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EDITOR'S NOTE **VOL 6, NO 3 (2016)**

Stevan Dedijer
1911-2004

What role does technology play for intelligence studies at the start of the 21st century?

All articles published in this issue show the role technology plays for intelligence studies in business. We see how patents can be used for competitive and business intelligence, how datamining and software can be used for geoeconomics, how it may measure the success of open source innovation in different cultures, how business intelligence software can be evaluated using fuzzy PROMETHEE and how software and the internet are used for economic and industrial espionage.

Singh writes on geoeconomics on a micro scale, the question about where a business should be located geographically to be economically viable. The author presents a new geospatial methodological approach using census data. ArcGIS software is used as a geospatial analytics tool for hotspot analysis and for producing maps.

Deshpande, Ahmed, and Khode's article entitled "Business intelligence evaluation model in enterprise systems using fuzzy PROMETHEE" presents a new model to evaluate business intelligence for enterprise systems.

The article by Capatina, Bleoju, Yamazaki and Nistor show how strategic intelligence solutions, once performed in a collaborative culture environment, will lead to the improvement of the partners' managerial competences and will act as enablers for competitive positioning, proving the added-value of the acquired know-how through open innovation practices.

The article by Maadi, Javidnia and Khatami shows how patents can be used as a source of information for competitive/business intelligence to highlight the technological trends in the field of energy efficient cooling of data centers. As such it is a good applied example for how patent analysis can be done in a specific industry.

The last article entitled "Economic and industrial espionage at the start of the 21st century – Status quaestionis" is by Solberg Søilen. It is an attempt to define where the field of economic and industrial espionage is today, more than ten years after the author wrote a dissertation on the subject.

As always, we would above all like to thank the authors for their contributions to this issue of JISIB. Thanks to Dr. Allison Perrigo for reviewing English grammar and helping with layout design for all articles and to the Swedish Research Council for continuous financial support.

On behalf of the Editorial Board,

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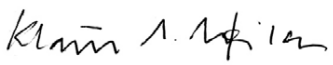

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Geospatial analysis of census data for targeting new businesses using geoeconomics

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ABSTRACT Geoeconomics plays a vital role in encouraging goods and services on new marketplaces. Selecting a "sweet-spot" for new businesses is one of the biggest challenges for new entrepreneurs, enterprises, and investors, especially in the restaurant industry. This paper aims to present a novel geospatial methodological approach for new businesses using census data to answer an important business question: Where I should start my new Asian cuisine restaurant? State and zip code tabulation area (ZCTA) level data on race and income, downloaded from the US census website, were applied for the analysis. ArcGIS software was used as a geospatial analytics tool for hotspot analysis and for producing maps. Based on the state level standard deviation map, California was found to have the second-highest relative Asian population as gauged by the standard deviation (Std. Dev.) from the mean (1.5-2.5 Std. Dev.), after Hawaii (>2.5 Std. Dev.), and followed by New Jersey, New York, Nevada, and Washington. The state of California was selected for further investigation. Seventeen of 58 counties were found to be Asian community hotspots in California. A majority (48%, 854 of 1763) of the ZCTA were found to be Asian community hotspots in these zip codes in this state, and this was statistically significant. Only 9% (163 of 1763) of the ZCTA were not statistically significant Asian community hotspots, while 43% of the ZCTA were found to be statistically significant coldspots of Asian communities in California. Among the 17 hotspot counties of Asian communities, 14 were also derived as hotspots of mean income. The road layer map revealed that these ZCTAs are well connected to major roads in the state. New entrepreneurs, enterprises, and investors, those who are willing to open and or invest in new restaurants, but are not sure about the location, could target hotspot ZCTAs in these counties for Asian cuisine. Integrating ArcGIS with census data for producing maps of statistically significant potential business locations could be used as an important decision-making tool for opening new businesses.

KEYWORDS Analytics, ArcGIS, Asian, business, California, census, geospatial, restaurants, ZCTA

1. INTRODUCTION

Geoeconomics is described as a theoretical and an applied science, and a methodical trend in socioeconomic geography, and can be applied in temporal, spatial, and political economic systems encouraging goods and services in new marketplaces (Alayev 1983, Anokhin and Lachininskii 2015). It is also considered to be a multidisciplinary science investigating economic activities and is defined as "the study of spatial, cultural, and strategic aspects of resources, with the aim of gaining a sustainable competitive advantage" (Søilen 2012). Since geoeconomics lies on a trifold of scientific domains, including sociology, geography, and economics, each component plays a vital role in promoting new economic activities at local and global levels (Renner

1942, Lachininskii 2013, Anokhin and Lachininskii 2015). Therefore, the geoeconomic space, which is a complex network transborder system, is vital in promoting new business activities (Gay 2012, Søilen 2012, Anokhin and Lachininskii 2015). Furthermore, the local economic groups may strongly influence the regional economic performance (Porter 2003). Besides, the economic, legal, political, infrastructure, ecological, technical, cultural, and social factors are vital macro-environments that help in business decision-making processes (Søilen 2012).

Selecting a "sweet-spot" for new businesses is one of the biggest challenges for new entrepreneurs, enterprises, and investors. In this study, a "sweet-spot" is defined as a geographic location where the likelihood of maximizing the benefits is the highest for a new business, considering the local environments. The location information plays a vital role in the establishment of new industries as it impacts the economic growth of the firms as well as the socioeconomic, environmental, and political status of the establishment area (Bhat et al. 2014, Demiriz and Ekizoğlu 2015, Mishra et al. 2015). The locational information could help in retail site selection (Karadeniz 2009), preventing retail banking fraud (Demiriz and Ekizoğlu 2015), financing commercial real estate acquisitions by real estate investment trusts (Conklin et al. 2016), fast-food industry (Austin et al. 2005) and much more. Moreover, the location could also impact the business-level innovation (Jordan 2015). The impact of taxes, subsidies and incentives, environmental regulations, quality of life and amenities, labor costs and availability, technical infrastructure, transportation, and accessibility have been reported as the most important factors in the assessment of finding potential locations for new businesses (Kimelberg and Williams 2013, Bhat et al. 2014). However, the socioeconomics and demographics of the potential customers are largely ignored in most of the studies. This could adversely impact a newly established business or firm. For example, in the restaurant industry, the theme, food quality, ambiance, aesthetics, the service, and economic shifts play a vital role in the success and the failure of the business (Murillo 2010, Kimelberg and Williams 2013). Nevertheless, selecting the wrong customer neighborhood, poor accessibility, and a less dense population in the surroundings may unfavorably impact the new establishments (Murillo 2010).

According to location theory, firms or enterprises tend to assess where and why economic activities happen so that they can maximize benefits (North 1955, Kimelberg and Williams 2013, Dubé et al. 2016). In this process, in most cases, non-spatial data, which are outcomes of small or large surveys, have been applied assessing the potential locations for establishing a new business (Kimelberg and Williams 2013). These surveys are very expensive and have inherent reliability challenges. Therefore, targeting a location for a new business based on the analysis of the survey data with a small sample size could be a big concern for entrepreneurs, investors, and enterprises.

The United States (US) census captures socioeconomics, demographics, and business information of the US population that could be used in business decision-making. However, this non-spatial data still lacks a geographical/spatial context. Spatial data have the advantage of showing patterns on maps and letting the users connect the dots, taking neighborhood geographies into consideration. Historically, presenting facts and figures on a map have played a vital role in both the political and the economic contexts (Søilen 2012). Geospatial analytics have emerged as an important method for the spatial and temporal analysis of data in various domains for informed decision-making (Prato et al. 1995, Boulos et al. 2011, Rey et al. 2015, Singh 2015, Singh and Vedwan 2015, Supak et al. 2015, Singh et al. 2016). However, in business, it is still in the rudimentary stages. The reason could be the lack of vision for integrating geospatial tools, such as Arc Geographical Information System (ArcGIS), in business decision-making. Similarly, the census data has been always available for public and private use, though it has not been integrated and/or used in business decision-making.

The main goal of this paper is to attempt to bridge the above-mentioned gaps and integrate US census data with ArcGIS to help new businesses answer an important business question: Where I should start my new Asian cuisine restaurant? There could be several business questions similar to this.

The state of California in the USA has been the center of economic growth with maximum wages and opportunities (Porter 2003). Because of the high rate of diverse immigration, the state became a hotspot for ethnic cuisine specially restaurants (Porter 2003, Capps 2007). The restaurant industry is

one of the fastest growing industries, and small to large business entities could be impacted if a poor site is chosen to start a business. The small business entities may not have enough resources to evaluate site selection. Therefore, the current approach, described in this paper, could be a cost-effective and more efficient way of selecting a site for new businesses within the restaurant industry. However, the approach could be adapted for any other industries.

2. MATERIALS AND METHODS

The state and the zip code level population data for Asian immigrants and household mean income in the zip code areas were used. State and zip code tabulation area (ZCTA) shapefiles were applied to perform geospatial analyses and to create maps.

2.1 Data collection

2.1.1 State and ZCTA level Asian population data

The state level race data was downloaded from the American Community Survey (ACS). A detailed description of the ACS and the data is found in the 2016 US Census (US-Census 2016). The ACS offers a total of nine different combinations of races at ZCTA level. For the current study, only HD01_VD05 (i.e. Asian alone) was selected. A detailed description on the ZCTA can be found at the US census site (US-Census 2016). In brief, the "ZCTAs are generalized areal representations of the United States Postal Service (USPS) ZIP Code service areas," however, the "USPS ZIP Codes are not areal features but a collection of mail delivery routes" (US-Census 2016).

2.1.2 ZCTA level income data

The ZCTA level mean income data was downloaded from the ACS. The ACS offers a total of 27 different combinations of mean income at ZCTA level. For the current study, only HC02_EST_VC02 (i.e. estimated mean income in dollars by all households) was selected (US-Census 2016).

2.1.3 State and ZCTA shapefiles

State and ZCTA shapefiles were downloaded from the US census website (US-Census 2014, 2015, 2016). These shapefiles were used to produce maps for geospatial analysis.

2.2 Data integration to ArcGIS, analysis, and mapping

The state and the ZCTA data were joined to the shapefiles within the ArcGIS environment using GEOID as a join key (ESRI 2012). ArcGIS is a mapping software, developed by

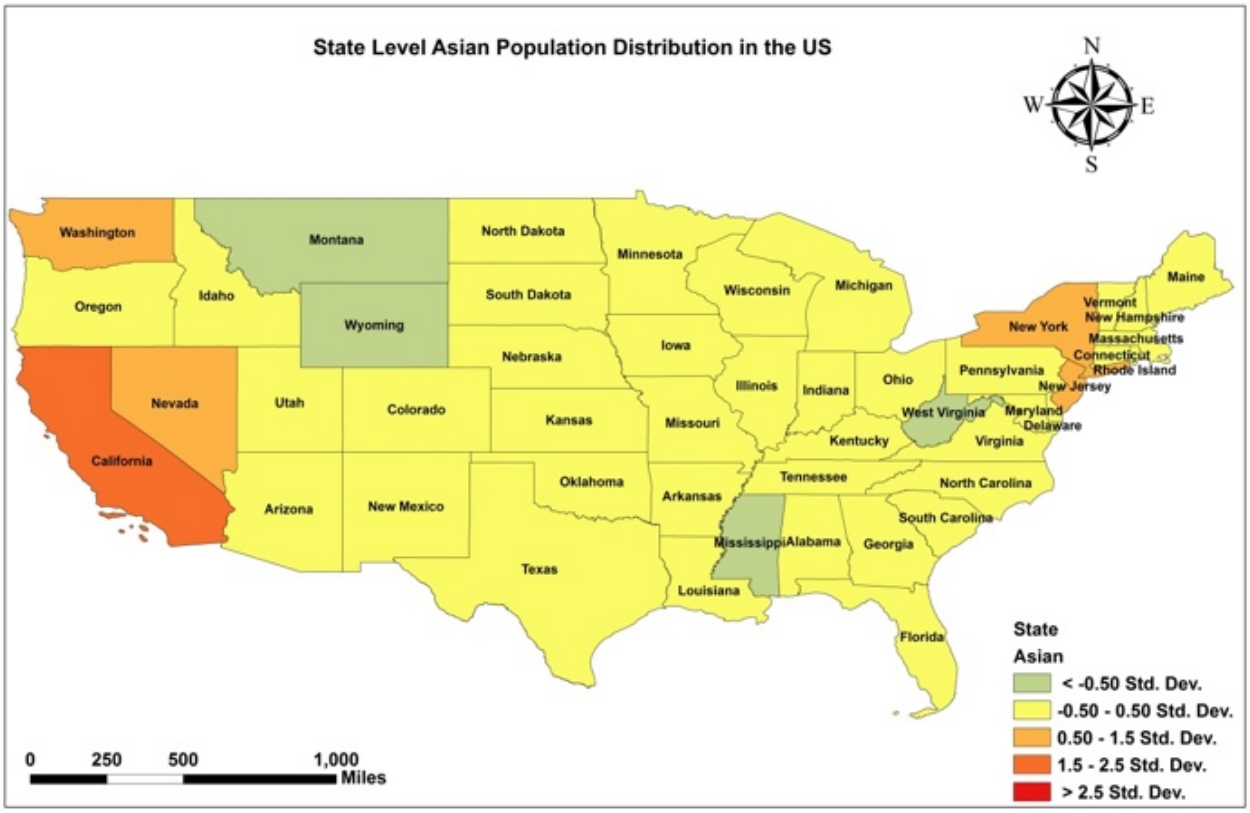

Figure 1 A standard deviation map of the Asian population in the United States.

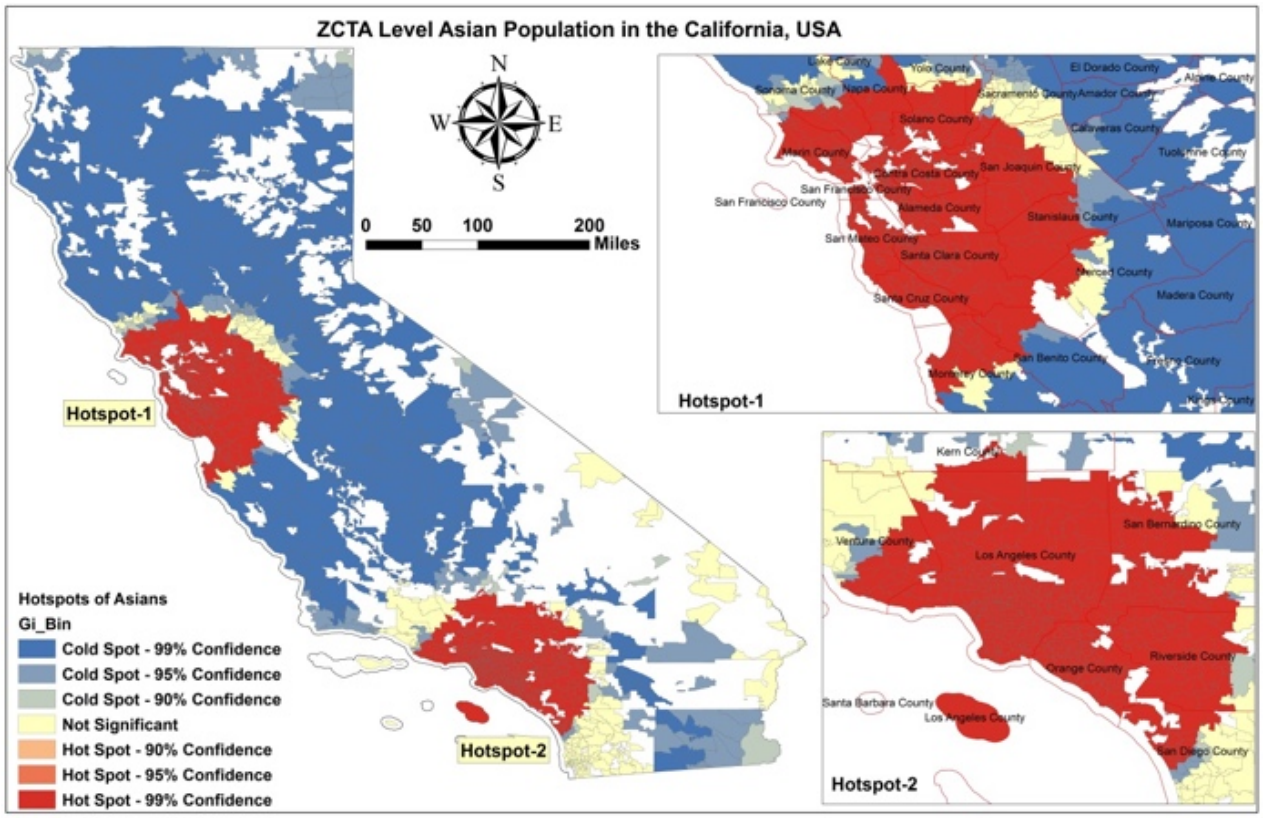

Figure 2 Hotspot and coldspot map of Asian communities in the Zip Code Tabulation Areas of California, United States.

the Environmental Systems Research Institute (ESRI), that offers several geospatial analytical tools (ESRI 2014). For all mapping and geospatial analyses, ArcGIS version 10.3.1 was used (ESRI 2014).

2.2.1 Standard deviation mapping

There are seven standard classification methods (manual, defined, equal, geometrical interval, quantile, natural breaks, and standard deviation) available in ArcGIS to spatially display numerical data on a map (ESRI 2012, 2014, 2016). The state level Asian population data, used in this study, is available in absolute numbers and in percentage. The standard deviation classification method was applied to produce a classification map of Asian populations at the state level. In this method, ArcMap derives the mean and standard deviation and produce maps displaying which feature polygons deviate (positively and negatively) from the mean (ESRI 2014, 2015). Based on the positive deviation and the highest standard deviation values, California was selected for further analysis.

