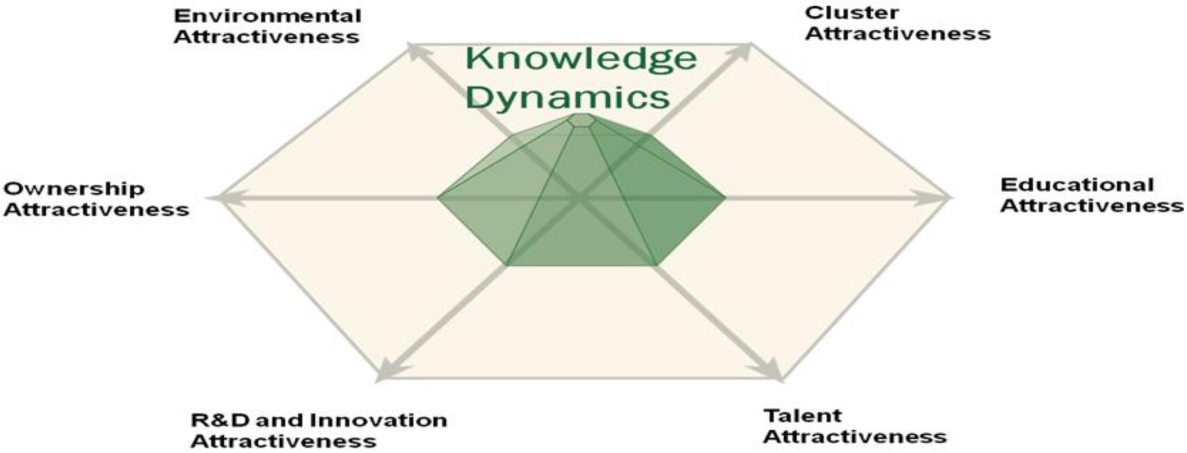


**Figure 2.** The emerald model adapted from Sasson and Reve (2012).

Educational attractiveness is the first dimension of competitiveness. It indicates the popularity of the cluster's field of education in the area and the existence of high quality educational institutions in the cluster attracting a high number of both domestic and foreign students to the region. Education lies at the heart of acquiring knowledge, and this is more than true in the case of IT knowledge. As a result, the dimension of educational attractiveness may be vital to impact on the cluster's knowledge base that would then affect the cluster's competitiveness and innovation performance.

The second dimension of competitiveness is talent attractiveness, which assesses the ability to attract talent to the cluster. Talent refers to the existence of qualified human resources who are the key knowledge assets to come up with new ideas for innovations in the cluster. Offering attractive opportunities for talent may increase the cluster's knowledge potential and result in superior competitiveness and innovation performance.

R&D and innovation attractiveness is the third dimension of competitiveness in the emerald model. It assesses the existence of R&D activities in the cluster as well as the amount of R&D investments. It may not be possible to create new knowledge and innovations without R&D activities especially in the IT sector. Thus, R&D activities may be positively correlated with competitiveness and innovation performance.

Ownership attractiveness, the fourth dimension of competitiveness, addresses the ease of starting new businesses in the cluster as well as the cluster's abilities to attract foreign ownership as well as financing (e.g., venture capital) for start-ups. In other words, it evaluates the attractiveness of a cluster's entrepreneurial ecosystem and the support it provides for start-ups. As the availability of finances and relevant support may play important role for enabling new business development, ownership attractiveness may both contribute to a cluster's competitiveness and be a motivating dimension for pursuing innovations. The results of a study by Bengtsson (2003) reveal that public financial support in form of venture capital seem to play an important role especially in the growth of technology firms.

Environmental attractiveness is the fifth dimension of competitiveness, which evaluates the cluster's abilities for producing environment friendly products and services with environment friendly operations. Sensitivity for environmental concerns may lead to the development of specialized knowledge in this field and contribute to relevant innovations in the development of more sustainable products, services, operations and business models and hence create competitive advantage (Porter and van der Linde 1995).

The sixth dimension of competitiveness is cluster attractiveness. This dimension measures the level of agglomeration and the level of specialization in the cluster. As argued by some cluster literature, a larger cluster with a higher degree of specialization is assumed to have more potential for generating new knowledge and related innovations (Porter 1998; Bathelt et al. 2004; Sölvell et al. 2008; Delgado et al. 2010).

Finally, knowledge dynamics is the moderator for competitiveness in the emerald model. It is the degree at which knowledge flows efficiently in the cluster resulting in dynamic interactions and relationships between related firms and institutions. In a dynamic cluster, one would expect intentional and unintentional knowledge spillovers that result in the creation of new knowledge (Tödtling et al. 2009; Jankowska and Pietrzykowski 2013). As a result, this new knowledge may in turn lead to higher level of innovations.

## 3. Methodology

This research pursues the philosophy of pragmatism in that in search for answers to the research questions it is the practical consequences that matter more than how the answers were obtained (James 1907). As such, it allows the application of multiple methods in the inquiry of the answers. This suits well the objectives of the research which are (i) to benchmark competitiveness of two clusters, (ii) to assess the value of the emerald model in assessing competitiveness of clusters, and (iii) to explore preliminarily the impact of the emerald model's dimensions on innovation performance.

The research design applied multiple case study and benchmarking as methodology. Two case clusters were selected and studied by operationalizing the emerald model. Case study methodology is suitable for the exploratory nature of this research (Yin 2003), and benchmarking methodology assesses how one case is placed and performs in relation to another one. This in turn allows to identify the underlying strengths and weaknesses of the two cases and to make practical suggestions for development, suiting well the philosophy of pragmatism.