2.2.2 Hotspot analysis

The hotspot analysis is one of the spatial statistical analysis tools in ArcMap that was applied for mapping spatial statistically significant clusters of high values (hotspots) and low values (coldspots) (ESRI 2014, 2016). The output feature class is in the form of a shapefile with a Giz-score, Gip-value, and Gi_Bin. The Giz-score and Gip-value measure the statistical significance and the Gi_Bin represents the confidence intervals at 90, 95, and 99% (ESRI 2014, 2016).

3. RESULTS AND DISCUSSION

3.1 State level distribution of Asian population in the US

The analysis revealed that the highest relative percentage (38%) of people identifying as Asian live in Hawaii, followed by 13% in California, 8.6% in Ney Jersey, 7.6% in New York, 7.4% in Nevada, and 7.3% in Washington. Although Hawaii has the highest relative Asian population, California was used for this case study because of the availability of other relevant data and the interest of new entrepreneurs, enterprises, and investors in California (Figure 1).

Later, the focus for further investigation was California and all the ZCTAs in the state.

3.2 ZCTA level distribution of Asian populations in the US

The ZCTA is the smallest census unit and may offer more specific information on the

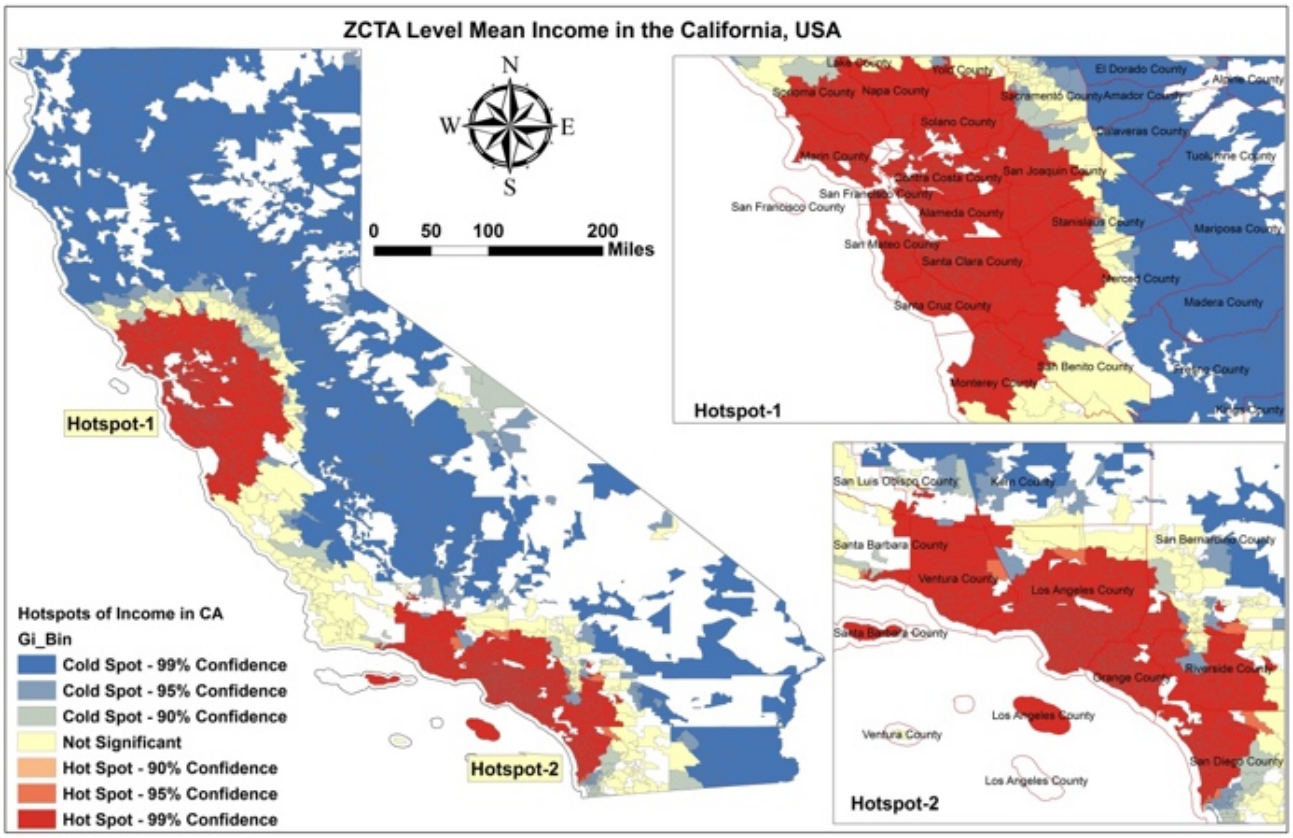

Figure 3 Hotspot and coldspot map of mean income in the Zip Code Tabulation Area of California, United States.

socioeconomics, demographics, and businesses of those who live within the ZCTA boundaries. The hotspot analysis of Asian communities clearly indicated two hotspots in California (Figure 2).

There are 1763 ZCTAs in California. The ZCTA level hotspot analysis of the Asian population revealed that a majority (48%, 854 of 1763) of the ZCTAs were found to be statistically significant Asian community hotspots (Figure 2). Only 9% (163 of 1763) of the ZCTAs were not statistically significant hotspots of Asian communities, while 43% of the ZCTAs were found to be statistically significant coldspots of Asian communities in California (Figure 2). This further explains that 854 ZCTAs are densely populated with Asian communities and could be potential locations for opening new Asian cuisine restaurants.

California has 58 counties (Figure 2), of which 17 counties are hotspots of Asian communities. Contra Costa, Los Angeles, Marin, Orange, San Francisco, San Mateo, Santa Clara, and Santa Cruz counties were found to be hotspots of Asian communities. However, Merced, Monterey, Riverside, San Bemardino, San Diego, San Joaquin, Solano, Stanislaus, and Ventura counties were partially categorized as hotspots of Asian communities in California (Figure 2).

3.3 ZCTA level distribution of mean income in California, US

The mean income in California ZCTAs ranges between $9,471 and $413,643. Furthermore, the hotspot analysis of ZCTA level mean income revealed that a majority (51% 894 of 1763) of the ZCTAs were found to be hotspots of mean income, and this was statistically significant (Figure 3) in the state.

Thirty-nine percent (746 of 1763) of the ZCTAs were found to be statistically significant coldspots relative to the mean income, while 10% (170 of 1763) of the ZCTAs were statistically not significant hotspots relative to the mean income in the California.

The hotspots of mean income cover a total of 20 counties (Figure 3). Marin, San Francisco, San Mateo, Santa Clara, Santa Cruz, Napa, Solano, Contra Costa, Ventura, Los Angeles, and Orange counties were found to be hotspots of mean income in the ZCTAs in the state. On the other hand, the areas of Sonoma, Monterey, Lake, Yolo, San Joaquin, Stanislaus, Santa Barbara, Riverside, and San Diego were partially indicated as hotspots of mean income in the ZCTAs in the state. The common

counties with the hotspots of Asian communities and mean income were derived (Table 1).

Table 1 Hotspot counties and the coverage of Asian population and mean income in California, United States. *NHS = not a hotspot.

Sl. No	Asian population Hotspots	Coverage of the county	
		Asian	Mean Income
1	Contra Costa County	Entire	Entire
2	Los Angeles County	Entire	Entire
3	Marin County	Entire	Entire
4	Merced County	Partial	NHS*
5	Monterey County	Partial	Partial
6	Orange County	Entire	Entire
7	Riverside County	Partial	Partial
8	San Bemardino County	Partial	NHS*
9	San Diego County	Partial	Partial
10	San Francisco County	Entire	Entire
11	San Joaquin County	Partial	Partial
12	San Mateo County	Entire	Entire
13	Santa Clara County	Entire	Entire
14	Santa Cruz County	Entire	Entire
15	Solano County	Partial	Entire
16	Stanislaus County	Partial	NHS*
17	Ventura County	Partial	Entire

Out of 17 counties with hotspots of Asian communities (Figure 2), 14 counties were either fully or partially identified as the hotspots of mean income (Table 1, Figure 2 and 3) in California. Only three hotspot counties with Asian communities, including Merced, San Bemardino, and Stanislaus were not hotspots of mean income (Table 1). Therefore, the above 14 counties could be targeted for new business establishments of Asian cuisine restaurants (Table 1).

3.4 Hotspot ZCTAs with roads, availability in California, US

As discussed in the introduction, the accessibility to the facilities plays an important role in the success of a newly established business. Therefore, the hotspot map of the Asian population was overlaid with a road layer to see whether the hotspot ZCTAs are close enough to roads and accessibility is not a constraint (Figure 4).

Both of the hotspots were found to have a good network of roads (Figure 4). Consequently, the 14 listed counties (Table 1) meet three major criteria for opening an Asian cuisine restaurant in California: high Asian population, higher mean income, and greater road network.

4. CONCLUSIONS

Geoeconomics can be examined at the lowest, low, middle, upper, and top geographical levels (Anokhin and Lachininskii 2015). In this study, the lowest geographic unit, the ZCTA, was used to show how social, economic, and geographic components could potentially impact new businesses. Additionally, ArcGIS offers several tools for geospatial analysis and could be used as decision-making tool for informed business management within geoeconomics. Moreover, census data offer various significant insights for the establishments of new businesses as well as for the existing businesses. Integrating ArcGIS with census data could help businesses accomplish their goals, starting from locating new sites to predicting their business growth. The socioeconomic and demographic data are freely available at the ZCTA level. These could be applied for informed business decision-making through geospatial analytics using ArcGIS. In this study, only race, mean income, and road network data were used for the analysis. However, the US census offers several other important attributes such as gender, age, occupation, and household, housing, and business data, and much more. These attributes could be applied in the selection of new business sites and/or for other business needs. The current geospatial approach described in this paper is a cost-effective, easy, and efficient way of selecting

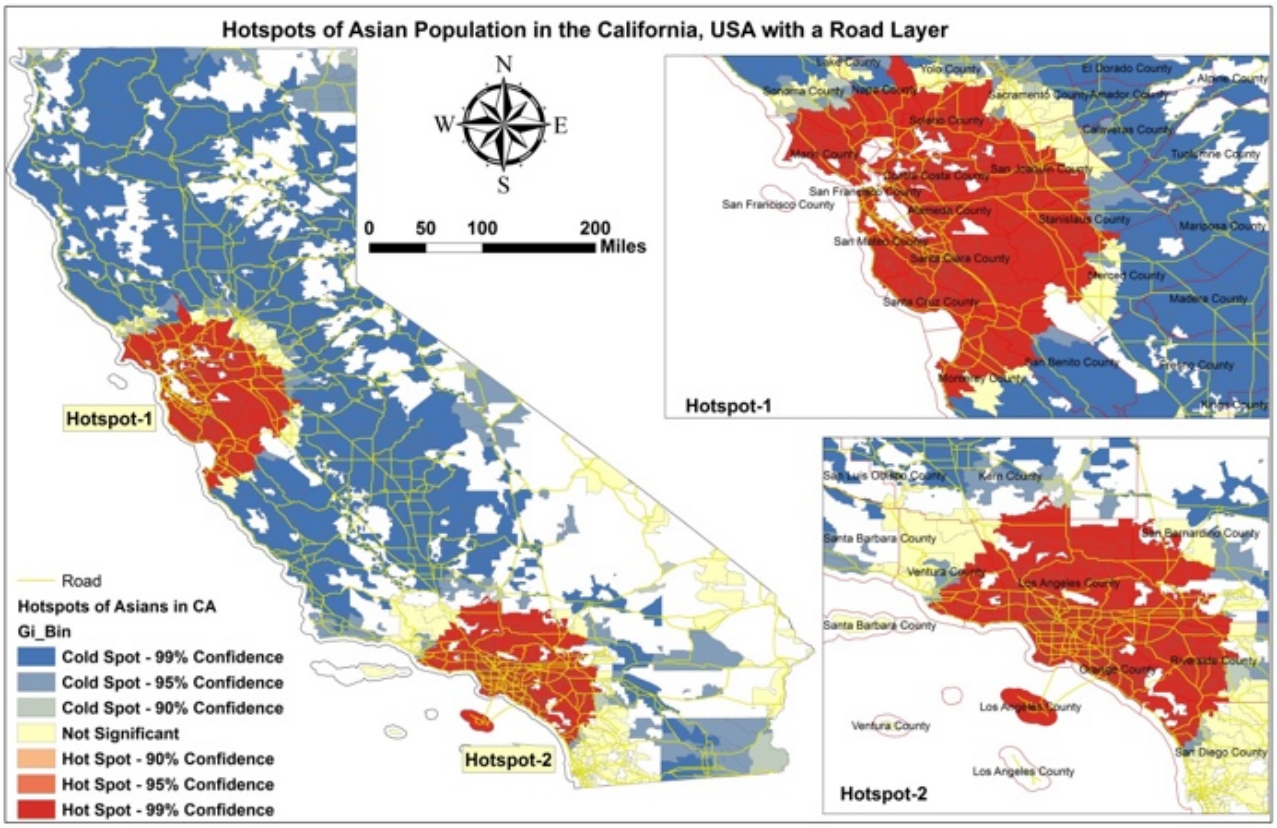

Figure 4 Hotspot and coldspot map of the Asian population overlaid with a road layer in the Zip Code Tabulation Areas of California, United States.

new business sites and could be used by small as well as large business entities within and outside the restaurant industry.

Acknowledgements

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Business intelligence through patinformatics: A study of energy efficient data centres using patent data

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ABSTRACT The advent of cloud computing has nurtured an unprecedented growth of data centres. With its growth, the main concern for service providers and data centre owners is to efficiently manage the energy of the data centres without compromising their computing capabilities. This concern is genuine as data centres utilise 10-30 times more energy than office spaces and also generate immense heat. As cooling accounts for half of the total power consumption in data centres, efficient cooling systems have become a vital need for data centres. This has resulted in increased research and innovation in the field of efficient cooling of data centres, which in turn has led to growth in filing of patents in this domain. Patents are techno-legal documents that contain different kinds of information that is accessible to all. In the present study, patents are used as source of information for competitive/business intelligence to highlight the technological trends in the field of energy efficient cooling of data centres. The study reveals that IBM, HP, Schneider and Hon Hai Industries are the major players working in this technological area. Contrary to the notion that air conditioning would be the most researched area for cooling data centres, the study reveals that there is also interest in the hardware of the servers and racks to produce less heat or to have built-in cooling mechanisms. The main technologies for which patents are being filed include ventilation using gaseous coolant, technologies related to rack design as well as liquid cooling. Original equipment manufacturers and other vendors have increased filings, along with cloud service providers. Most of these technologies originate from Asia-Pacific and this region is a strong market, following the USA.

KEYWORDS Cooling, data centres, energy efficiency, green data centres, patents, patinformatics

1. INTRODUCTION

To survive in the dynamic business environment, it is imperative for organisations to have relevant and timely business information for decision making. This has lead to the emergence of business intelligence as a vital decision support system. Business intelligence is a tool that helps organisations to refine business related information for making effective business decisions (Ghoshal and Kim, 1986). Business intelligence provides information that can be used for actionable assessments in a timely manner. By means of discovery, analysis and querying, business intelligence provides the ability to reason and understand the meaning behind business information (Azoff and Charlesworth, 2004). Business intelligence is also referred to as competitive intelligence, market Intelligence, customer intelligence, competitor intelligence, strategic intelligence or technical intelligence (Lönnqvist and Pirttimäki, 2006). Business intelligence or competitive intelligence is considered to be an interdisciplinary field

(Walker, 1994). According to Solberg-Søilen (2010) competitive intelligence is a subset of marketing management. However, studies also suggest that competitive intelligence is associated with strategic management and knowledge management (Gabriel and Adiele, 2012; Calof and Viviers 2001). Kahaner (1998) defines competitive intelligence as the process of "gathering and analysing information about your competitors' activities and general business trends to further your own company's goals". Toit (2015) observed that successful enterprises have a formal competitive intelligence functioning unit, which may follow a competitive intelligence cycle consisting of the following activities (Viviers et al., 2005):

- Planning for the collection of information;
- Collecting information from relevant sources;
- Analysing information using analytical tools; and
- Preparing reports for management

In addition to publicly available financial statements for gathering competitive information (Ditter et al, 2011), studies suggest that patent data is also a valuable source of competitive intelligence from which to derive a strategic advantage (Rouach and Santi, 2001; Dou et al., 2005; Grandjean et al., 2005; Shih et al., 2010). In the present study, patents are used as a source of information for competitive/business intelligence and highlight the technological trends in the field of energy efficient cooling of data centres.

Traditionally, the development of computing systems has been focused on performance improvement, which was driven by a demand for applications from consumer, scientific and business domains (Beloglazov et al., 2011). This resulted in rapid growth in the demand for computational power and this in turn led to the creation of large-scale data centres (Beloglazov and Buyya, 2010). Moreover, due to the advent of cloud computing environments, data centres have experienced unprecedented growth in their size and population (Judge, 2015; Jones Lang LaSalle, 2016). These densely populated data centres dissipate heat and needs large cooling units to keep temperatures within the functional levels, thereby increasing the demand for power (Suja et al., 2012).

Data centres use nearly 10-30 times more energy per square foot than office spaces (Caldow, 2008). Like energy costs, the energy used in data centres is also increasing two-fold every five years (Uddin and Rahman, 2010). If we assume that data centre energy costs continue to double every five years, they will increase by 1,600 percent between 2005 and 2025 (Emma, 2008).

The ever-increasing energy consumption of data centres has started to limit their growth due to overwhelming electricity bills and large-scale carbon dioxide (CO_2) emissions (Beloglazov et al., 2011). Cooling accounts for half of the total power consumption in data centres (Brown, 2008). Therefore, the focus of recent data centre technologies and computer system designs has shifted to power and energy efficient cooling systems for data centres without compromising computing capabilities (Daim et al., 2009)

Patent data available from the patent offices of different nations are a huge resource of techno-legal information. If this patent data is properly analysed, it can provide various business intelligence insights focusing on technological trends and their patent filings, the newly emerging technologies and products in a particular domain and also competitors' intellectual property strategies (Deshpande et al., 2014; Ahmed et al., 2013).

Of the various approaches used in data centre cooling, the technologies using cold aisle containment pod deployment are expected to become the future standard in data centre design (Hawkin, 2015). This is also reflected in the patent data available, revealing that patents relating to aisle cooling technology have been already granted or filed. Table 1 lists examples of a few related patents and applications in this field.

Table 1 List of a sample of patent numbers and their assignees for aisle based cooling systems.

Assignee	*Patent Number*	*Asssignee (cont)*	*Patent Number*
Facebook	US9144181	HP	US8984906
Amazon	US9152191	Hon Hai	US8405977
Bripco	US20150305208	Schneider	EP1882402
IBM	US9072196		

2. METHODOLOGY

The Thomson Innovation Database (www.thomsoninnovation.com) was used for extracting the data. The text mining and visualization tool VantagePoint (www.thevantagepoint.com) was used to clean,

normalise and analyse the patent data. The methodology involved the two major steps outlined below.

2.1 Information gathering

In order to find patents and applications in the data centre cooling field, a search strategy was prepared and a search was executed on the commercially available database, Thomson Innovation. Patents published through November 15th 2016 were considered in the study. The search strategy consisted of a combination of keywords and International Patent Classification (IPC; WIPO, 2016) and Cooperative Patent Classification (CPC; European Patent Office, 2016) classification codes relevant to the topic, as they are considered to be a proxy technology indicator based on hierarchical assignment and the categories to which every patent may belong (Pulate et al., 2015).

The keywords used for the search were datacenter, data center, server room, datacentre, and data centre and were combined with the terms cool* and ventilat*.

The following IPC and CPC codes specific to cooling in data centres listed in Table 2 were used in the search in combination with the keywords.

Table 2 International Patent Classification (IPC) and Cooperative Patent Classification (CPC) codes and their descriptions.

IPC / CPC Code	*Description*
H05K00071485	Mounting supporting structure in casing or on frame or rack used/placed in servers; data centre rooms
H05K000720	Modifications to facilitate cooling, ventilating, or heating.

The keywords were searched in the title, abstract and claims. The actual search query that was executed in Thomson Innovation was: CTB=(datacenter OR data ADJ center OR server ADJ room OR datacentre OR data ADJ centre) AND (cool* OR ventilat*)) OR AIC=(H05K00071485 AND H05K000720) AND DP>=(18000101).

This search strategy resulted in 7640 hits. Patents are territorial in nature so the same invention may be duplicated by way of multiple filings in different countries, known as patent families (European Patent Office, 2016). To reduce this form of duplication, one representative for each patent family was retained to obtain a dataset of 3036 records. The bibliographic details such as the title, abstract, priority date, assignee name, inventor names, and INPADOC family members were collected and stored in a spreadsheet for further processing and analysis.

2.2 Data cleaning

While looking for competitive Intelligence, there was a need to take into consideration variations in the spellings of names, typographical errors, corporate hierarchies and mergers or acquisitions of various organizations. Thus data was normalized for assignee names by replacing name variants with a standard name. For example, there were many different companies such as Consolidation Coal Co, Entek Corp and Du Pont Iberica SL all listed under Du Pont (E.I.) de Nemours & Co. Assignee normalization replaced all these variants with Du Pont (E.I.) de Nemours & Co. Assignee normalization was also carried out using the assignee clean up feature tool VantagePoint. Similarly, the inventor list was also cleaned using the VantagePoint inventor clean-up list tool.

3. ANALYSIS AND VISUALISATION

3.1 Patenting activity in the field of energy efficient cooling of data centres

Patenting activity related to energy efficient cooling of data centres and server rooms can be seen from 1995. This patenting activity, however, gained momentum from the year 2008 and has been on the rise since 2010. This can be seen from the overall patenting activity graph shown in Figure 1.

From Figure 1, it can be seen that less activity was performed in the domain of energy efficient cooling of data centres before 2010.

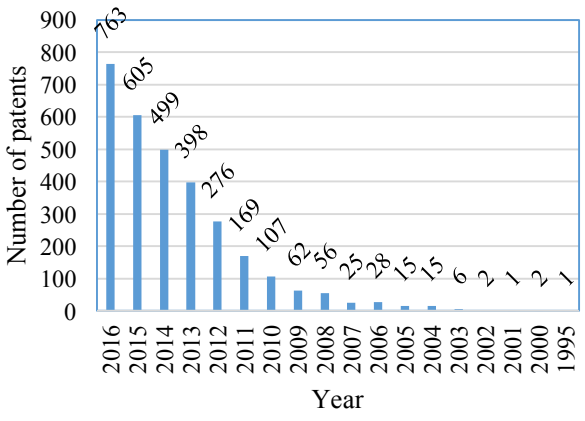


Figure 1 Patenting activity in energy efficient data centre cooling from 1995-2016.

The cloud environment came into dominance from 2008 (Columbus, 2015), and there was a need for energy efficient cooling of data centres, thereby leading to more R&D output in this field from 2008 onwards. As is evident from Figure 1, there is a seven-fold increase in patent filings from year 2010 to year 2016.

3.2 Top assignees in the area of energy efficient cooling of data centres:

IT Companies like IBM, HP, Amazon, Google, Amazon, Yahoo Dell, Microsoft and Oracle, which are active in cloud computing and data centre services are amongst the major assignees in the patenting area of efficient cooling of data centres, as is evident from Figure 2. While Amazon Web Services (AWS) is the leader in the public cloud computing space, companies like IBM, HP, Microsoft, Dell, Oracle, Baidu and Google are the obvious players in this domain as IBM, Dell, Oracle and HP are traditionally involved in hardware related products and services while Google has its own data centres across the globe (Kepes, 2015; Weinberge, 2015) and Baidu has its presence in China and is slowly moving to a global position. Hence these companies are interested in improving and protecting technologies that are energy efficient.

Companies such as Schneider Corp. and Hon Hai Precision Industry Co. Ltd. are amongst the leaders in the patent assignee group, even though they do not have data centres of their own. For example, Hon Hai is an electronics contract manufacturing company also known as Foxconn Technology Group and Hongfujin Precision Industry Co., a subsidiary of Foxconn. Its clients include major American, European, Japanese, and Canadian electronics and information technology companies, which might be the reason behind their interest in the energy efficient cooling data centres' patent portfolio. On the other hand, Schneider Electric develops technologies and solutions to make energy safe, reliable, efficient, productive and green. NEC Corporation is a Japanese multinational provider of information technology (IT) services and products involving innovative technology development to enable data centres to reduce air conditioning power consumption. Hence it can be said that the consumers of data centres as well as the suppliers for data centres are both actively pursuing research in the field of energy efficient data centres. What is striking in this data is the presence of Xi'an Polytechnic University, the only academic institution amongst the top twenty patent filing applicants for energy efficient cooling of data centres.

While normalizing the data, Emerson and Liebert were merged together. Motorola Mobility was merged with Google. Further, the same was applied for merging Sun and Oracle, VMWare, EMC and Dell.

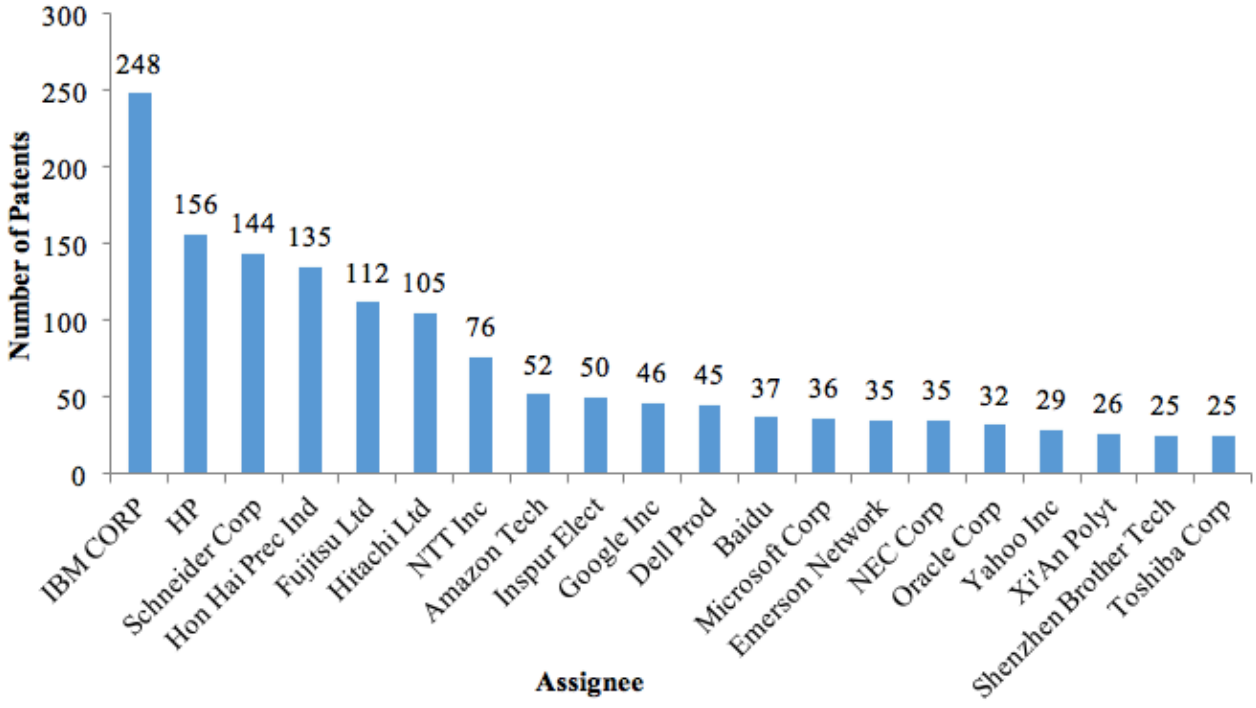
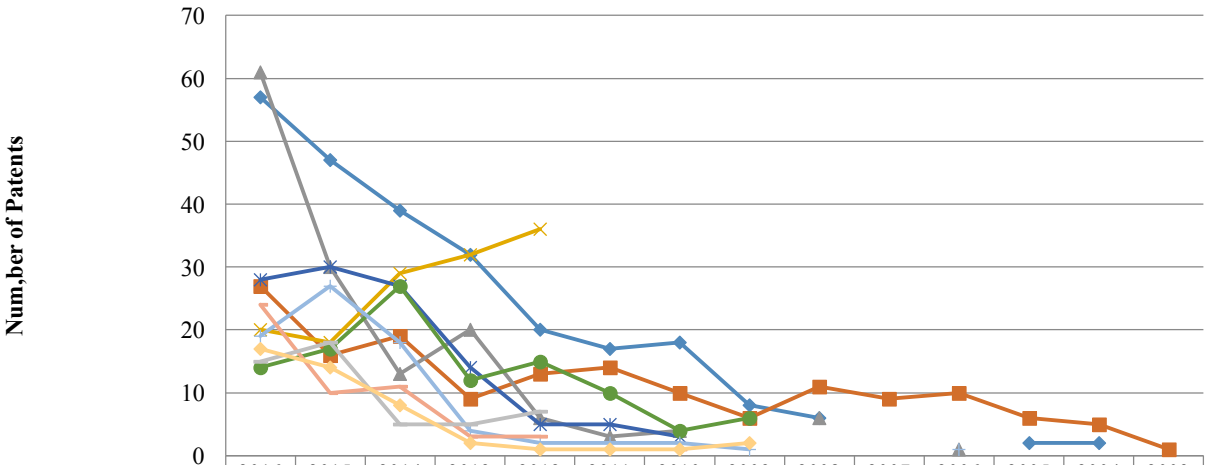


Figure 2 Top patent assignees in energy efficient data centre cooling, listed by company.



	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
IBM Corp	57	47	39	32	20	17	18	8	6			2	2	
HP	27	16	19	9	13	14	10	6	11	9	10	6	5	1
Schneider Corp	61	30	13	20	6	3	4		6		1			
Hon Hai Prec	20	18	29	32	36									
Fujitsu Ltd	28	30	27	14	5	5	3							
Hitachi Ltd	14	17	27	12	15	10	4	6						
NTT INC	19	27	18	4	2	2	2	1			1			
Amazon Tech	24	10	11	3	3		1							
Inspur Elect	15	18	5	5	7									
Google Inc	17	14	8	2	1	1	1	2						

Figure 3 Yearwise assignee trends

3.3 Top assignee for each year

Year by year technology advancement based on patent filings by individual companies reveals that HP was in the field from the beginning. They were followed by IBM. Figure 3 shows that product based companies such as Hon Hai Precision Industry, Schneider and Fujitsu have increased their filings at a constant rate since 2012, while cloud based service providers such as Google and Amazon entered the field later and have only been active during the last five years. Surprisingly, Inspur Electricals started filing many patents in the domain of energy efficient cooling of data centres only in the last 2 years. Inspur is a Chinese multinational information technology company focusing in server hardware and also acts as a software developer providing outsourcing for USA and Japan.

3.4 Origin of invention

The origin of inventions can be found using patent data. The priority filing country shown in the patent document is considered to be an

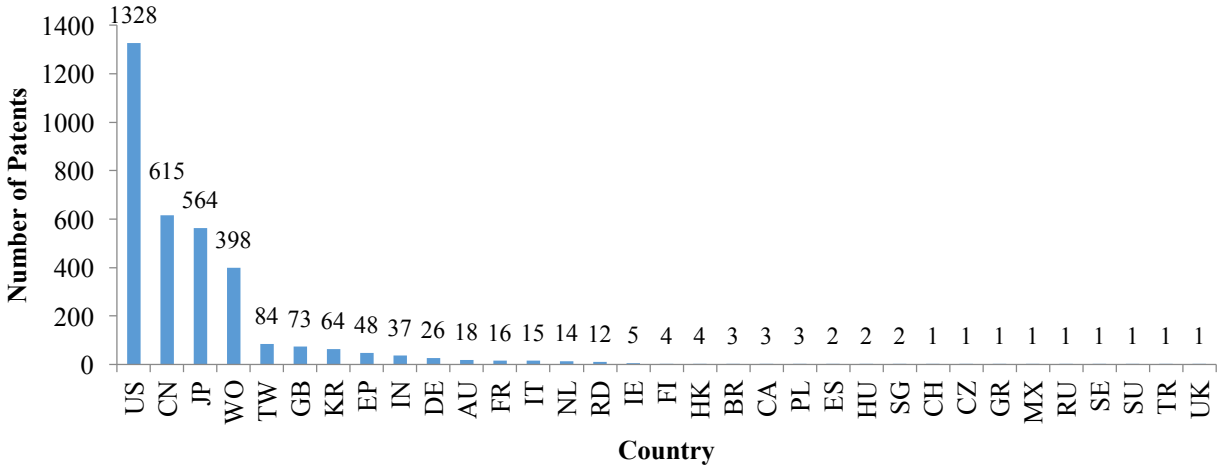


Figure 4 Origin of inventions by country

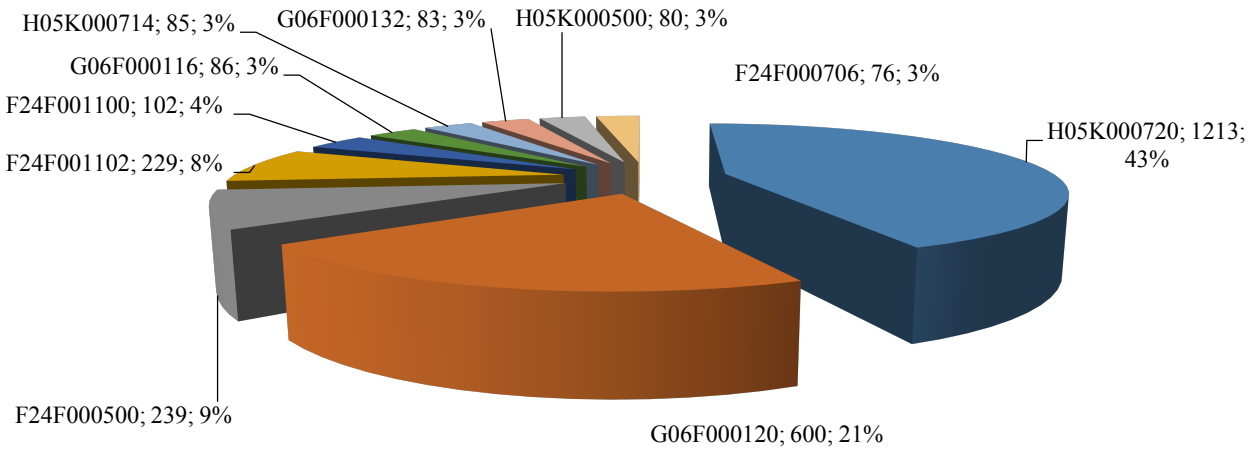


Figure 5 Distribution of top ten IPCs

indicator for the origin of a particular invention (UK Intellectual Property Office, 2014) as companies normally prefer to first file for a patent in the same country in which it is invented (Figure 4).

It can be seen from Figure 4 that the USA is leading with the most patents relating to energy efficient cooling for data centres, followed by China and Japan. However, it is interesting to see that countries from the Asian continent, and Asia Pacific in general, are ahead in the innovation of efficient cooling of data centres, as almost 50% of the technology patents originate from this region. China leads Asia, followed by Japan and Taiwan. European companies also have a presence but are minor when compared to the US and Asia.