### *3.1. Research Settings*

In this study the ITU Arı Technopark cluster in Sarıyer in Istanbul, Turkey was benchmarked with its peer IT cluster in the region of Central Finland. The IT sector was selected as it is defined as one of the key drivers of the global economic growth, and as such it is recognized by policy makers as strategically important. Finland was selected as a benchmark country because ranking 2$^{nd}$ in the IT competitiveness index, it is a leading country in this sector, and the cluster in Central Finland was selected as it is the residential area of one of the authors enabling ease of access to the cluster. Turkey, on the other hand, was selected as a contradictory case country. Despite having great ambitions in the IT sector, the country has room for improvement as it ranks 41st in the IT competitiveness index. The cluster in Sarıyer, Istanbul was selected because Istanbul is the most competitive city in Turkey, and the cluster is within ease of access of the other author. The cluster in Sarıyer is different than its peer in Central Finland in that it is smaller in terms of both number of firms (86 versus 410) and generated annual revenues (86 million Euro versus 527 million Euro) but larger in terms of employment (3,832 versus 2,913). From managerial and policy perspectives there may be learning opportunities for the Turkish cluster from its peer in Finland. While the cluster selected from Finland belongs to a region (the region of Central Finland), it was a deliberate decision to select only one IT cluster from the city of Istanbul. Istanbul has a number of independent IT clusters which are different from each other, so taking Istanbul's all IT clusters in the study would have provided mixed results. There would also be a huge size differential in favour of Istanbul. However, in doing that, one should be aware that thanks to close proximity, the cluster in Sarıyer could benefit from spillover effects from the other IT clusters. One benefit can be that Istanbul is identified as the most competitive city in Turkey, and Sarıyer is an attractive place to work and study. Therefore, people living in other districts or cities may be coming to Sarıyer for those purposes. Another benefit can be through collaboration and competition between clusters in Sarıyer and other municipalities of Istanbul as some of the firms operating in the ITU Arı Technopark cluster have headquarters or other offices in different parts of the city. Moreover, the cluster in Sarıyer is a constructed science park located in the campus of ITU, subject to special regulations and incentives, while the IT cluster in Central Finland is an evolutionary one. As suggested by Löfsten and Lindelöf (2002) and Link and Scott (2006) the formation of science parks results in employment growth especially in cases where the park is close to the university. Despite these factors and possible spillover effects in favour of Sarıyer, the application of the framework to conduct such a benchmarking study is expected to assess the functionality of the emerald model in assessing the competitiveness of clusters with different characteristics and provide learning opportunities for both clusters.

### *3.2. Measurements and Data Collection*

According to Siegel et al. (2003) it is inappropriate to assess the outcomes by solely collecting perceptual data from entrepreneurs and/or firms as such data suffer from several limitations such as a sample of entrepreneurs or firms not being representative of the whole population and the possibility of the entrepreneurs and/or firms overestimating the effectiveness of the results. Accordingly a variety of data was collected for the study from both secondary and primary sources.

Innovation measurements can be based on inputs or outputs of the innovation process. Measurements based on inputs can be R&D budget, existence of formalized R&D, and number of R&D staff, and measurements based on outputs can be number of patents, number of innovations, absolute amount of sales of innovative products, and increase in market share (Massa and Testa 2008). In this research the innovation performance was measured by the average annual number of patent registrations per firm in the cluster during 2007-2011. Five year average data was used instead of a single year in order to account for fluctuations over the years. The annual number of patent registrations per employee in the cluster was not used as a performance measure since we were informed that firms the Sarıyer IT cluster were overpopulated to take advantage of incentives provided by the government.

A number of measures borrowed from Sasson and Reve (2012) were obtained from multiple sources and used for operationalizing the dimensions of the emerald model (see Table 1). Use of multiple measures allowed to capture a comprehensive understanding for each dimension.

**Table 1.** Measures for the dimensions of competitiveness and their sources of data.

| Dimensions | Measures | Data sources |
|---|---|---|
| Educational attractiveness | Annual number of students accepted to university degree programmes in IT related fields, ratio of students studying IT to all students (%), number of bachelor, master and doctoral graduates in IT related fields per year | University records and Statistics Finland |
| Talent attractiveness | Purchasing power parity adjusted average wage per employee in the clusters, and index of average wage per employee in the cluster versus average wage per employee in the country | HAY Group and Statistics Finland |
| R&D and innovation attractiveness | Ratio of annual R&D spending to gross domestic product (GDP) | OECD, Turkish Statistical Institute, Statistics Finland, Information Society Strategy Portal, and interviews |
| Ownership attractiveness | Ratio of FDI stock in the cluster to total investment stock (%), and ratio of venture capital stock in the cluster to investment stock (%) | OECD, Turkish Statistical Institute, Statistics Finland, Arı Technopark, Information Society Strategy Portal, and interviews |
| Environmental attractiveness | Level of air pollution (particulate matter concentration (PM10), and amount of waste (kg) per person per day | World Health Organization, Ministry of Environment and Urban Planning, Anıl et al. (2009), Statistics Finland, and Air Quality in Finland |
| Cluster attractiveness | Absolute cluster size (no. of employees), regional specialization (location quotient), and cluster size as percentage of regional employment | European Cluster Observatory, Turkish Statistical Institute, Statistics Finland, and interviews |
| Knowledge dynamics | Degree of cooperation in the cluster, degree of competition in the cluster, and employee turnover rate | Interviews with firms and ITU Arı Technopark management |