3.5 Technological Trends

Figure 5 depicts the top 10 international patent code (IPC) classes revealed from an analysis based on the IPCs assigned to patents and applications related to energy efficient cooling in data centres. It is observed that most of the inventions are focused on the construction detail or modifications related to cooling, ventilating or heating. About 60 % of the patents are related to cooling through ventilation whereas 30 % of the patents focus on constructional aspects for facilitating the cooling of data centres. A short description of the top 10 IPC classes is given in Table 3.

Figure 6 highlights the year-wise IPC trends. It shows that patents with code H05K7/20 (indicating modifications to facilitate cooling, ventilating, or heating) are the most sought after and researched technology, having a huge surge in the last couple of years. The IPC G06F1/20 (indicating constructional details or arrangements for cooling means) also shows a higher growth in the last couple of years compared to other technologies. Figure 6 also shows that companies are not only focusing on the basic research in cooling but also giving priority to the constructional changes and modifications that enable efficient cooling of data centres.

Table 3 IPC classes and their descriptions

IPC design.	Description
H05K000720	Modifications to facilitate cooling, ventilating, or heating.
G06F000120	Constructional details or arrangements for cooling means.
F24F000500	Air conditioning systems
F24F001102	Arrangements or mounting of control or safety devices related to air conditioning or air humidification or ventilation
F24F001100	Control or safety systems or apparatuses for air conditioning or air humidification or ventilation
G06F000116	Constructional details or arrangements of data processing equipment
H05K000714	Constructional details related to mounting supporting structures in casing or on frames or racks
G06F000132	Power saving means
H05K000500	Casings cabinets or drawers for electric apparatuses
F24F000706	Ventilation with ducting systems using forced air circulation

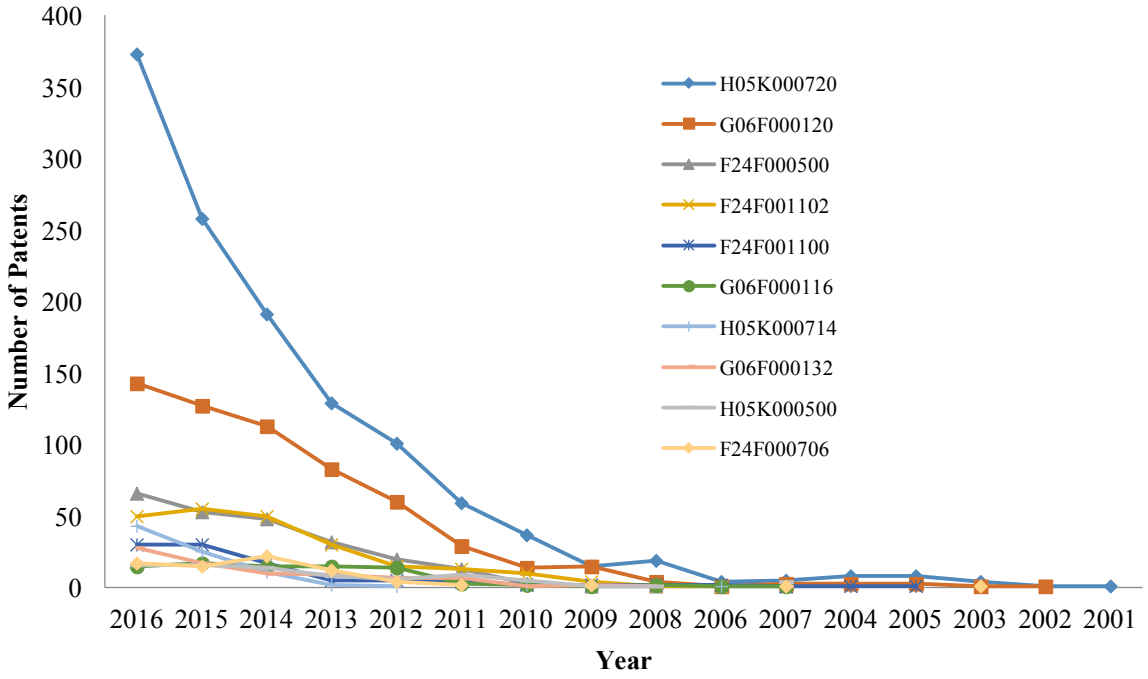


Figure 6 Yearwise IPC trends

Figure 7 highlights the distribution of core technologies derived from the patent analysis. The figure shows that approaches focusing on thermal management and gaseous cooling are the preferred approaches for energy efficient cooling of data centres.

A further analysis of patents reveals that the above mentioned technologies existed for more than a decade, with a surge in technological advancements after 2010, except for approaches focusing on resource allocation (Figure 8). Figure 9 illustrates in-depth technology breakup. It is observed that technologies using forced ventilation with gaseous coolants and thermal management of racks are gradually on the rise when compared with other technologies.

Figure 10 illustrates the top assignees for the top 10 CPCs available in the area of

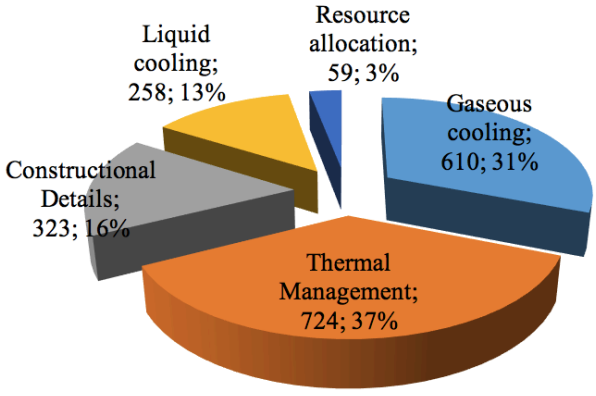


Figure 7 Distribution of core technology

efficient cooling of data centres. The data reveals that there are about 251 patents in CPC H05K000720836, which is related to thermal management for server racks or cabinets. IBM is leading in patents in this technology, followed by HP and Fujitsu. These three companies deal with server and rack products. CPC class H05K0007200745 deals with forced ventilation using gaseous coolant within rooms for removing heat from cabinets. IBM again leads in this technology, followed by Hon Hai Precision and HP. IBM leads with most patents in the CPC H05K00072079, which is related to thermal management for server racks or cabinets and liquid cooling within rooms for removing heat from cabinets. It is important to note IBM has about 38 patents in the technological area of liquid cooling within rooms, whereas Hon Hai, with the second most patents in this field, has only 9. Hon Hai is very active in the CPC H05K00071497, which deals with the construction of mounting structures in data centre rooms, and they have half of all the patents, while Amazon and Google follow with 7 and 5 patents in this area, respectivly. The data also reveal that IBM leads in the CPC class H05K000720781, with about 75% of all the patents available in this field that deals with liquid cooling within cabinets for removing heat from server blades. This is logical, as IBM is involved in the sale of blade servers. What is surprising is that the patents

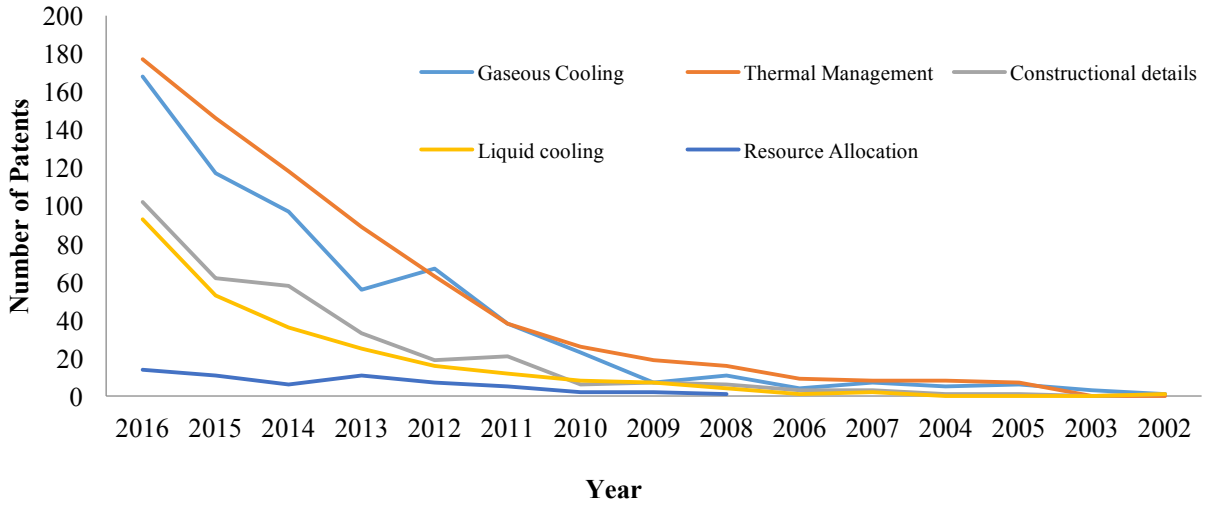


Figure 8 Yearwise core technology trends

for this CPC class are very low for HP even though they are leaders in the supply of blade servers (Gartner, 2016; International Data Corporation, 2016). This same is again true for CPC class H05K000720736, which deas with gaseous cooling within cabinets for removing heat from server blades, where IBM has one third of all patents and HP's presence is low.

Figure 11 displays the similarity between technologies used by the top 10 assignees in the field of energy efficient cooling of data centres. It is observed that companies such as Inspur and NTT are patenting in technologies that are different from other players based on CPC codes. On the other hand, companies such as HP, Schneider, and Fujitsu are working in similar technological areas.

As patents rights are territorial in nature, they need to be protected in various jurisdictions. As such, inventions remain the same but are protected in different regions are called "patent family members". Further, the

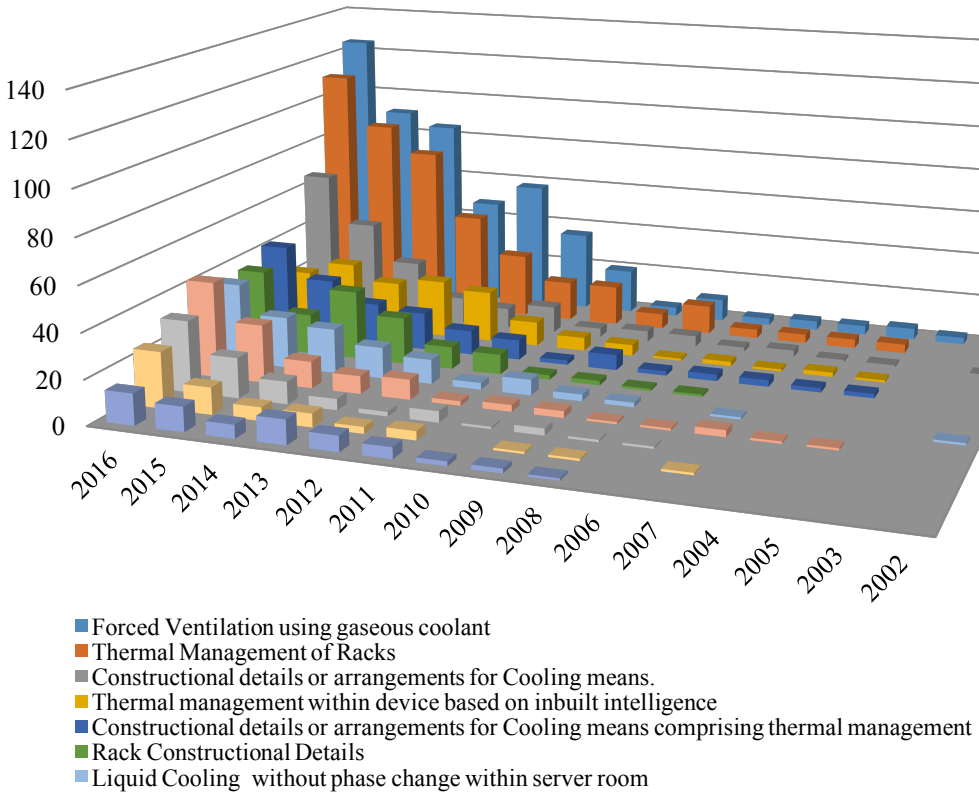
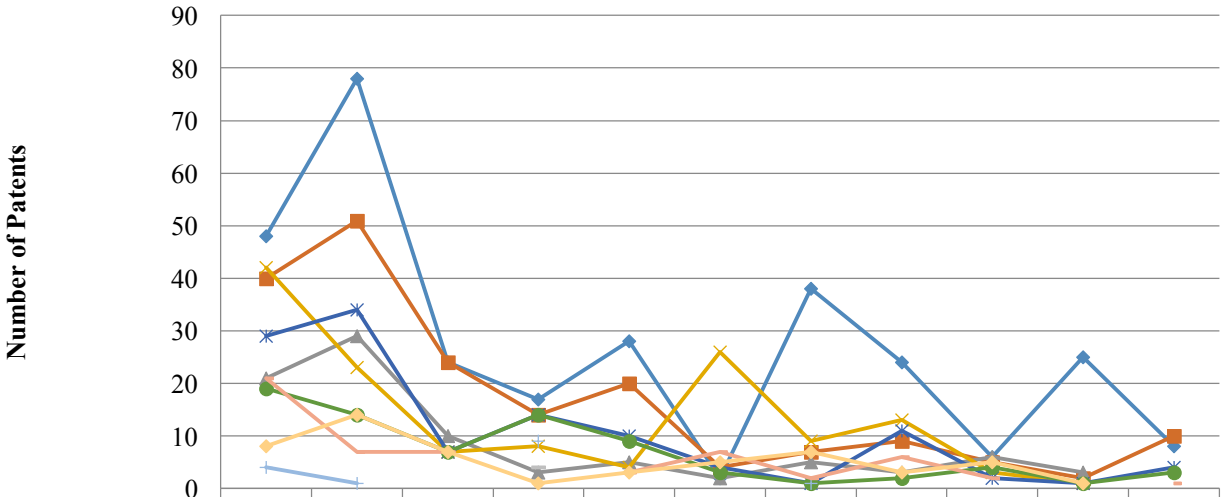


Figure 9 Yearwise technology breakup



	H05K00 0720745	H05K00 0720836	G06F00 0120	Y02B00 601275	G06F00 01206	H05K00 071497	H05K00 072079	H05K00 0720736	H05K00 0720827	H05K00 0720781	Y02B00 60142
IBM Corp	48	78	24	17	28	2	38	24	6	25	8
HP	40	51	24	14	20	4	7	9	5	2	10
Schneider Elec	21	29	10	3	5	2	5	3	6	3	
Hon Hai Prec	42	23	7	8	4	26	9	13	3	1	
Fujitsu Ltd	29	34	7	14	10	4	1	11	2	1	4
Hitachi Ltd	19	14	7	14	9	3	1	2	4	1	3
NTT Inc	4	1		9			1				
Amazon Tech	21	7	7		3	7	2	6	2		1
Inspur Elect				4							
Google Inc	8	14	7	1	3	5	7	3	5	1	

Figure 10 Top assignee-wise CPC distribution

protection is generally sought in countries where markets exist. Figure 12 illustrates the top 10 markets for energy efficient cooling of data centres represented by family patent filing coverage. USA seems to be the major market. However, more than one third of the market is concentrated in Asia Pacific, which includes China, Japan, Korea and Taiwan.

Figure 13 illustrates the market focus of the top 10 assignees based on family patent filings because companies file patents only in the regions where there is a potential market for such technologies. IBM and HP consider the USA to be their major market, while Schnider has its presence in Europe and China along with the USA. Hon Hai has filed patents in the USA, Taiwan and China indicating these to be their markets. Fujitsu, Hitachi and NTT have more patents in Japan. However, Inspur has filed patents only in China indicating it is focussing only on the national level for its products. Further analysis of this data reveals that about 40% of the technology market lies in Asia. This is contrary to the belief that the USA is the major market for data centres. This is also illustrated in Figure 14.

Figure 14 shows that 13 percent of patents for efficient cooling of data centres are filed through the Patent Cooperation Treaty (PCT, WIPO). The PCT assists applicants in seeking patent protection internationally for their inventions, helps patent offices with their patent granting decisions, and facilitates public access to a wealth of technical information relating to those inventions.

Figure 15 illustrates the patent filings for energy efficient cooling of data centres in Europe. It is observed that more than 60 percent of the filings in this region are through the European Patent Office, which offers inventors a uniform application procedure that enables them to seek patent protection in up to 40 European countries.