Sources of secondary data included databases of Tilastokeskus (Statistics Finland) (http://www.stat.fi), OECD (http://stats.oecd.org/), European Cluster Observatory (http://www.clusterobservatory.eu/), Turkish Statistical Institute (http://www.turkstat.gov.tr), HAY Group (http://www.haygroup.com), Air Quality in Finland (http://www.ilmanlaatu.fi/index.php), Ministry of Environment and Urban Planning Turkey (http://www.csb.gov.tr/turkce/index.php), World Health Organization (http://who.int/whosis), and Anıl et al. (2009). Besides secondary data collection, all firms in both clusters were contacted for interviews, but only a total of 20 interviews (12 in Finland and 8 in Turkey) could be conducted (acceptance rate of 4.0%). The interviews aimed primarily to reveal the degrees of competition, cooperation and employee turnover in the cluster (variables of knowledge dynamics dimension). These were measured using Likert scale (1-5). There were also open ended questions to gain insights about barriers and enablers of innovations in the clusters (see Appendix 1 for the set of interview questions). In addition, an extensive interview with the Public Relations Manager of the management organization of ITU Arı Technopark cluster provided further insights.

There were a few limitations in accessing cluster-level statistics. In such cases (e.g., talent attractiveness measures, R&D and innovation attractiveness measures, and ownership attractiveness measures) country-level IT sector data was used as best estimates to replace cluster-level data. Data was mostly from year 2011, but in the cases of number of graduates and inward FDI, five-year average data from 2007-2011 was used in order to account for annual fluctuations in data. The data analysis was based on benchmarking of the two clusters along each dimension.

### *3.3. Data Analysis by Benchmarking*

To enable an easy comparison, a new methodology was invented in this research and added to the emerald model, where each numerical measure for the selected dimensions were converted into categorical measures from 1 to 3 using minimum, average, and maximum possible values as classification criteria (see Table 2 in the results section). In this classification, level 1 means low degree of attractiveness, level 2 means moderate degree of attractiveness, and level 3 means high degree of attractiveness. The cut-off points of these classification criteria were calculated differently for each variable.

For educational attractiveness, the cut-off points were calculated taking into account the number of bachelor, master and doctoral students accepted per programme and the number of programmes offered. In the case of bachelor programmes, a degree programme was assumed to have an intake of 50 students per year. In the case of master and doctoral programmes, the intake was assumed to be 15 and 5 students per year respectively. As a result, low degree of attractiveness corresponds to having one programme in the region resulting in maximum 50 bachelor graduates, 15 master graduates and 5 doctoral graduates per year (see Table 2). Applying similar logic, moderate degree of attractiveness corresponds to having two degree programmes at each level, and high degree of attractiveness corresponds to having three or more degree programmes at each level.

For talent attractiveness, the cut-off points were calculated using statistical figures from the study of HAY Group (2014) and European Cluster Observatory (2014).

For R&D and innovation attractiveness and also for ownership attractiveness, the cut-off points were calculated using statistical figures from OECD (2014).

For environmental attractiveness, the cut-off points were calculated using statistical figures from World Health Organization (2014) and OECD (2014).

For cluster attractiveness, the cut-off points were based on the work of Sölvell et al. (2008).

For knowledge dynamics, the cut-off points were calculated based on equal distance between the Likert scale values of 1 and 5.

Finally, each variable in every dimension was given equal weight, and categorical measures for the dimensions were calculated as the averages of the categorical measures for the variables under the dimensions.

## 4. Results

### *4.1 Innovation performance*

The average annual number of patent registrations per firm during 2007-2011 was 0.16 in the Central Finland IT cluster (Tilastokeskus 2014b) and 0.17 in the Sarıyer IT cluster (retrieved from records of the technopark). This suggests that the innovation performances of the two clusters are equal in number of patent registrations when adjusted for the cluster size difference.

Although the Sarıyer IT cluster is located in the same campus with a university, the innovation performance was not assessed to be greater than the cluster in Central Finland. This finding is in line with the findings of Phillips and Yeung (2003) regarding the research on Singapore Science Park Phillips, where the extent of R&D activities and collaboration among tenant firms of the park are identified to be relatively low. The main reason behind the failure regarding the park's enhancement of R&D activities is identified as the lack of compatible and cohesive relationships among the institutions and the firms situated in the park, as all the tenants in the park do not feel the need to utilize the R&D facilities. This can be a viable reason in the case of the Sarıyer IT cluster, as ITU Arı Technopark is not a science park dedicated to IT firms, and there are many firms situated within the technopark operating in non-IT sectors.

### *4.2 Educational attractiveness*

There are five universities with campuses in Sarıyer admitting altogether 11,584 students per year (retrieved from records of the universities). These universities have a total quota of 1,049 students for IT-related studies (9.1% of students in all studies), such as computer engineering, electronics engineering, electrics and electronics engineering, electronics and communication engineering, software engineering, information technologies, management information systems, and computer programming (retrieved from records of the universities). The annual number of graduates from this field during 2007-2011 was on average 700 (582 with bachelor, 101 with master and 17 with doctoral degrees) (retrieved from records of the universities). There is a vocational school offering computer programming and electronic technology courses with a yearly quota of 160 students (retrieved from records of the vocational school). There have been on average 104 graduates per annum from this school during 2007-2011 (retrieved from records of the vocational school). Moreover, there are several certificate programmes offered by universities in the area, such as web application design and development, software and web site development, MS Office, information systems, management information systems.