4. CONCLUSIONS

The growth of data centres, and their consumption of power along with the heat generated from them has led to a call for energy efficient cooling technologies for data centres. Using patent data as a business intelligence indicator to highlight the technological advancements and trends in this domain found that cooling in data centres is not limited to air

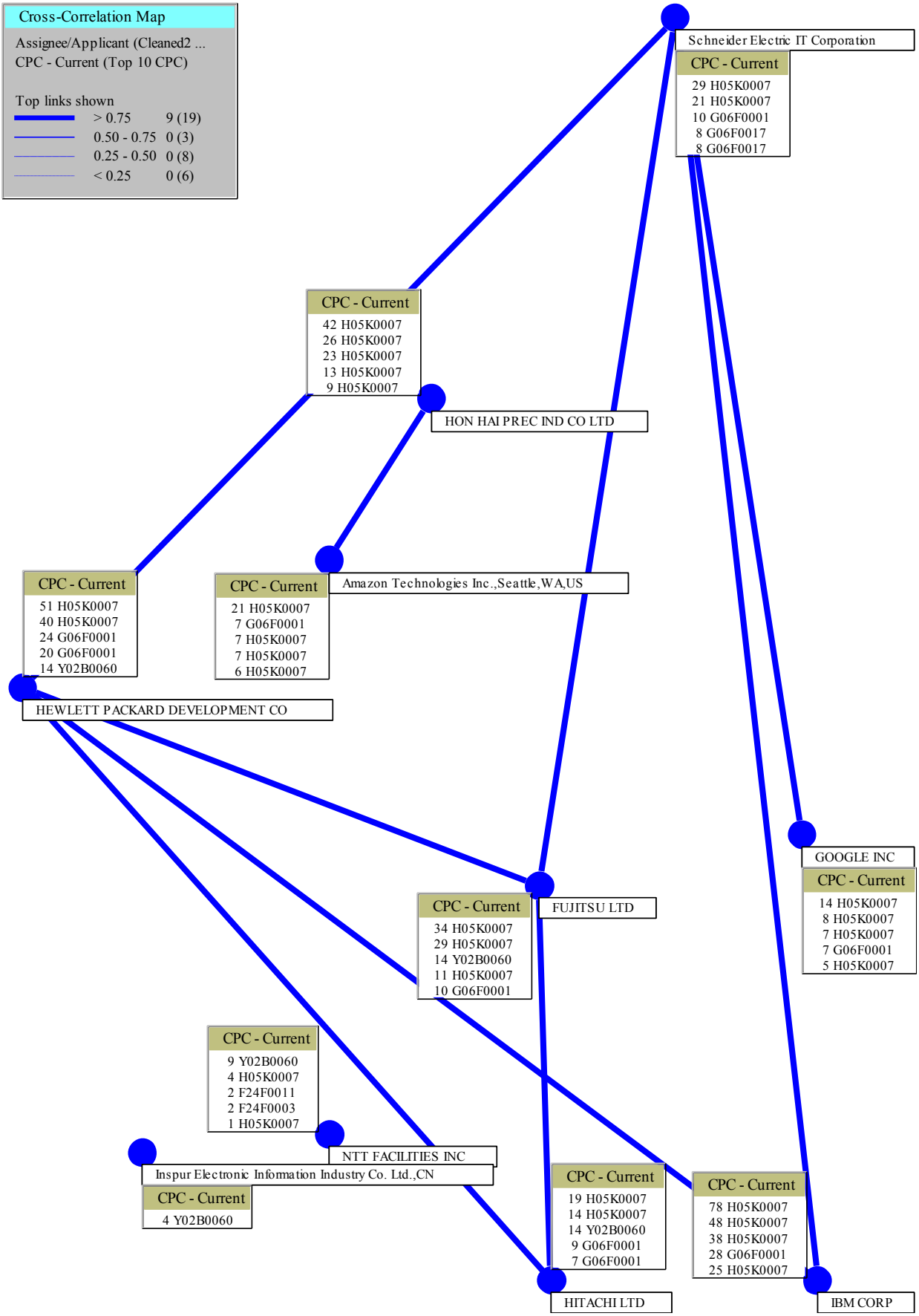


Figure 11 Top assignee technology similarity network

conditioners but also includes the design of the servers and racks to produce minimum heat as well as to have mechanism to cool the devices.

This study highlights that apart from traditional cooling device manufacturers, other players such as data centre owners, IT service

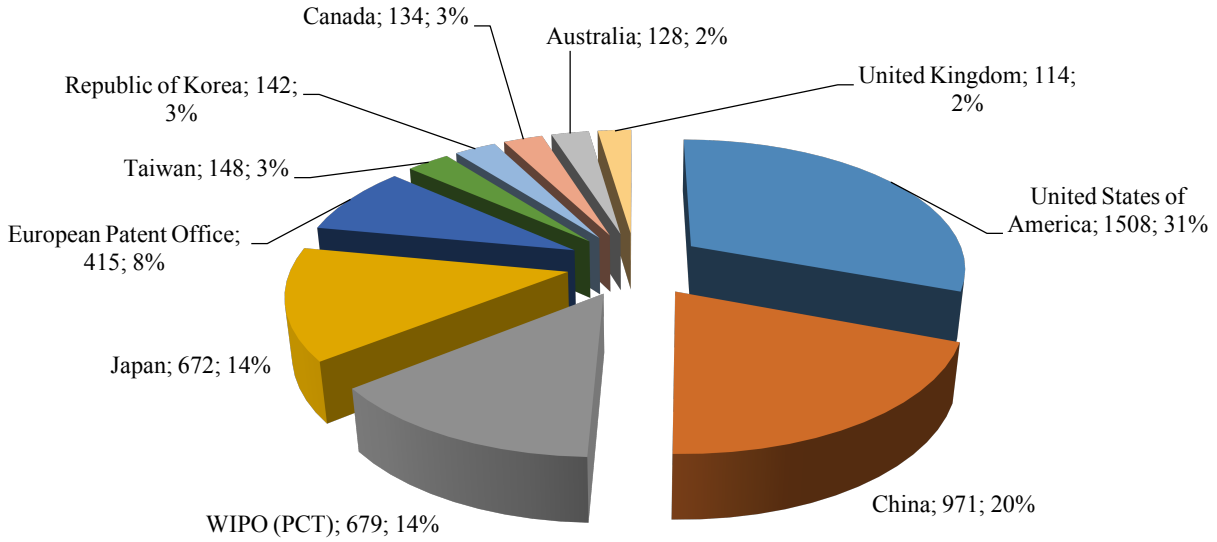


Figure 12 Top ten markets

providers, and hardware vendors, as well as electronics manufacturing companies, are also active in innovating and protecting their inventions. The dominance of cloud computing has led to more research and development in the field of energy efficient data centres from 2008 onwards. Electronic manufacturing companies and hardware vendors have increased their number of filings since 2012, whereas cloud based service providers and owners have entered the field relatively late. Although the USA is the major filing country for energy efficient cooling for data centres, it is found that half of the technologies originated from the Asia Pacific region with Japan, China and Taiwan at the forefront. Modifications to facilitate cooling, ventilating, or heating is the most researched technology, with a non-linear increase in patents in the last several years. Thermal management and gaseous and liquid cooling, as well as technology related to rack design, are the major technological topics for energy efficient cooling and their patent filing increase can be seen post-2010. Companies

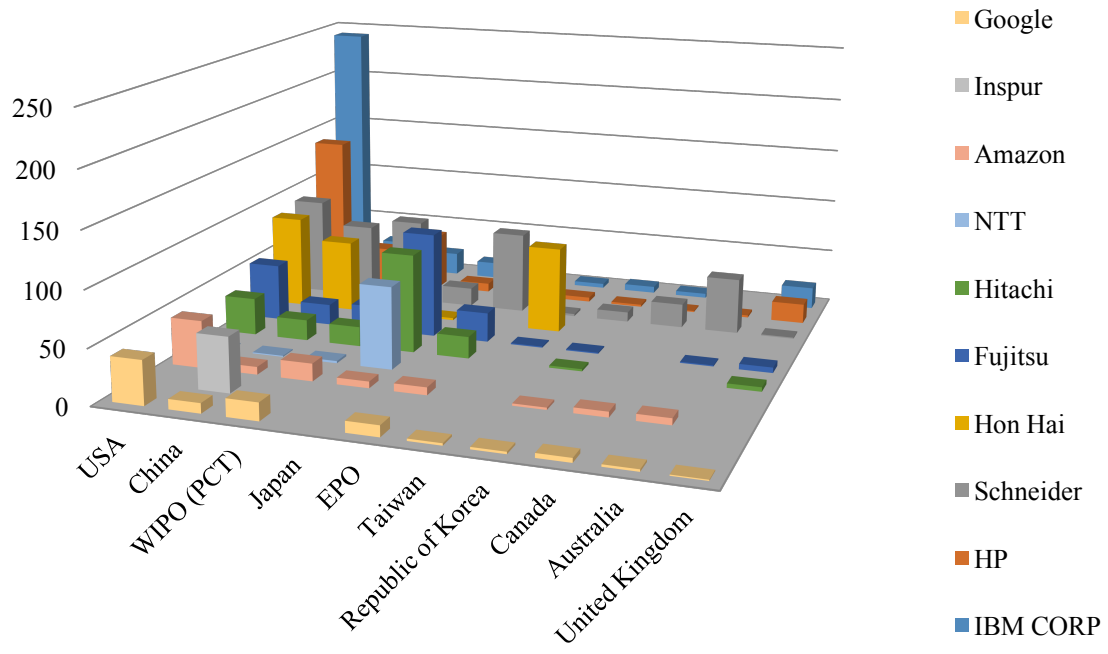


Figure 13 Assignee-wise market focus

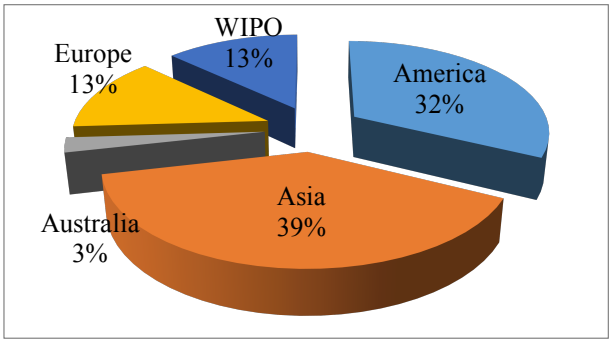


Figure 13 Continent-wise market distribution

dealing with server racks and cabinets are leaders in the area of thermal management for the cooling of data centres and in this area, IBM leads followed by HP and Fujitsu. Hon Hai is very active in the area relating to the construction of mounting structures in data centre rooms, with half of all the patents. IBM has about 75% of all patents available in the field that deals with liquid cooling within cabinets for removing heat from server blades. IBM also leads for gaseous cooling within cabinets for removing heat from server blades where IBM has one third of all patents. IBM's dominance in this area is expected, as it is involved in the sale of blade servers. Analyses show that IBM is an active player in protecting its inventions in thermal management for server racks or cabinets and liquid cooling, whereas despite HP's global leadership in the blade server market they are not an active innovator in this technology. Companies that deal with energy efficient cooling for data centres look at the USA and Asia Pacific as the major markets for technology deployment.

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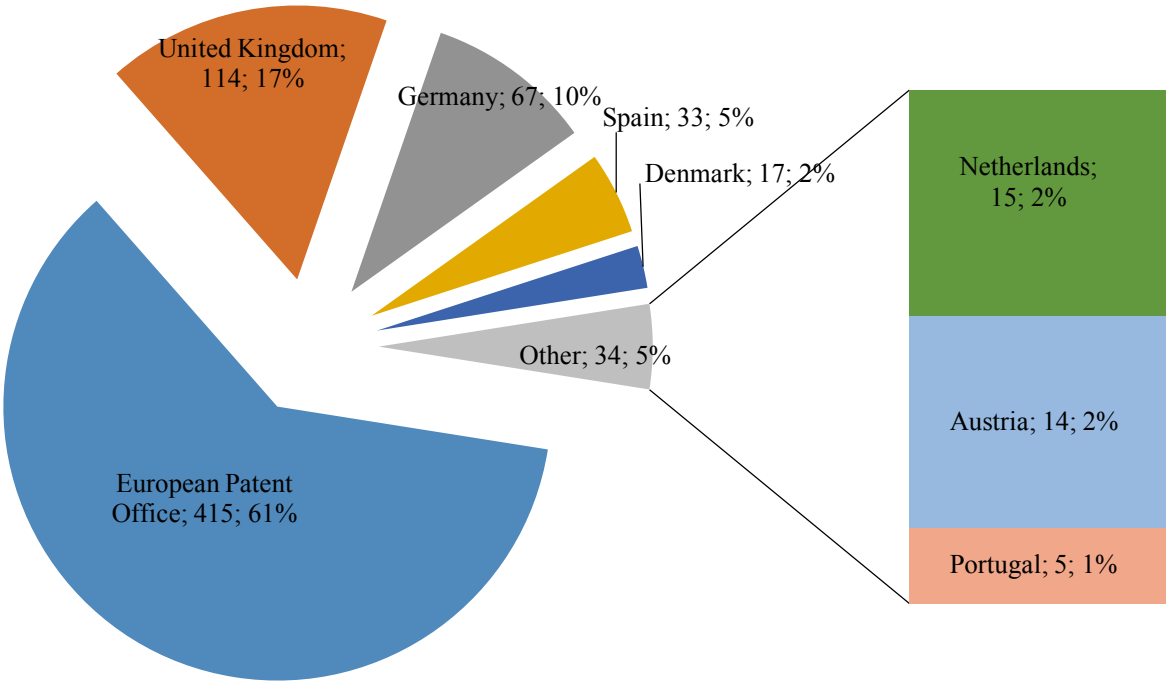

Figure 14 Country-wise patent filing in Europe

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Cross-cultural strategic intelligence solutions for leveraging open innovation opportunities

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ABSTRACT Although the concept of open innovation has become widely discussed by scholars and practitioners, few cross-cultural studies focus on the assessment of companies' behaviours towards "not invented here" and "not sold here" syndromes. The purpose of this paper is to investigate the profiles of Japanese and Romanian companies operating in two fields, IT and manufacturing, from the open innovation perspective. The goal of this study is therefore to provide comprehensive empirical evidence for the adoption of inbound and outbound open innovation activities in the companies from these two target countries. Data from a sample of Japanese companies and Romanian companies were used to test two hypotheses on open innovation behaviour, in the context of a cross-cultural comparative approach. The results show that technology isolationists are more frequently found among the Romanian companies (especially in the manufacturing field), than the Japanese companies, which can be explained by the fact that Japanese firms are mainly based on leading innovative technologies, while Romanian firms are early adopters of the advanced technologies, due to the economic circumstances. Japanese companies included in the sample are defined as technology fountains, followed by technology brokers, proving their appetite for outbound open innovation. In this context, strategic intelligence solutions, once performed in collaborative culture environments, will lead to the improvement of the partners' managerial competences and will act as enablers for competitive positioning, proving the added-value of the acquired know-how through open innovation practices.

KEYWORDS Disruptive intelligence, japan, open innovation, romania, strategic intelligence, technology brokers, technology fountains, technology isolationists, technology sponges

1. INTRODUCTION

Cross-cultural strategic intelligence configuration, designed to enhance open innovation benefits, challenges managerial skills to reframe and upgrade rooted companies' high tech patterns of cooperation, through refining drivers of associating cultural diversity and open innovation.

Furthermore, the cross cultural-open innovation hybrid approach requires efforts toward building new managerial capability to anchor specific coordination mechanisms, enabling the best matching of strategic intelligence configuration and high-tech partnership outcomes.

This cross-cultural research is mainly focused on the assessment of the correlations between Japanese and Romanian companies' profiles from an open innovation perspective and the field in which these companies are operating. The four clusters of firms, in the context of their involvement in innovation-based activities are represented by the technology isolationists (characterized by high levels of both "not invented here" and "not sold

here" syndromes), technology fountains (characterized by high levels of "not invented here" syndrome and low levels of "not sold here" syndrome), technology sponges (characterized by low levels of "not invented here" syndrome and high levels of "not sold here" syndrome) and technology brokers (characterized by low levels of both "not invented here" and "not sold here" syndromes) (Lichtenthaler et al., 2011).

The research question refers to the fact that the existence of correlations between the companies' profiles (technology fountains, technology sponges, technology brokers and technology isolationists) and the field in which they are operating (IT, manufacturing) depends on the target country to which they belong (Japan and Romania).

Erickson and Rothberg (2013) suggest that decision-makers should be aware that a balance between knowledge sharing and protection is compulsory, giving particular attention to industry-by-industry conditions, demanding more or less protection when innovation is a high priority. As a result, they must be able to decide when to develop and share proprietary knowledge assets widely (outbound open innovation) and when not to (inbound open innovation). In their opinion, the propensity to outbound innovation increases the competitive intelligence risks.

The open innovation's approach by means of cross-cultural strategic intelligence allows the mutual adjustment of intra-firm managerial procedures, based on cultural differences harmonization and will enable collaborative learning based upon shared perspectives and lists of opportunities to target. The successful valorization of open innovation opportunities based upon cross-cultural strategic intelligence is setting new equilibria between short and long term firm interests. It allows superior understanding and early opportunities recognition/capturing and insures a better competitiveness differentiator for strategic behaviour profiling.

The cross-cultural partnerships between Japanese and Romanian high-tech companies addresses the main issues of emergent markets' scanning: finding the right answer to the strategic challenge (fighting or engaging in disruption) and preventing blind spots in gathering disruptive intelligence (Vriens and Søilen, 2014).

This paper is organised as follows: in the first section, dedicated to the comparative analyses reflecting the features of open innovation within Japan and Romania, we highlighted the issues referring to the ways in which open innovation is perceived by the business environments from the two target countries; the second section is a description of our research methodology and tools; in the third section, we presented the main findings of the correlation study, using the facilities provided by SPSS software; in the last section, we presented the conclusions, the limitations of our study, its practical implications and the directions in the future research agenda.

2. THEORETICAL BACKGROUND

Despite the interest in open innovation, a comprehensive review of academic publications in the area does not seem to exist (Elmquist et al., 2009). Open innovation describes an emergent model of innovation in which firms draw on research and development that may lie outside their own boundaries, revealing the fact that valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well (Chesbrough et al., 2008). Inbound open innovation refers to the internal use of external knowledge, while outbound open innovation refers to the external exploitation of internal knowledge. Two practitioners in this field distinguish between three knowledge processes (knowledge exploration, retention, and exploitation) that can be performed either internally or externally (Lichtenthaler, 2009). The main objectives pursued by open innovation strategies are the following: gaining access to new knowledge, multiplication of own technologies, learning from knowledge transfer, controlling technological trajectories, external exploitation as a core business model and exerting control over the market environment (Kutvonen, 2011).

The open innovation approach overcomes managerial difficulties to understand the dynamics of innovation, through balancing both disruptive and sustaining innovation (Paap and Katz, 2004).

The open innovation approach is compatible with disruptive business-model behaviour, in the following circumstances (Markides, 2006): when companies enter into a new market, where strong competitors have first-mover advantages and when they attempts to scale up an innovative product to make it attractive to the mass market.

Building upon cross-cultural and open innovation approaches, disruptive innovation emerges from a successful combination of

several smaller ideas based on observing the world differently (Assink, 2006).

The concept of open innovation embraces the strategic intent behind the use of both internal and external resources and is defined as the dynamic capability to manage technology both within and outside firms (Suh and Kim, 2012).

The investigation of the reasons for which companies open up their innovation processes is a central issue in this field (Huizingh, 2011). Both offensive reasons (e.g., stimulating business development) and defensive ones (e.g., decreasing costs and risks) are emphasized. Two empirical studies conducted in this way proved that offensive reasons were more important than defensive reasons (Chesbrough and Crowther, 2006; Van de Vrande et al., 2009).

Trends such as outsourcing, agility and flexibility had already forced companies to reconsider their strategies and processes in other areas and to become network organizations, which integrate open innovation into their business model (Gassmann, 2006). A regularly updated technology focused-strategic intelligence process, which presents multiple technologies as options on a technology radar, leads to increased opportunity awareness of external high-potential technologies (Veugelers et al., 2010). The future of intelligence studies in business continues to lie primarily with its symbiosis with new technology (Søilen, 2016).

The openness of the outside-in process in R&D management is of crucial importance for achieving high direct and indirect innovation output effects (Inauen and Schenker-Wicki, 2011). From a strategic perspective, open innovation needs executive level commitment, as this is generally the most important obstacle that companies face in trying to adopt it (Sloane, 2011).

Research undertaken in UK manufacturing firms reveals the lack of firms' openness to their external environment, reflecting organizational myopia and indicating that managers may overemphasize internal sources and under emphasize external sources (Keld and Salter, 2006). The results of a survey undertaken in Spain emphasizes that open innovators are smaller and less R&D intensive than semi-open ones, although larger and more R&D intensive than closed innovators (Barge-Gil, 2010). Another study developed in China has shown how firms' open innovation practices influence the national systems of innovation and how the policy-makers' decisions can foster and speed up open innovation practices (Wang and Zhou, 2012). Generally, open innovation doesn't adversely affect competitive advantage, but the companies whose advantage is driven by barriers to entry, skills in innovation and anticipating customer needs, or that rely on proprietary product designs, can face difficulties in the long term (Reed et al., 2012).

The main findings of a survey focused on the measurement of open innovation outputs support the expectations that the ability to build inter-organizational relationships in a knowledge-rich environment increase the efficacy of inbound open innovation for gaining superior financial performance (Sisodiya et al., 2013). Moreover, open innovation activities strengthen the positive effects of dynamic innovation capabilities on disruptive innovation (Cheng and Chen, 2013).

Regarding innovation measurement, companies are still looking for adequate indicators that monitor the investments and the effects of open versus closed innovation approaches. In this way, there is interesting research that provides relevant answers as to how the adoption of open innovation practices is linked to financial performances of companies (Michelino et al., 2014).

3. PECULIARITIES OF OPEN INNOVATION IN THE TARGET COUNTRIES INVOLVED IN CROSS-CULTURAL RESEARCH: JAPAN AND ROMANIA

Open innovation is in essence a cross-cultural phenomenon, involving dynamic processes of knowledge creation, diffusion and use (Del Giudice et al., 2012). Innovative firms are more successful in international business, putting them into contact with alternative business cultures and open innovation contexts and making them more able to compete internationally (Filippetti et al., 2011). The literature related to open innovation reveals minimal empirical evidence on cross-cultural surveys focused on the assessment of companies' cultural profiles in the context of open innovation practices. A previous cross-cultural survey developed in four countries (Japan, Romania, Tunisia and Turkey) emphasized the distribution of the companies' profiles in four clusters (technology isolationists, technology fountains, technology sponges and technology brokers), but its main limitations refer to the significant gaps in the

distribution of companies on different sectors within the national samples and the lack of correlation tests between specific variables (Yamazaki et al., 2012).

According to Christensen (2016, p .12), "in the period 1970-1980, Japan was quite successful in generating disruptive and market-creating innovations. However, disruptive and market-creating innovations have been disappearing over the last 25 years, because the focus has changed from market-creation to efficiency. The problem is not innovation but management style to support new ideas".

The open innovation approach in Japanese firms is highly related to their capacity to incorporate promising disruptive technologies from inside and outside, in line with their program entitled Impulsing Paradigm Change through Disruptive Technologies (ImPACT).

Open innovation, characterized by using not only in-house but also external R&D resources (Chesbrough, 2003), is perceived as a sustainable competitive advantage by the Japanese companies. According to many opinions, Japan's system of innovation is mainly driven by large corporations, but external collaboration in R&D has been developed and promoted at a large scale in the last decade. Capturing opportunities for managing internally, all R&D resources became a trend for Japanese high-tech companies. The intelligent positioning of Japanese high-tech firms resides on two pillars: searching for future growth potential through open innovation, and installing itself into new markets through globalization (Motohashi, 2011).

The Innovation Network Corporation of Japan (INCJ) insures a long-term partnership between the Japanese government and major high-tech corporations. INCJ encourages open innovation, providing patterns for how to strategically move technology and expertise beyond the boundaries of existing organizational structures. One of the most important roles played by INCJ is to conduct targeted research in order to facilitate successful collaborative innovations in an open context (Lippitz, 2012).

The long-term cooperation between high-tech firms is already specific and can be considered to be a pattern for Japanese firms; SMEs became aware of the fact that technology plays an important role in their business models and they found solutions to support open innovation.

Making sense of contractual incompleteness, pertinent analyses related to Japanese SMEs regarding open innovation, focuses on the real challenge to unambiguously deal with foreseeable contingences: whether open cooperation can be constructed, whether cooperation among organizations can be formed, who bears costs for constructing collaboration, and whether mutual trust can be formed (Idota et al., 2012).

A recent survey conducted in Japan proposes and tests a model of innovation process management used to clarify the managerial strategies required to achieve it in Japanese enterprises (Ota et al., 2013). The authors found specific practices and capabilities that were statistically significant in Japan's manufacturing companies. The importance of structured process in the Japanese manufacturing sector was confirmed, comprising scanning, idea occurrence, strategy formulation, resource procurement, implementation and value creation.

The results of a survey conducted on 180 European companies show that inbound open innovation is more commonly used than outbound open innovation, which can be explained by insufficiencies in the market or the organization, confirming its role as a complement for internal R&D (Schroll and Mild, 2011). The firms operating in emerging economies need not necessarily rely on entrepreneurial behaviour to sustain business growth, although involvement in open innovation may enhance business performance (Chaston and Scott, 2012). The emerging countries with weak capabilities, in both firms and national systems of innovation, have the opportunity to employ the open innovation approach in order to accelerate their technological learning and development (Wang et al., 2012). In this context, the integration in the European Union has changed the managerial mentalities within Romanian companies, which previously assigned less importance to R&D activities. However, a significant lag between open innovation and technology transfer is still reminiscent in the Romanian business culture (Borcea and Fuica, 2012).

Regarding the propensity of emerging economies to engage in successful cross-cultural partnerships with developed countries, consistent evidence relies upon rethinking the core causality of making poorly stimulated innovation policy and fragile SME organizational capabilities.

Re-contextualization should focus on understanding new causal factors, which best fit the socio-economic context and organizational capabilities, in order to overcome obvious technological gaps between developed countries versus emergent ones (Karo and Kattel, 2011).

The performances related to Romania's innovation system remains are smaller, when compared to other EU countries. Positioned in a cohort of 'catching–up' countries, Romania's economic background is characterized by a positive economic trend, mainly based on low cost labour and low value-added exports; the big problem and challenge, at the same time, is represented by the low level of innovation infrastructure, at an early development stage. PRO INNO Europe highlights that Romanian innovative companies are less than a fifth of the country's total number of active firms. The profile of a Romanian innovative is the following: SME, operating in the software industry, in internet and new media. The low level of public funding for innovation (only 10% of innovative firms receive funding), correlates to very low levels of innovation expenditures (in most cases, they don't exceed 3% of innovative firms' turnovers) explain the reality in Romania's innovative business landscape. Although significant progress has been made in order to foster the weak innovation culture in the country, further measures are needed to increase the application of R&D results by business and to turn innovation into a driver of national competitiveness.

A recent study focused on the perspectives of the Romanian SME sector in the context of innovation and knowledge creation (Purcarea et al., 2013). It emphasizes a learning orientation related to innovation, using best practices within the organization and networking with external partners as internal sources for learning, whereas in terms of external support for learning, SMEs consider changes that take place in the market, changes in technology and the input from experts and consultants.

Many Romanian entrepreneurs, endowed with disruptive innovation potential, are not able to perform optimally, as there is a lack of access to relevant market information for attracting investment flows, which can finance their innovations.

4. RESEARCH METHODOLOGY

In order to achieve the research goal, we designed and developed a questionnaire as the main research tool focused on data collection, in which 20 questions (items) were grouped in four categories, corresponding to the four types of open innovation cultures (Figure 1).

The five items focused on technology fountains reveal a low attractiveness for external technology sourcing and implicitly a high degree of independence of technology to different providers, associated with a high interest for commercialization strategy of the company's internally developed technologies, without concern for losing control over them.

The five items focused on technology sponges emphasize an improvement of the internal innovation process by means of acquiring technology from external sources as a result of strategic intelligence mechanisms, correlated with internal agreements which don't allow the IP transfer to other companies.

The five items focused on technology brokers reveal the situations in which companies proceed to external technology acquisitions in order to the improve the R&D process and internal technology selling in order to provide additional revenue.

The five items focused on technology isolationists highlight the situations in which companies benefit from the technologies developed internally and retain full control of their intellectual property, preventing other organizations from making a profit from their technologies.

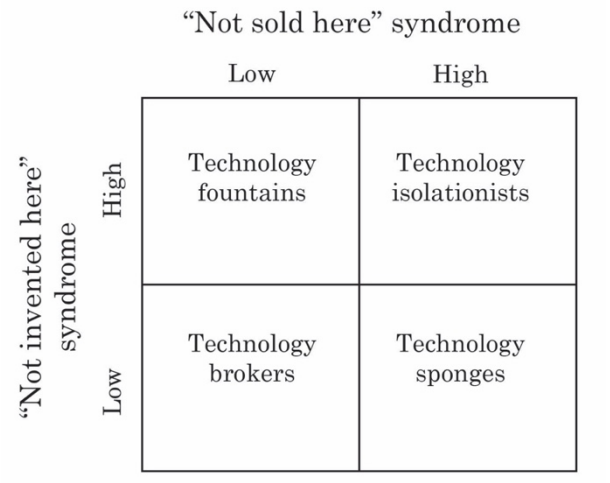

Figure 1 Four clusters of companies' profiles in the context of open innovation. Adapted from Lichtenthaler et al., 2011.

We sent the questionnaire to a convenience sample formed of Japanese and Romanian companies from the fields of manufacturing and IT. Questionnaires were transferred to the selected participants through electronic mail system, including our commitment to respect the confidentiality and anonymity of the answers. Each questionnaire's results were

processed by means of an automatic coding scheme in SPSS software, in order to avoid data input errors. Finally, 80 returned questionnaires per country were stored in a SPSS database, after eliminating the incomplete answers. The structure of the sample was the same in the two target countries: 40 companies from the manufacturing field, as well as 40 companies from the IT field.

Consequently, two hypotheses were proposed to be tested by means of appropriate statistical methods.

H1: In the case of Japanese companies included in the sample, their profiles (technology fountains, technology sponges, technology brokers and technology isolationists) are positively related to the field in which they are operating (IT or manufacturing).

In this situation, the independent variable is represented by the Japanese companies' profiles, while the field in which these companies are operating reflects the dependent variable.

H2: In the case of Romanian companies included in the sample, their profiles (technology fountains, technology sponges, technology brokers and technology isolationists) are positively related to the field in which they are operating (IT or manufacturing).

In this situation, the independent variable is represented by the Romanian companies' profiles, while the field in which these companies are operating reflects the dependent variable.

The statistical methods that we used in order to test the hypotheses are chi-square, Pearson's R and Spearman coefficients of correlation. The chi-square test is applied in order to determine whether there is a significant difference between the expected frequencies and the observed frequencies in one or more categories. The use of the chi-square test involves the design of two hypotheses: the null hypothesis states that there is no significant difference between the expected and observed frequencies, while the alternative hypothesis states they are different. The level of significance (the point at which we can say with 95% confidence that the difference is not due to chance alone) is set at 0.05. The Pearson's R correlation coefficient is a useful descriptor of the degree of linear association between two variables, having two key properties of magnitude and direction. When it is near zero, there is no correlation, but as it exceeds -0.1 or 0.1 there is a negative or positive relationship, respectively, between the variables; if they are close to - 1 or +1, there is a strong negative or positive relationship between the variables. The sign of the Spearman correlation coefficient indicates the direction of association between the independent variable and the dependent variable. If the dependent variable tends to increase when the independent variable increases, the Spearman correlation coefficient is positive; otherwise, the Spearman correlation coefficient is negative. A Spearman correlation coefficient near zero indicates that there is no tendency for the dependent variable to either increase or decrease when the independent variable increases.

5. FINDINGS AND DISCUSSIONS

The use of the descriptive statistics methods, on the one hand, and the illustration of the in-depth analyses of the research results, on the other hand, involved the distribution of the respondents' answers in two contingency tables, reflecting the correlations between companies' profiles and the fields where they operate, in the case of each target country.

The distribution of research results corresponding to the first hypothesis involved the design of a contingency table with double entry, which allows the classification of the observed frequencies (Table 1).

Table 1 Contingency table associated with the first hypothesis test (H1).

Cross-tabulation results		**Field**		**Total**
		IT	Manufacturing	
Japanese companies' profiles	Technology fountain	11	16	27
	Technology sponge	10	6	16
	Technology broker	15	9	24
	Technology isolationist	4	9	13
	Total	40	40	80

Table 2 First hypothesis tested by the chi-squared method.

Indicator	Value	Degrees of freedom	Asymptotic significance
Pearson chi-square	5.349	3	0.148
Likelihood ratio	5.432	3	0.143
Linear-by-Linear Association	0.010	1	0.919
Number of valid cases		80	

Table 3 First hypothesis test by means of Pearson's R and Spearman correlation coefficients. [a] Not assuming the null hypothesis, [b] Using the asymptotic standard error assuming the null hypothesis, [c] Based on normal approximation. Int = interval, Ord = ordinal.

Symmetric Measures		Value	Asymptotic Std. Error [a]	Approx. T[b]	Approx. Sig. [c]
Int. by Int.	Pearson's R	-0.011	0.112	-0.101	0.920
Ord. by Ord.	Spearman Correlation	-0.020	0.114	-0.174	0.862
Number of Valid Cases			80		

Table 4 Contingency table associated with the second hypothesis test (H2).

Cross-tabulation results		Field		Total
		IT	Manufacturing	
Romanian companies' profiles	Technology fountain	7	6	13
	Technology sponge	11	12	23
	Technology broker	16	5	21
	Technology isolationist	6	17	23
Total		40	40	80

As we can observe from Table 1, the majority of the Japanese companies included in the sample are identified as technology fountains, followed by technology brokers, proving other empirical findings which emphasize the adoption at a large scale of open innovation in Japanese high-tech companies. By taking into consideration the field in which these companies are operating, we can observe that technology fountains and technology isolationists are more common in manufacturing, while technology sponges and technology brokers are more common in the IT field.

We can state that the results are relevant to the reality of the Japanese economy, in the context in which all the players from the business environment are aware of the opportunities to boost technology, in order to promote open innovation. The systematic approach of open innovation led Japanese companies to gain permanently sustainable advantages, being able to successfully expand internationally.

The results correspond to the test of the first hypothesis. The results of the cross-tabulation process using the respondents' answers stored in the SPSS database are revealed in Tables 2 and 3.

In this case, the value associated to the asymptotic significance (0.148) is higher than the level of significance (0.05) and the Pearson Chi-Square value (5.349) is lower than the chi-squared value corresponding to the statistics table (7.82), with three degrees of freedom; consequently, the hypothesis is rejected, so the profiles of the Japanese companies included in the sample are not influenced by the field in which they are operating (IT or manufacturing).

Table 5 Second hypothesis evaluated by means of a chi-squared test.

Indicator	Value	Degrees of freedom	Asymptotic significance
Pearson's chi-square	11.143	3	0.011
Likelihood ratio	11.662	3	0.009
Linear-by-linear association	1.588	1	0.208
Number of valid cases		80	

Table 6 First hypothesis test by means of Pearson's R and Spearman correlation coefficients. Int = interval, Ord = ordinal.

Symmetric measures		Value	Asymptotic std. error	Approx. T	Approx. sig.
Int. by int.	Pearson's R	0.142	0.110	1.265	0.210
Ord. by ord.	Spearman correlation	0.146	0.113	1.303	0.197
Number of valid cases			80		

The results of the first hypothesis test process are also validated by Pearson's R and Spearman correlation coefficients (Table 3), because their values (-0.011, respectively -0.020) are negative, but situated near zero, emphasizing the lack of correlation between the independent variable (Japanese companies' profiles) and dependent variable (the field in which the companies are operating).

We view the Pearson's R and Spearman correlation coefficients as useful descriptors of the degree of linear association between the variables related to the research conceptual model, as they revealed the lack of correlation between the variables.

The distribution of research results corresponding to the second hypothesis involved the design of a new contingency table with double entry, which allows the classification of the observed frequencies (Table 4).

The in-depth analysis of the research results outlines the fact that, in the case of the Romanian companies included in the sample, their profiles correspond mostly to technology sponges and technology isolationists, unlike the companies from Japan, focused to a great extent to the other two profiles. Moreover, we can observe high discrepancies in what concerns the distribution of the companies' profiles in the technology broker and technology isolationists clusters; in the first case, the majority of firms belong to the IT field, while in the second case, the majority of firms belong to the manufacturing field. These findings can be explained by taking into consideration the fast development of the Romanian IT and software services industry, as a result of open innovation adoption; in the situation of Romanian manufacturers, we still perceive a resistance towards open innovation, reflected in a high number of technology isolationists, which can be associated with a reduced appetite for risk.