There is a university and a university of applied sciences in Jyväskylä admitting around 4,400 students per year (retrieved from records of the universities). Jyväskylä University offers three bachelor programmes, four master programmes and four doctoral programmes in IT-related studies. JAMK University of Applied Sciences offers four bachelor programmes and one master programme. Total number of admissions to these programmes in the two institutions is around 400 students per year (9.1% of students in all studies) (retrieved from records of the universities). The annual number of students graduated from this field during 2007-2011 was on average 354 (223 with bachelor, 115 with masters, and 16 with doctoral degrees) (Tilastokeskus 2014c; Tilastokeskus 2014d). In addition, there are certificate programmes in IT fields offered by these institutions.

The figures reveal that IT education is a popular in both regions accommodating ca. 9% of all students. The number of graduates per year is similar in master and doctoral studies, but significantly in favour of the Sarıyer cluster in bachelor studies. This is because Sarıyer region hosts some of the leading universities of Turkey such as Boğaziçi University, Koç University and ITU. Moreover, the fact that the Sarıyer IT cluster is situated in the same campus with ITU can also lead to a higher concentration of students and faculty within the area. As a result, it can be concluded that the two clusters are both highly attractive from an educational perspective (level 3 in Table 2 and Figure 3).

### *4.3 Talent attractiveness*

As it was not possible to learn the wage statistics of the clusters, public statistical data from the IT sectors in the two countries were utilized in order to assess the wage levels. Most of the employees in ITU Arı Technopark are graduates of universities and secondary schools. According to HAY Group survey results, the average gross salary for IT professionals in Turkey is equal to 3,436 Euros per month, which is about 49% higher than the aggregate average salary level in Turkey (index of 1.49). The difference is due to the higher than average qualifications of the R&D personnel and the nature of some highly specialized technical positions. Moreover, the net salaries of IT professionals working in the Sarıyer cluster can even be higher than Turkish average due to tax incentives offered to the firms located within the science park. Taking into account the purchasing power parity between Turkey and Finland, the equivalent of 3,436 Euros earned in Turkey is calculated to be equal to 6,136 Euros in Finland.

The average gross salary in Finland's IT sector in 2011 was 4,500 Euros per month (Tilastokeskus 2014e), which is about 42% higher than the aggregate average wage level in Finland (index of 1.42). This figure would be representative for the IT cluster in Central Finland.

Figures suggest that IT sector is highly attractive in both countries for talent (level 3 in Table 2 and Figure 3). Given the purchasing power parity difference, one can argue that Turkey is even a more attractive location for IT professionals.

### *4.4 R&D and innovation attractiveness*

Statistical data related to the R&D expenditures of the two clusters could not be accessed. As a result, country-level data was used regarding the ratio of annual R&D expenditures to GDP. This was complemented by insights from the interviews.

Turkey's total R&D expenditure was 5,070 million Euro in 2011 (ca. 0.9% of GDP) (OECD 2014; Turkish Statistical Institute 2014). This low figure is also evidenced from the IT Industry Competitiveness Index in Figure 1. This is further confirmed by Deloitte and Yased's (2012) argument that there is a lack of R&D investment in the Turkish IT sector. Based on these figures, it can be assumed that the IT cluster in Sarıyer has low attractiveness. However, the interviews revealed that the firms in the Sarıyer IT cluster were provided significant tax incentives for employing R&D staff and the incentives were given on the basis of the number and scope of the R&D projects carried out by these personnel within the year. Taking this into consideration, we consider the R&D and innovation attractiveness of the Sarıyer IT cluster better than the average for Turkey's IT sector, and thus we assign level 2 in Table 2 and Figure 3. This is due to the fact that the Sarıyer IT cluster is a constructed cluster, admitting firms or departments of firms involved in R&D activities, with the aim of enhancing knowledge transfer from university to the firms and fostering new technology business formations. Respectively, firms operating within those parks have significantly higher elasticity of R&D with respect to other firms, as the science park offers a clustering effect and establishes links among firms and research institutions (Yang et al., 2009), and the performance of new technology based firms located on the science parks place significantly greater emphasis on innovative activities (Lindelöf and Löfsten, 2003). Moreover, research on two Taiwanese science parks at different stages of development reveals that the spatial proximity of firms within these science parks increases interaction among high-tech personnel and the expansion of their professional networks, thus promoting innovation and R&D activities (Hu 2008).

Finland's total R&D expenditure was 7,164 million Euro in 2011 (ca. 3.7% of GDP) (OECD 2014), and the IT sector is one of the leading sectors in R&D investments in Finland (Tieke 2009; Ministry of Employment and the Economy 2013). This is also supported by the R&D pillar result from the IT Industry Competitiveness Index in Figure 1. As such, it can be assumed that the IT cluster in Central Finland is highly attractive in this dimension (level 3 in Table 2 and Figure 3).

*4.5 Ownership attractiveness*

The information on the ownership structures of each firm in the clusters was not accessible. Therefore, the FDI in the IT sector at country level was taken into consideration for benchmarking. The total amount of FDI to Turkey's IT sector during 2007-2011 was equal to 455 million USD (OECD 2014; Turkish Statistical Institute 2014). This is a relatively low figure accounting for 0.6% of the total FDI to the country during the same period. Hence, the Turkish IT sector has a low attractiveness level to foreign investors (level 1 in Table 2). Total FDI to Finland's IT sector was 2,719 million USD during 2007-2011, accounting for 12.8% of all FDI into the country during those years (OECD 2014). Although this is much better compared to the situation in Turkey, Finland's level of attractiveness for foreign investors in the IT sector is moderate (level 2 in Table 2).

Introduction of venture capital in Turkey is relatively new, and according to the interview with the public relations manager of the technopark, its usage in the Sarıyer IT cluster has been insignificant with total of 10 venture capital investments since the cluster's establishment (less than 1% of all investments). Here it should be noted that when assessing the amount of venture capital investments, only the firms or business units of firms operating within the ITU Arı Technopark are taken into consideration.

Accounting for average 4% of funding used by start-ups, venture capital cannot be considered as a popular means of external funding in Finland, either. However, different than in Turkey, public actors in the Finnish innovation system offer better support in terms of funding innovation projects and incubating start-ups with guidance and support during their early stages of establishment. Based on FDI and venture capital figures along with feedback from cluster interviews Turkey's attractiveness for venture capital is low (level 1 in Table 2), and that of Finland is moderate (level 2 in Table 2).

Taking into account both measures, the IT cluster in Sarıyer has low attractiveness in ownership (level 1 in Table 2 and Figure 3), and the IT cluster in Central Finland has moderate attractiveness (level 2 in Table 2 and Figure 3).

*4.6 Environmental attractiveness*

Air is much more polluted in Turkey with annual mean particulate matter concentration (PM10) of 66 ug/m$^3$ (OECD 2014) than in Finland with average annual PM10 of 19 ug/m$^3$ (ibid.). The corresponding figures for Sarıyer and Jyväskylä are 52 ug/m$^3$ (Anıl et al. 2009) and 12 ug/m$^3$ (Air Quality in Finland 2014) respectively. The amount of waste per person in Sarıyer is 2.58 kg/person/day (Ministry of Environment and Urban Planning Turkey 2014), and this is much larger than Jyväskylä's corresponding figure of 1.10 kg/person/day (Tilastokeskus 2014f). Based on these comparisons Jyväskylä has significantly high knowledge potential in environmental issues (level 3 in Table 2 and Figure 3) while Sarıyer's attractiveness is limited at level 1 (see Table 2 and Figure 3).

*4.7 Cluster attractiveness*

Following Sölvell et al. (2008), the variables that were used to reveal cluster attractiveness are cluster size, the ratio of cluster employment to the region's total employment, and the location quotient, which is an analytical statistic that measures a region's industrial specialization relative to a larger geographical unit (US Department of Commerce Bureau of Economic Analysis 2014), was used in addition to cluster size and the ratio The IT cluster in Sarıyer is small in international standards with a total of 3,832 employees (retrieved from records of the technopark). However, this figure represents a high rate of employment for Sarıyer, as it is equal to 4% of the region's total employment. In addition, the region is highly specialized in the IT sector, as the location quotient is 15.07 compared to Turkey (calculated using data from European Cluster Observatory 2014 and Turkish Statistical Institute 2014). Taking into account the low location quotient of Turkey in IT (0.63 compared to the EU average) (calculated using data from European Cluster Observatory 2014 and Turkish Statistical Institute 2014), the specialization level of Sarıyer in IT is still high at 9.49 compared to the EU average. Despite its small size, the IT cluster in Sarıyer has moderate level of cluster attractiveness thanks to its high degree of specialization (level 2 in Table 2 and Figure 3). This result is compatible with previous studies on science parks such as Löfsten and Lindelöf (2002) and Link and Scott (2006) reporting that firms located in science parks have a higher rate of job creation.

The IT cluster in Central Finland is also small in international standards with a total of 2,913 employees (Tilastokeskus 2014a). However, measured in terms of number of firms, it is almost five times bigger than the Sarıyer cluster. Similar to the situation in Sarıyer, the IT cluster in Central Finland accounts for a high share of the region's employment at 4.6%. In the IT sector, Central Finland's location quotient is 1.43 compared to Finland, and Finland's location quotient is 7.51 compared to the EU average (calculated using data from European Cluster Observatory 2014 and Tilastokeskus 2014a). This makes Central Finland highly specialized in the IT sector with a location quotient of 10.74 compared to the EU average. Like its peer in Sarıyer, the IT cluster in Finland has a moderate level of cluster attractiveness, balanced between small size and high degree of specialization (level 2 in Table 2 and Figure 3).

### *4.8 Knowledge dynamics*

Data for knowledge dynamics was collected in interviews with cluster firms on three variables (degree of cooperation, degree of competition, and employee turnover rate) using the Likert scale (1-5) measurements. It should be noted that the assessment of cooperation and competition are confined to firms operating within the cluster and not evaluated for firms having headquarters or branches outside the science park in the case of ITU Arı Technopark.

The degree of cooperation at the Sarıyer IT cluster is reported at interviews to be high at 3.6 points out of 5.0, and firms indicated that they cooperate mostly with their customers. There are several software development firms specialized in telecom and finance, cooperating with the leading firms in the sector located in Maslak, Sarıyer, at a walking distance from the cluster. There are also various firms providing software development services in customer relationship management and enterprise resource planning for firms situated in Maslak. Moreover, firms founded by ITU faculty and students are allowed to have 50% discount on the rents and as a result, almost 30% of the firms operating in the area are owned by academicians. Sharing of mutual background has a positive effect on cooperation through trust and informal communication. There is moderate amount of competition among firms in the cluster at 2.8 points, and the employee turnover in the cluster is reported to be moderate at 2.7 points. Based on the average of these measures, the knowledge dynamics in the IT cluster of Sarıyer assessed to be moderate (level 2 in Table 2 and Figure 3).