The results corresponding to the test of the second hypothesis, after the configuration of the cross-tabulation process using the respondents' answers stored in the SPSS database, are shown in Tables 5 and 6.

In this particular situation, the value of the asymptotic significance (0.011) is lower than the level of significance (0.05) and the Pearson's chi-squared value (11.143) is higher than the chi-squared value corresponding to the statistics table (7.82), with three degrees of freedom; the hypothesis is accepted, so the profiles of the Romanian companies from an open innovation perspective are positively related to the field in which they are operating (IT or manufacturing).

The results of the second hypothesis test process are also validated by Pearson's R and Spearman correlation coefficients (Table 6), because their values (0.142 and 0.146,

respectively) are positive, emphasizing the fact that the dependent variable (the field in which the Romanian companies are operating) tends to increase when the independent variable increases (the number of Romanian companies' profiles in a certain cluster).

Another assumption is that there is a monotonic relationship between the independent and dependent variables, determined by the existence of relevant gaps in the distribution of Romanian companies' profiles in the technology broker and technology isolationist clusters, as well as minimal differences in the case of the other two clusters.

6. CONCLUSIONS, MANAGERIAL IMPLICATIONS AND FUTURE RESEARCH AGENDA

Tracking high tech innovation partnerships' practices of cross-cultural collaboration, while being aware of open innovation opportunities for capture, it's compelling to assume causally contrasting elements are challenging for setting the leveraging role of coming strategic intelligence configurations.

Nevertheless, the current research efforts to test theory building in searching for pertinent constructs to validate the above hybrid approach, are upgrading previous coherent relevant insights, exploring partnership coordination mechanisms—capable of overcoming cultural dissonance—while capitalizing upon open innovation opportunities.

As main challenge is culturally specific, we assert that strategic intelligence solutions—as part of managerial communalities—should be designed and deployed through the hybrid organization's internal environment adjustment, focus on cooperation perspective and not on "fixing the gaps" perspective, which is more consistent with open innovation principles. We understand that by managerial communality the cross-cultural coordination mechanism (agreed between partners)—which is considered a strategic intelligence solution—can take advantage of the cultural differences, as opposed to minimizing the gap.

The above considerations also support that open innovation approach is matching the emergent new managerial models, such as "harmocracy." The principles of both of these are common. The educated collaborative practices are evolving toward enlightened management, capable of channeling the valorisation of open innovation opportunities through a communion of scope strategy, expectations, strategic scope and results.

The results provided by the hypothesis analyses are representative of the development stages of the two target countries. Japan is one of the highly developed countries, while Romania is still in transition towards a competitive economy. Moreover, they are coherent with the actual stage of the global economy, affected by the effects of the financial and economic crisis (with important consequences in the field of business efficiency, operating cost cuts and revenue increases).

Thus, from an innovation perspective, both countries are characterized by appreciatively similar distributions of the companies from the research sample in the "technology brokers" cluster. This is proof that the financial and economic crisis forced companies, regardless of their country, to reduce operating costs (with the adoption of innovative technologies being a solution) and to increase revenue regardless of their nature. In Romania, the companies from the IT field are more aware of the benefits of open innovation than the companies from manufacturing, as they are part of an industry less affected by the crisis.

A significant number of companies included in the technology sponges cluster can be found in both target countries (approx. 20% from the Japanese sample and 29% from the Romanian sample). The fields in which the companies act is not relevant for the behaviour in these countries, as there are firms with important financial resources which don't pay attention on the short term to the opportunities related to revenues increases. Only the evolution of the macroeconomic factors will or will not support such a behaviour.

The situation of the companies included in the final two clusters, technology fountains and technology isolationists, is the opposite. In Japan, fountain-type behaviour is more diffuse, being characteristic of a developed economy based on leading technologies. In Romania, there are more isolationists, especially in the manufacturing field, as a consequence of the fact that gathering competitive advantages is possible only by means of an isolationist behaviour regarding selling or acquiring advanced technologies.

The cross-cultural partnerships between Japanese and Romanian companies should be built upon two pillars: transfer of disruptive technologies in an open innovation context and Romanian high-tech companies' capability to learn from Japanese high-tech companies'

knowledge and anticipative capability. Anchoring disruptive intelligence in a cross-cultural context enlightens strategic trajectories towards opportunities to create entirely new markets.

The first vulnerability to highlight is the level of accuracy in terms of predictability in the case of an obvious gap in the development stage model of the country and open innovation profiling behaviour. A better differentiator could be identified by setting output variables of open innovation to: the number of patents of each sector, intra-sectorial synergies, and the span and degree of globalization captured opportunities of each sector, for example.

A qualitative approach of crisis consequences must be performed. In this way, we advance the hypothesis that open innovation and cost shrinking correlation is debatable, as it is obvious that open innovation becomes the solution for emergence from the economic crisis.

We are also aware that open innovation is generating high transaction costs and it is requiring specific managerial coordination and limited transferable organizational practices: it is emerging in a new generation of managerial models, with more appropriate practices, which insure the alignment of open innovation opportunities with strategic behaviour profiling.

It is hard to imagine how it will change the behaviours of the IT and manufacturing firms from these two countries towards innovation. If short-term change is predictable, as our research reflects, on the long term the behaviour of these companies will face factors such as advancements in IT evolution as well as the development of the economies of the two countries. Due to these issues, a longitudinal research project will be conducted after two to three years in order to verify the pertinence of the hypotheses tested above. At this point, we will be available to assess other types of behaviour towards innovation, which weren't emphasized and formalized in this research.

We encourage future cross-cultural research in order to investigate more deeply the links between open innovation practices in different countries. In particular, we will try to build a collaborative research network by addressing invitations to researchers interested in approaching this topic to attend a cross-cultural survey. Empirical, comparative and co-relational analyses of behaviours towards open innovation in various countries could be one way of discovering which open innovation practices influence the national systems of innovation.

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Business intelligence evaluation model in enterprise systems using fuzzy PROMETHEE

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ABSTRACT In this paper, a new model to evaluate business intelligence (BI) for enterprise systems is presented. Evaluation of BI before making decisions about buying and deployment can be an important decision support system for managers in organizations. In this paper, a simple and practical method is presented that evaluates BI for enterprise systems. In this way, after reviewing different papers in the literature, 34 criteria for BI specifications are determined, and then by applying fuzzy PROMETHEE, different enterprise systems are ranked. To continue to assess the proposed model and as a case study, five enterprise systems were selected and ranked using the proposed model. The advantages of PROMETHEE over other multi-criteria decision making methods and the use of fuzzy theory to deal with uncertainty in decision making is assessed and it is found that the proposed model can be a useful and applied method to help managers make decisions in organizations.

KEYWORDS Business intelligence, enterprise systems, Fuzzy PROMETHEE, fuzzy theory, PROMETHEE

1. INTRODUCTION

Traditional industrial informatics focus on how to provide more efficient and productive operations. But nowadays they cannot stay competitive just by providing more efficient and productive operations. They are facing the challenge of processing huge amounts of data and turning it into smart and timely decisions to deliver better products and services (Lian & Li 2012). In the present competitive world, accurate and up-to-date knowledge and information is considered to be a crucial factor for all organizations. In fact, today organizations need knowledge and information to achieve a competitive advantage when making important decisions. IT development in recent decades has led to the appearance of different enterprise information systems such as enterprise resources planning (ERP), supply chain management (SCM) and customer relationship management (CRM), which are introduced as modern tools in important enterprise decision-makings by storing different data in themselves (Alter 2004; Power 2008). Enterprise information systems or enterprise systems can be defined as follows: software systems for business management, encompassing modules supporting enterprise functional areas such as planning, manufacturing, sales, marketing, distribution, accounting, finance, human resources management, project management, inventory management, service and maintenance, transportation and e-business (Rashid et al. 2002).

In order to deliver useful information for decision-making, business intelligence (BI) is a key technology (Moss & Atre 2003). BI software is among the many software products that organizations utilize to ensure their place in the market (Abzaltynova & Williams 2013).

Most companies today use a set of different BI tools, instead of focusing only on one. The reason for this may be that different users prefer different types of BI tools (Sabanovic & Søilen 2012). The concept of BI was first introduced by the Gartner group and in general it refers to tools and technologies such as data storing, reporting and analyzing information. In the past, researchers dealt with presenting tools for evaluating BI in enterprise systems. But in most studies, BI was examined and analyzed as an independent tool from enterprise systems. Until 2006 and before Lönnqvist & Pirttimäki's study, the existing studies in the field of BI tried to explain and prove the need for investment and the value of BI. Lönnqvist & Pirttimäki (2006) for the first time introduced a set of criteria for examining the performance of BI. Albashir et al. (2008) investigated the effect of BI systems on business procedures and presented a method to measure the effect. In 2009, Lin et al. established a performance assessment model based on analytic network process (ANP) for an independent system (Lin et al. 2009). Nyblom et al. (2012) proposed a simple model for evaluating the performance of BI software systems based on what companies find to be most important; efficiency, user friendliness, overall satisfaction, price and adaptability. Fourati-Jamoussi & Niamba (2016) proposed an evaluation model for BI tools using cluster analysis. Ghazanfari et al.'s study in 2011 can be regarded as the first study to investigate BI in enterprise systems in which the authors have presented some criteria to evaluate BI in enterprise systems by examining different studies of BI and enterprise systems (Ghazanfari et al. 2011). In 2012, Rouhani et al. presented the fuzzy TOPSIS method for evaluating BI in enterprise systems. Also, in 2015, Rouhani & Zare presented a method for evaluating BI by using a fuzzy analytic network process (F-ANP) (Rouhani & Zare 2015).

One of the actions that influences the efficiency of decisions while making them is choosing a suitable method for decision-making among the existing methods. The Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) is one of the best known decision-making methods. Compared with other methods, this method is considered to be the best and has more advantages in different factors such as the ease of use, interpretation of parameters, reliability of results, amount of interaction required by the user and ease of understanding (Al-Shemmeri et al. 1997; Gilliams, 2005; Mahmoud & Garcia, 2000). On the other hand, since the existing data on decision-making methods are usually based on opinions and the experiences of decision-makers and are expressed qualitatively, it is more likely to have errors in opinion interpretation. This has led to the suggestion of using fuzzy theory in solving problems with qualitative observations. In this paper, a model for evaluating BI in enterprise systems based on a fuzzy PROMETHEE method is presented. The rest of the paper is organized as follows: the second section of the paper deals with introducing the concept of BI and its definitions. Also in this section, the PROMETHEE method is briefly described. The third section covers the description of the steps for the fuzzy PROMETHEE method for evaluating BI in enterprise systems. Finally, the conclusion section deals with conclusions, results and suggestions.

2. THEORETICAL BASICS

2.1 Business intelligence

Business intelligence can bring critical capabilities to an organization, but the implementation of such capabilities is often problematic (Adamala & Cidrin 2011). BI was first defined by Howard Dresner, a researcher of the Gartner group, and incipiently referred to the tools and technologies including data warehouses, reporting query and analysis (Lian & Li 2012). BI helps organizations make on-time decisions to reach their goals through using an advanced tool of analysis and prediction and by covering tasks like gathering, processing and analyzing large amount of data. Ghoshal & Kim (1986) defined BI as a management philosophy in the business environment. Lönnqvist & Pirttimäki (2006) used "business intelligence" for the two following concepts:

1. Related information and knowledge of an organization, which describe the business environment, the organization itself, the conditions of the market, customers and competitors and economic issues;
2. Systemic and systematic processes, by which organizations obtain, analyze and distribute the information for making decisions about business operations.

The main purpose of BI is to help organizations to improve their performance and promote their competitive benefits in the market. Through evaluation of whether activities lead to organizations' progress toward their goals or not, BI helps in better decision-making (Mohaghar et al. 2008). By investigating the literature on BI we encounter two attitudes toward it. First, a management attitude which looks at it as a procedure in which data is gathered and organized from inside and outside of the organization to provide information related to decision-making procedures. The second attitude is technical and introduces it as a set of tools which support the aforementioned procedures. In this respect, the focus is on the algorithms and tools which provide capabilities of data storing, recovery, gathering and analyzing, instead of procedures.

2.2 PROMETHEE

PROMETHEE is a preferred structural method for evaluation and a multi criteria decision making (MCDM) method which was introduced by Brans et al. in 1986. This method is well adapted to problems where a finite number of alternative actions are to be ranked with respect to several, sometimes conflicting criteria. The first method provides a partial priority relationship for ranking the alternatives while the second method assigns a numerical privilege for each alternative which is used in ranking (Brans et al. 1986). A few years later, several versions of the PROMETHEE method have been developed. The implementation of PROMETHEE requires two additional types of information. The first one is information on the relative importance of the criteria, which is their weights, and the second one is the information on the decision maker's preference function, which the decision maker uses when comparing the contribution of the alternatives in terms of each separate criterion. In PROMETHEE, six basic types of preference functions are used: the usual function, the U-shape function, the V-shape function, the level function, the linear function and the Gaussion function. The choice of preference function depends on decision-makers and analyzers and their understanding of the relationship between the alternatives and criteria. The following parameters are used in these functions:

q: Indifference threshold.

p: Total preference threshold.

σ: It is a parameter which shows the distance between p and q.

Considering the data matrix $A = (a_1, a_2, a_3, \dots, a_n)$ with n alternatives that should be evaluated by K criteria $c = (f_1, f_2, \dots, f_k)$ with the weights of $w = (w_1, w_2, \dots, w_k)$, the steps of the PROMETHEE method are as follows:

Step 1: determination of deviations based on pair-wise comparisons of two alternatives, a and b:

$$d_j(a,b) = f_j(a) - f_j(b) \quad (1)$$

Where $d_j(a,b)$ is the difference of the value of "a" and "b" in each criterion.

Step 2: application of preference function:

$$p_j(a,b) = G_j[d_j(a,b)] \quad (2)$$

Where $p_j(a,b)$ denotes the preference of alternative "a" with regard to alternative "b" in each criterion, as a function of $d_j(a,b)$. The preference function can have a value in the range of 0 to 1 and it is interpreting the difference in terms of a specific criterion between the evaluations of a and b.

Step 3: calculation of global preference index:

$$\forall\, a, b \in A \quad \pi(a,b) = \sum_{j=1}^{k} p_j(a,b)\, w_j \quad (3)$$

Where $\pi(a,b)$ is defined as the weighted sum of $p_j(a,b)$ for each criterion.

Step 4: calculation of outranking flows for all alternatives as follow:

$$\Phi^{+}(a) = \frac{1}{n-1}\sum_{x \in A} \pi(a,x) \quad (4)$$

$$\Phi^{-}(a) = \frac{1}{n-1}\sum_{x \in A} \pi(x,a) \quad (5)$$

$$\Phi^{net}(a) = \Phi^{+}(a) - \Phi^{-}(a) \quad (6)$$

In this step $\Phi^{+}(a)$ is the measure of how alternative *"a"* dominates the other alternatives of A and $\Phi^{-}(a)$ gives how alternative *"a"* is dominated by all the other alternatives of A. $\Phi^{net}(a)$ represents a value function whereby a higher value reflects a higher attractiveness of alternative "a" and is called net flow.

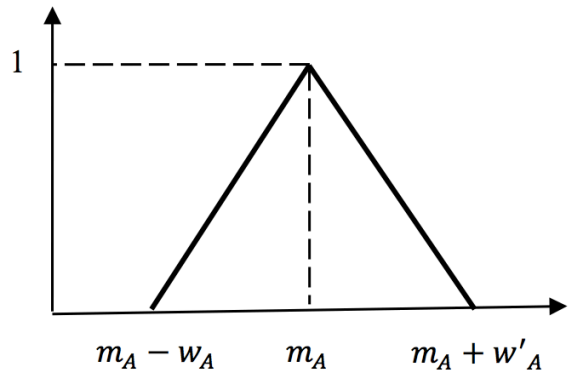

Figure 1 LR triangular fuzzy number.

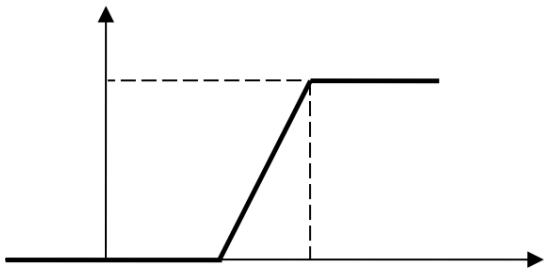

Figure 2 V-shape preference function.

PROMETHEE I is based on partial ranking, an alternative "a" is preferred to alternative "b" according to Eq. 7, alternatives "a" and "b" are indifferent according to Eq. 8 and alternatives of "a" and "b" are incomparable according to Eq. 9.

$$\begin{aligned} &\Phi^+(a) > \Phi^+(b) \ \ \& \ \ \Phi^-(a) < \Phi^-(b); or \\ &\Phi^+(a) > \Phi^+(b) \ \ \& \ \ \Phi^-(a) = \Phi^-(b); or \\ &\Phi^+(a) = \Phi^+(b) \ \ \& \ \ \Phi^-(a) < \Phi^-(b) \end{aligned} \quad (7)$$

$$\Phi^+(a) = \Phi^+(b) \ \ \& \ \ \Phi^-(a) = \Phi^-(b) \quad (8)$$

$$\begin{aligned} &\Phi^+(a) > \Phi^+(b) \ \ \& \ \ \Phi^-(a) > \Phi^-(b); or \\ &\Phi^+(a) < \Phi^+(b) \ \ \& \ \ \Phi^-(a) < \Phi^-(b); \end{aligned} \quad (9)$$

PROMETHEE II is a complete ranking whereby alternatives are ranked from the best to the worst using net flows. The alternative with the highest net flow is assumed to be superior to the others and the rest of the alternatives are ranked by their net flow values as well.