Based on interview results, the levels of cooperation vary in the IT cluster of Central Finland depending on cooperation partners. The highest levels of cooperation are with customers (4.3 points) and suppliers (3.5 points). The levels of cooperation are modest with research institutes, governmental organizations and related industries (2.6 points), and it is lowest with competitors (1.8 points). On average level of cooperation is moderate at 3.1 points. Competition, on the other hand, is high with 3.7 points, and employee turnover is moderate at 2.8 points. Based on the average of these measures knowledge dynamics in the IT cluster of Central Finland is also assessed to be moderate (level 2 in Table 2 and Figure 3).

This result is in line with several studies regarding the interaction level between on-park firms and between the firms and local universities as results of studies reveal contradictory results. Some studies acknowledge benefits generated through collaborative R&D activities with universities (Löfsten and Lindelöf 2002; Link and Scott 2006; Fukugawa 2006; Almeida et al. 2008; Hu 2008; Yang et al. 2009; Koçak and Can 2013) and advantages of having an access to a wide and well-nurtured network of existing firms (Hansson et al. 2005) when others point out to the low interaction between firms and the universities (Phillips and Yeung 2003; Hansson et al. 2005), to parks not creating mutually beneficial interdependencies between the firms and research institutions (Saxenian 1994; Gertler et al. 2000) and to science parks' locations having only a weak and indirect relationship with the innovation level (Felsenstein 1994). Moreover, some studies suggest that science parks are mostly beneficial to the universities rather than firms, as they contribute to the research environment, resulting in a more applied university curriculum (Link and Scott 2006).

### *4.9 Summary*

Table 2 shows the detailed assessment of the two clusters in each dimension of the emerald model, and Figure 3 summarizes the results from Table 2.

**Table 2.** Comparative assessments of the clusters.

| Measures | Values for Sarıyer | Values for Central Finland | Assessment criteria | Assessment (1..3) for Sarıyer | Assessment (1..3) for Central Finland |
|---|---|---|---|---|---|
| Annual number of students accepted to university degree programmes in IT related fields | 1,049 | 400 | 1: 0-50; 2: 51-100; 3: >100 | 3 | 3 |
| Ratio of students studying IT to all students (%) | 9.1% | 9.1% | 1: <1%; 2: 1-3%; 3: >3% | 3 | 3 |
| Number of bachelor graduates per year | 582 | 223 | 1: 0-50; 2: 51-100; 3: >100 | 3 | 3 |
| Number of master graduates per year | 101 | 115 | 1: 0-15; 2: 16-30; 3: >30 | 3 | 3 |
| Number of doctoral graduates per year | 17 | 16 | 1: 0-5; 2: 6-10; 3: >10 | 3 | 3 |
| **Overall rating for educational attractiveness** | | | | **3** | **3** |
| Purchasing power parity adjusted average wage per employee in the clusters (Euro) | 6,136 | 4,500 | 1: 0-2,500; 2: 2,501-4,000; 3: >4,000 | 3 | 3 |
| Index of average wage per employee in the cluster versus average wage per employee in the country | 1.49 | 1.42 | 1: 0-0.8; 2: 0.8-1.2; 3: >1.2 | 3 | 3 |
| **Overall rating for talent attractiveness** | | | | **3** | **3** |
| Ratio of R&D spending to GDP (%) | 0.9% | 3.7% | 1: <1%; 2: 1-3%; 3: >3% | 2* | 3 |
| **Overall rating for R&D and innovation attractiveness** | | | | **2** | **3** |
| Ratio of foreign direct investment (FDI) stock in the cluster to total investment stock (%) | 0.6% | 12.8% | 1: <10%; 2: 10-30%; 3: >30% | 1 | 2 |
| Ratio of venture capital stock in the cluster to investment stock (%) | <1% | 4% | 1: <1%; 2: 1-5%; 3: >5% | 1 | 2 |
| **Overall rating for ownership attractiveness** | | | | **1** | **2** |
| Level of air pollution (particulate matter concentration (PM10) | 52 | 12 | 1: >60; 2: 30-60; 3: <30 | 2 | 3 |
| Amount of waste (kg) per person per day | 2.58 | 1.10 | 1: >2.5; 2: 1.5-2.5; 3: <1.5 | 1 | 3 |
| **Overall rating for environmental attractiveness** | | | | **1** | **3** |
| Absolute cluster size (number of employees) | 3,832 | 2,913 | 1: 0-5,000; 2: 5,001-10,000; 3: >10,000 | 1 | 1 |
| Regional agglomeration (location quotient) | 9.49 | 10.74 | 1: <1; 2: 1-2; 3: >2 | 3 | 3 |
| Cluster size as percentage of regional employment | 4.0% | 4.6% | 1: <1%; 2: 1-3%; 3: 3% | 3 | 3 |
| **Overall rating for cluster attractiveness** | | | | **2** | **2** |
| Degree of cooperation in the cluster (Likert scale 1-5) | 3.6 | 3.1 | 1: 1-2.5; 2: 2.6-3.5; 3: 3.6-5 | 3 | 2 |
| Degree of competition in the cluster (Likert scale 1-5) | 2.8 | 3.7 | 1: 1-2.5; 2: 2.6-3.5; 3: 3.6-5 | 2 | 3 |
| Employee turnover rate (Likert scale 1-5) | 2.7 | 2.8 | 1: 1-2.5; 2: 2.6-3.5; 3: 3.6-5 | 2 | 2 |
| **Overall rating for knowledge dynamics** | | | | **2** | **2** |

* Level 2 was awarded to the Sarıyer IT cluster in R&D and innovation attractiveness taking into account tax incentives for R&D staff.

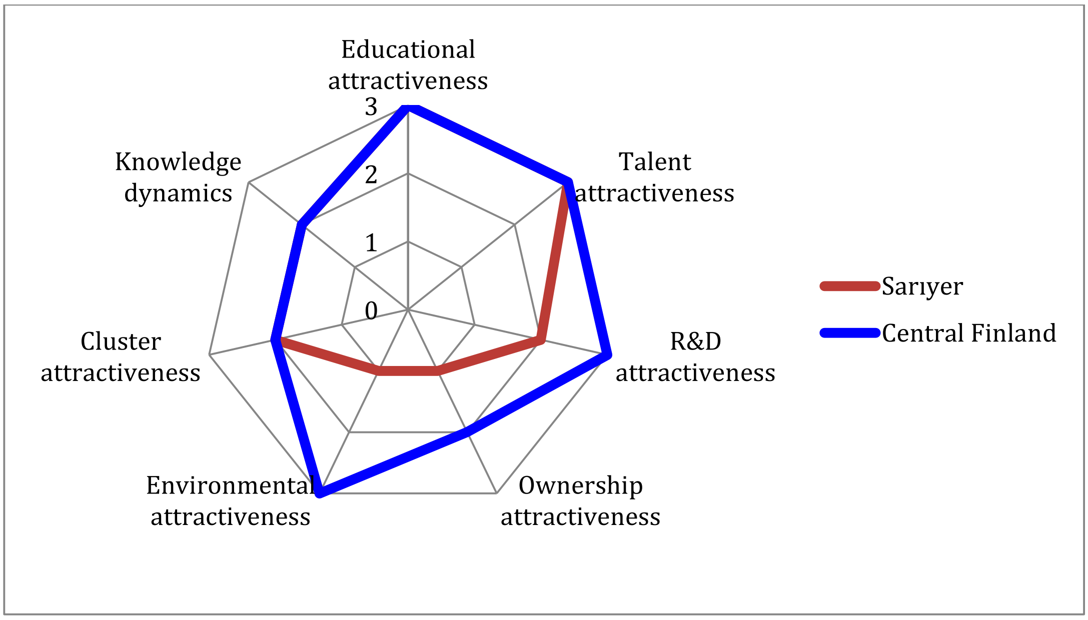


**Figure 3.** Comparison of the two clusters in dimensions of the emerald model.

The two clusters are similar in terms of educational attractiveness (level 3), talent attractiveness (level 3), cluster attractiveness (level 2), and knowledge dynamics (level 2). The IT cluster in Central Finland performs better in R&D and innovation attractiveness (level 3 versus level 2), ownership attractiveness (level 2 versus level 1), and environmental attractiveness (level 3 versus level 1). Despite that the Central Finland cluster is more competitive, the two clusters perform equally in terms of number of innovations per firm. This result suggests that there may not be a direct link between all dimensions of the emerald model and innovation performance. This will be discussed in the next section.

## 5. Discussion

This research benchmarked the competitiveness and innovation performances in two IT clusters using the emerald model by Sasson and Reve (2012). Operationalization of the model through the development of an assessment scheme (see Table 2) to understand the competitiveness of clusters is a key contribution of this study. The emerald model was easy to apply and operationalize at cluster level, but there were some challenges and limitations. First of all, the clusters to be analyzed should have well-established statistical databases. This is especially challenging in the cases of small, regional clusters from emerging economies where statistics are difficult to access and not always reliable. In overcoming this challenge, the emerald model was adapted based on the availability of data, and in some cases measures for the country replaced cluster data. This was the situation for talent attractiveness (average wages in the country were used to predict average wages in the cluster), R&D and innovation attractiveness (ratio of R&D spending to GDP was calculated using country level figures), and ownership attractiveness (FDI in the IT sectors of the countries and venture capital available in the countries were used to predict cluster figures). A second challenge was about the comparability of clusters with different backgrounds, different sizes and different forms. Contextual differences may impact on the results of the study. In this study size difference of the two clusters was taken into account for benchmarking purposes. The acquaintance of the authors with contextual factors through analysis of IT cluster reports and interviews with cluster members also contributed in interpreting the results taking into account contextual differences. A third challenge was the low response rate from cluster firms. Responses from a total of 20 firms created a limitation in the assessment of Likert scale results on knowledge dynamics, and it was not possible to generalize the results statistically. They were used as indicative measures, which is tolerable regarding the exploratory nature of this study.

The results of this study are in line with IT competitiveness index comparison between Finland and Turkey (see Figure 1) in that the IT cluster in Central Finland is more competitive than the IT cluster in Sarıyer in the overall, particularly in the dimensions of R&D and innovation attractiveness, environmental attractiveness, and ownership attractiveness. The IT cluster in Sarıyer performs equally well (and sometimes better) in the dimensions of educational attractiveness, talent attractiveness, cluster attractiveness, and knowledge dynamics.

One would expect R&D and innovation attractiveness and ownership attractiveness to be the influential factors in driving a cluster's innovation performance especially in the context of knowledge-intensive IT clusters. Based on the benchmark, it can be suggested that this is not necessarily the case. According to the expectation, as the Central Finland IT cluster performs better in both dimensions, it should have a better innovation performance. Surprisingly, the firms in the two clusters are on average equal in their innovation performances measured by the number of patent applications per annum. There could be three complementary explanations for this result. The first one is that perhaps other factors where the two clusters are equally competitive such as educational attractiveness, talent attractiveness, cluster attractiveness and knowledge dynamics are equally influential in matching of the two IT clusters' innovation performances. The second explanation is related to the nature of the Sarıyer cluster, i.e. being a constructed science park with special regulations and financial incentives for R&D staff and collaboration opportunities with the universities or other scientific institutions within the park. These measures in the Sarıyer IT cluster may have significantly improved the innovation performance as the cluster is highly populated with R&D staff and there are several firms formed by students and faculty from the university situated in the park. Finally, the third explanation may be that the Sarıyer IT cluster benefits from the fact that IT firms in this cluster are branches of existing IT firms located in other regions of Istanbul.

According to the results of this study, environmental attractiveness was not perceived as an influential factor driving innovation performance. This leads us to question whether environmental attractiveness should at all be included as a dimension of competitiveness. Although it may not be a relevant for the IT sector, it can nevertheless have important effects when assessing the competitiveness of other sectors such as tourism (Akpinar and Mermercioglu, in press). We recommend further application of the emerald model in other sectors to answer this question.

Education attractiveness and talent attractiveness seem to be highly important drivers of innovation performance in the IT sectors, and both clusters were highly competitive in these dimensions. This is not a surprising finding since IT is a knowledge-intensive sector, and education and human capital are needed for combining existing knowledge to create new knowledge.

Cluster attractiveness may impact positively the innovation performance, but this is not evident from the results. Specialization enables smart allocation of limited resources to strategically important focus areas, and this can create competitive knowledge, which may lead to innovations. Further research is needed to evaluate the impacts of specialization on innovation performance.

The impact of knowledge dynamics on innovation performance is not clear from the results of this research, either. Earlier literature praises cluster dynamics as a stimulator of innovations (Sölvell et al. 2008). However, it may be that higher level of interaction in the cluster need not result in transfer of tacit and confidential knowledge which lies at the heart of innovations in the IT sector. Transfer of such knowledge between firms may be prohibited through legislation and practices regarding intellectual property rights. Moreover, noting that the Sarıyer IT technopark was formed as a science park, it might not be sufficient to provide just physical infrastructure and investment benefits. There is a need for understanding actor-specific strategies, their enrolment in innovation networks and for enabling institutional pre-conditions in order to embed R&D activities (Phillips and Yeung 2003). Accordingly, further research is recommended to understand and test more thoroughly the nature of the knowledge that is transferred in the cluster and the knowledge that drives innovations.

This was an exploratory study to benchmark the competitiveness of two IT clusters and explore the link between competitiveness and innovation performance. There is need to test the findings statistically in the future using a large sample of clusters. The developed operational framework allows for such testing. There may be criticism that the selected clusters are from different contextual backgrounds. An international study was conducted on purpose in order to incorporate differences in dimensions that are affected by national policies. For example, measures in talent attractiveness, R&D and innovation attractiveness, ownership attractiveness, and environmental attractiveness are determined to a higher extent by the national circumstances. Finland was selected because it is a forerunner in IT competitiveness index, and Turkey was selected because it is a developing country, which has ambitions in the sector. The size differences of the clusters were accounted for in the judgment of findings. Future research could benchmark IT clusters in the same country using the same theoretical framework and methodology. Another criticism may be that Sarıyer is a municipality of Istanbul, so there could be spillover effects between IT clusters in the city that are not taken into account in the study. Istanbul is a metropolitan city, which cannot be compared with Central Finland. Therefore, it was a deliberate decision to focus on a specific cluster in a municipality in order to eliminate the size differential. The relevance of spillover effects between IT clusters in Istanbul may be one potential area for further research.

Despite criticisms and some limitations in data collection, the emerald model is a useful framework to analyze knowledge potentials of clusters. The developed assessment scheme enables its operationalization, and benchmarking methodology offers insights for assessing strengths and weaknesses of clusters and identifying areas for improvement. In future research the framework can be applied to other IT clusters in the world or clusters from different industries in order to identify their competitiveness. Reproduction of similar studies would test the credibility of the framework in different contexts and contribute to its improvement.

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**Appendix 1. Interview questions**

Name of organization:
Type of organization:
Name of person:
Title of person:

1. How many key competitors do you have in the cluster? How tough is competition among you: could you grade from 1 to 5, 1 is not competitive at all, 5 is extremely competitive?
2. How would you grade the strength of your collaboration with suppliers, customers, research institutes, competitors, and governmental organizations in the cluster from 1 to 5? 1 is no collaboration at all, and 5 is very high level of collaboration.
   Suppliers:
   Customers:
   Research institutes:
   Competitors:
   Governmental organizations:
3. Do you collaborate with firms from other industries in the cluster? Which industries? How would you grade the strength of your collaboration with them from 1 to 5? 1 is no collaboration at all, and 5 is very high level of collaboration.
   Industry name 1:
   Industry name 2:
4. How often do employees change jobs in the cluster? Can you grade from 1 to 5: 1 means very rare, and 5 means very often.
5. What are key barriers to innovation in your cluster?
6. What are key enablers to innovation in your cluster?