Since in some problems certain figures cannot exactly express a decision maker's opinions and conditions of the alternatives, fuzzy number and fuzzy set theory provides a thorough approach which can help remove data's ambiguity. In this paper, the Menhaj symbolizing method is used for fuzzy calculations in which the fuzzy number A is from LR type. In this way, every fuzzy number is shown by special functions, called reference functions, which determine the right and left sides of the fuzzy membership function. Figure 1 presents fuzzy number $A = (a, w_A, w'_A)$.

In this article, the fuzzy PROMETHEE method explained by Goumas and Lygerou (2000) is used. In this method, numbers used in calculations of the PROMETHEE method are fuzzy numbers. Of course, total preference and indifference thresholds (p,q) are expressed as definite numbers.

If these numbers were fuzzy, some assessments would become inexact (Goumas and Lygerou, 2000). In addition, the indices' weights can't be expressed as fuzzy numbers because in PROMETHEE the sum of indices' weights should be exactly equal to 1. The preference function applied in this paper is the V-shape function, which is shown in Figure 2.

In Figure 2, d shows the difference between two compared alternatives, q is the indifference threshold and p is the total preference threshold. If d is expressed as a fuzzy number, the V-shape preference function can be written as Eq.10.

$$P(d) = \begin{cases} 0 & (a - w_A) < q \\ \dfrac{(a, w_A w'_A) - q}{p - q} & (a - w_A) \geq q \text{ and } (a + w'_A) \leq p \\ 1 & (a + w'_A) > p \end{cases} \quad (10)$$

Fuzzy operations for calculations using fuzzy numbers to apply the above function are briefly explained in Table 1.

The overall preference of each alternative compared with other alternatives should be calculated and at the end, input and output flows and net flows should be determined for all alternatives.

By finishing the calculations, fuzzy numbers are used to make the comparisons. First, through Eq. 11, fuzzy numbers are changed to definite numbers and then comparisons are made.

$$X = a + \frac{w'_A - w_A}{4} \quad (11)$$

In Eq.11, X is a definite number equivalent to the fuzzy number (a, w_A, w'_A).

3. SUGGESTED METHOD

To evaluate BI in enterprise systems using the fuzzy PROMETHEE method, first the evaluation criteria should be identified. To do so, after studying and examining the literature on this subject, 34 factors influencing BI were identified and are mentioned in Table 2. After identifying evaluation criteria, five enterprise systems were chosen for evaluation and were named ES1, ES2, ES3, ES4, and ES5, respectively.

Table 1 Basic fuzzy operations

Type	Equation
Addition	$(a, w_A, w'_A)_{LR} + (\mathrm{b}, w_B, w'_B)_{LR} = (\mathrm{a}+\mathrm{b}, w_A + w_B, w'_A + w'_B)_{LR}$
Opposite	$-A = -(a, w_A, w'_A)_{LR} = (a, w_A, w'_A)_{RL}$
Subtraction	$(a, w_A, w'_A)_{LR} - (\mathrm{b}, w_B, w'_{\square})_{LR} = (\mathrm{a}-\mathrm{b}, w_A + w_B', w_A' + w_B)_{LR}$
Multiplication by Scalar	$c.A = c.(a, w_A, w'_A)_{LR} = (ca, cw_A, cw'_A)_{LR}$
Multiplication by fuzzy	$(a, w_A, w'_A)_{LR}.(\mathrm{b}, w_B, w'_B)_{LR} = (\mathrm{ab}, bw_{\square} + aw_B, bw'_A + aw'_B)_{LR} \quad A>0, B>0$ $(a, w_A, w'_A)_{LR}.(\mathrm{b}, w_B, w'_B)_{LR} \approx (\mathrm{ab}, bw_A - aw'_B, -bw'_A - aw_B)_{RL} \quad A<0, B>0$ $(a, w_A, w'_A)_{LR}.(\mathrm{b}, w_B, w'_B)_{LR} \approx (\mathrm{ab}, -bw'_A - aw'_B, -bw_A - aw_B)_{RL} \quad A<0, B<0$
Inverse	$(a, w_A, w'_A)^{-1}{}_{LR} \equiv (a^{-1}, w_A a^{-2}, w'_A a^{-2})_{RL}$
Division	$(a, w_A, w_A')_{LR} \div (\mathrm{b}, w_B, w_B')_{LR} = \left(\frac{a}{b}, \frac{bw_A + aw'_B}{b^2}, \frac{bw'_A + aw_B}{b^2}\right) \quad A>0, B>0$

To evaluate the above systems by a decision-making team, six linguistic values were used. These values and their equivalent fuzzy numbers are shown in Table 3. All fuzzy numbers shown in Table 3 are LR. According to linguistic values of Table 3, five alternatives were examined based on 34 criteria by the decision-making team. The fuzzy decision-making matrix for five enterprise systems of the article based on experts' judgment is shown in Table 4. In the following, the procedure of solving the problem using the fuzzy PROMETHEE method will be explained.

Table 2 Business intelligence evaluation criteria (continued on next page).

Criteria ID	Criteria name	Related studies
C1	Group wares	Shim et al. (2002), Reich & Kapeliuk (2005), Damart et al. (2007), Marinoni et al. (2009)
C2	Group decision-making	Eom (1999), Evers (2008), Yu et al. (2009)
C3	Flexibility of decision-making model	Reich & Kapeliuk (2005), Zack (2007), Lin et al. (2009)
C4	Problem clustering	Reich & Kapeliuk (2005), Loebbecke & Huyskens (2007), Lamptey et al. (2008)
C5	Optimization technique	Lee & Park (2005), Nie et al. (2008), Shang et al. (2008), Azadivar et al. (2009), Delorme et al. (2009)
C6	Learning technique	Power & Sharda (2007), Ranjan (2008), Li et al. (2009), Zhan et al. (2009)
C7	Import data from other systems	Ozbayrak & Bell (2003), Alter (2004), Shang et al. (2008), Quinn (2009)
C8	Export reports to other systems	Ozbayrak & Bell (2003), Shi et al. (2007), Shang et al. (2008)
C9	Simulation models	Power & Sharda (2007), Shang et al. (2008), Quinn (2009), Zhan et al. (2009)
C10	Risk simulation	Evers (2008), Galasso & Thierry (2008)
C11	Financial analysis tools	Santhanam & Guimaraes (1995), Raggad (1997), Gao & Xu (2009)
C12	Visual graphs	Noori & Salimi (2005), Kwon et al. (2007), Power & Sharda (2007), Li et al. (2008), Azadivar et al. (2009)
C13	Summarization	Bolloju et al. (2002), Hemsley-Brown (2005), Power & Sharda (2007), Power (2008)
C14	Evolutionary prototyping model	Fazlollahi & Vahidov (2001), Bolloju et al. (2002), Gao & Xu (2009), Zhang et al. (2009)
C15	Dynamic model prototyping	Koutsoukis et al. (2000), Bolloju et al. (2002), Goul & Corral (2007), González et al. (2008), Pitty et al. (2008)
C16	Forward and backward reasoning	Gottschalk (2006), Evers (2008), Zhang et al. (2009)

C17	Knowledge reasoning	Ozbayrak & Bell (2003), Plessis & Toit (2006), Evers (2008)
C18	Alarming and warning	Power (2008), Ross et al. (2009), Zhang et al. (2009)
C19	Recommender/ dashboard	Nemati et al. (2002), Hedgebeth (2007), Bose (2009)
C20	Combination of experiments	Courtney (2001), Nemati et al. (2002), Gottschalk (2006), Gonnet et al. (2007), Ross et al. (2009), Hewettet al. (2009)
C21	Situation awareness modeling	Raggad (1997), Plessis & Toit (2006), Feng et al. (2009)
C22	Environmental awareness	Phillips-Wren et al. (2004), Koo et al. (2008), GüngörSen et al. (2008)
C23	Fuzzy decision	Metaxiotis et al. (2003), Zack (2007), Makropoulos et al. (2008), Wadhwa et al. (2009), Yu et al. (2009)
C24	OLAP (online analysis processing tool)	Tan et al. (2003), Lau et al. (2004), Rivest et al. (2005), Shi et al. (2007), Berzal et al. (2008), Lee et al. (2009)
C25	Data mining techniques	Bolloju et al. (2002), Shi et al. (2007), Berzal et al. (2008), Cheng et al. (2009)
C26	Data warehouses	Tan et al. (2003), Tseng & Chou (2006), March & Hevner (2007), Nguyen et al. (2007)
C27	Web channel	Tan et al. (2003), Oppong et al. (2005), Anderson et al. (2007), Power (2008)
C28	Mobile channel	Power (2008), Wen et al. (2008), Cheng et al. (2009)
C29	E-mail channel	Granebring & Re'vay (2007), Baars & Kemper (2008), Wen et al. (2008)
C30	Intelligent agent	Gao & Xu (2009), Lee et al. (2009), Yu et al. (2009)
C31	Multi agent	Bui & Lee (1999), Xu & Wang (2002), Granebring & Re'vay (2007)
C32	Multi-criteria decision-making tools	Hung et al. (2007), Yang (2008), Marinoni et al. (2009), TanselIç & Yurdakul (2009)
C33	Stakeholders' satisfaction	Goodhuea et al. (2000), Lönnqvist & Pirttimäki (2006), Evers (2008), González et al. (2008)
C34	Accuracy and reliability of analysis	Gregg et al. (2002), Lönnqvist & Pirttimäki (2006), Phillips-Wren et al. (2007), Zack (2007),González et al. (2008), Power (2008)

Step 1: After determining the fuzzy decision-making matrix, the difference between each of the two alternatives is calculated as *d,* in the form of a pair. These numbers are calculated by subtraction relation, shown in Table 1.

Step 2: In this phase, the amount of P(d) is obtained through Eq. 10 with regard to the preference function used in the article.

Step 3: In this phase, the decision-making team is asked to determine the weight of each criterion by using LR fuzzy numbers. Then, by normalizing the weight of each criterion through Eq.12, which is in the form of fuzzy numbers, the definite weight of each criterion is obtained.

$$W_j = \frac{a_j}{\sum_{j=1}^{m} a_j} \tag{12}$$

Step 4: After determining the values of P_j and definite weights, the overall preference indexes should be calculated through Eq.13. In this method, $j = 1,2,\dots,m$ indicates the criteria.

$$\pi(a,b) = \sum_{j=1}^{m} p_j(a,b).w_j \tag{13}$$

Table 3 Linguistic values and fuzzy numbers.

Linguistic value	Fuzzy number
Very low	(0 , 0, 0.2)
Low	(0, 0.2, 0.2)
Medium	(0.4, 0.2, 0.2)
High	(0.6, 0.2, 0.2)
Very high	(0.8, 0.2, 0.2)
Excellent	(1, 0.2, 0)

Step 5: In this phase, the leaving flow ($\emptyset^+$) and entering flow ($\emptyset^-$) for each alternative are calculated with regard to the amounts obtained in step 4 and by using Eq.14 and Eq.15. In these, A is a set of alternatives and n is the number of alternatives.

$$\emptyset^+(a) = \frac{1}{n-1} \times \sum_{x \in A} \pi(a,x) \tag{14}$$

$$\emptyset^-(a) = \frac{1}{n-1} \times \sum_{x \in A} \pi(x,a) \tag{15}$$

For example, in the problem under examination, leaving flow and entering flow values for ES1 are calculated as follows:

$$\emptyset^+ = \frac{\left(\pi(ES1,ES2) + \pi(ES1,ES3) + \pi(ES1,ES4) + \pi(ES1,ES5)\right)}{4}$$

$$\emptyset^- = \frac{\left(\pi(ES2,ES1) + \pi(ES3,ES1) + \pi(ES4,ES1) + \pi(ES5,ES1)\right)}{4}$$

Step 6: The leaving flow and entering flow values cannot rank the alternatives completely. Therefore, another concept named the net flow value is introduced, which is an instrument for ranking all alternatives. This value is obtained through Eq.16.

$$\emptyset\,(a) = \emptyset^{+}(a) - \emptyset^{-}(a) \qquad (16)$$

Step 7: In this phase, through Eq.11, we can change net flow values that are fuzzy numbers into definite numbers and rank the enterprise systems with regard to the results.

In Table 5, the leaving and entering flow values of all five enterprise systems are shown in columns 1 and 2. The fuzzy net flow values and their definite equivalence values for different alternatives are described in columns 3 and 4. Indifference threshold is considered to be zero for all alternatives and the total preference threshold is set to 0.9.

Regarding the net flow values of five alternatives, the final ranking of the enterprise systems is: ES4, ES2, ES5, ES1 and ES3 respectively. The evaluation of the obtained results shows that the suggested method has a good performance in determining the best enterprise system.

4. CONCLUSION

A correct evaluation of enterprise systems is important for organizations' managers. BI evaluation tools and models used as a decision support system in enterprise systems can help managers to make the right choice and decisions. Therefore, in the present paper a model is presented to evaluate and rank the enterprise systems using BI and it is tested through a case study. The suggested model uses the fuzzy PROMETHEE method for evaluation and ranking, based on the PROMETHEE method as one of the best methods of multi-criteria decision-making.

Table 4 Fuzzy decision matrix.

Criteria	Alternatives					
	ES1	ES2	ES3	ES4	ES5	
C1	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	
C2	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	
C3	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	
C4	(0.2 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	
C5	(0.6 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	
C6	(0.4 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0 ,0 ,0.2)	
C7	(0.8 ,0.2 ,0.2)	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)	(1 ,0.2 ,0)	(0 ,0 ,0.2)	
C8	(0.6 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)	
C9	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.6 ,0.2 ,0.2)	
C10	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	
C11	(0.4 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	
C12	(1 ,0.2 ,0)	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	
C13	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(1 ,0.2 ,0)	
C14	(0.8 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0 ,0 ,0.2)	
C15	(0.2 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0 ,0 ,0.2)	
C16	(0.2 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0 ,0 ,0.2)	
C17	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0 ,0 ,0.2)	
C18	(0.6 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	
C19	(0.8 ,0.2 ,0.2)	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	
C20	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	
C21	(0.2 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	
C22	(0 ,0 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0 ,0 ,0.2)	
C23	(0 ,0 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	
C24	(0.6 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(1 ,0.2 ,0)	(0.4 ,0.2 ,0.2)	
C25	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	
C26	(0.8 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)	
C27	(1 ,0.2 ,0)	(0.8 ,0.2 ,0.2)	(1 ,0.2 ,0)	(1 ,0.2 ,0)	(0.8 ,0.2 ,0.2)	
C28	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(1 ,0.2 ,0)	
C29	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	
C30	(0 ,0 ,0.2)	(0.6 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	
C31	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.4 ,0.2 ,0.2)	
C32	(0.6 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	
C33	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	
C34	(0.6 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	

Table 5 Ranking with PROMETHEE. Alt. = alternative, D∅ = defuzzied ∅, R = rank

Alt.	$\emptyset^+$			$\emptyset^-$			$\emptyset^{net}$			D ∅	R
ES1	(0.596	,0.057	,0.046)	(0.085	,0.075	,0.043)	(-0.026	,0.100	,0.121)	-0.0209	**4**
ES2	(0.074	,0.097	,0.075)	(0.054	,0.050	,0.035)	(0.019	,0.132	,0.125)	0.0174	**2**
ES3	(0.046	,0.044	,0.022)	(0.080	,0.100	,0.081)	(-0.033	,0.125	,0.122)	-0.0367	**5**
ES4	(0.112	,0.100	,0.069)	(0.050	,0.046	,0.029)	(0.062	,0.130	,0.115)	0.0586	**1**
ES5	(0.076	,0.064	,0.041)	(0.097	,0.092	,0.065)	(-0.021	,0.129	,0.133)	-0.0204	**3**

In order to remove the problems and ambiguities that result from changing the observations to definite variables; fuzzy numbers are used in the calculations of the PROMETHEE method. Here, 34 criteria were examined to evaluate the enterprise systems identified by reviewing the literature.

To improve and develop the present study, the following ideas are suggested for further research;

1. Using other multi-criteria decision-making models to rank enterprise systems;
2. Investigating other multi-criteria decision-making models in fuzzy and definite moods and comparing the results with each other;
3. Finding the most influential and the most influenced factors among the 34 factors.

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Economic and industrial espionage at the start of the 21st century – Status quaestionis

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ABSTRACT This article is a literature review where the aim is to define a *status quaestionis* for the field of economic and industrial espionage. History shows how those who engage in these activities often are the scientifically and industrially weaker party, the party that is learning or trying to catch up. On a global scale economic and industrial espionage can be seen as a form of *involuntarily sharing* that has a series of positive results for economic development. On the scale of the individual businesses attacked, and for tax authorities in those countries, it is a troublesome phenomenon that must be regulated and punished. Governments must prepare society for systematic and frequent cyberattacks. Private companies are wise to move to stricter security controls, which must include encryption. A number of specific research projects are suggested throughout the article. In the literature we have identified the following agent motives: the employee who *needs money, has split loyalties, leaves angry, the occasional thieve and the professional spy.*

KEYWORDS Economic espionage, hacking, industrial espionage, literature review, signal intelligence

1. INTRODUCTION

About ten years ago - in 2005 - I defended a doctoral thesis on industrial espionage in Germany (Solberg Søilen, 2005). Now the question arises: what has changed in this field over the past decade? A quick look shows that the capabilities and practices have seen a degree of change that is nothing short of a revolution. In the late 1990s, when I did most of the literature research, government institutions were lagging far behind in technology. Private companies were dominating the field with customer relation management (CRM), business intelligence (BI) and what was to become data mining (DM). The important technical contributions all came from different private actors, but it was made possible by massive government funding. It is a myth that the internet was created within the military. Espionage companies were suddenly doing what only states had done previously. After the Cold War thousands of spies had been dismissed and were seeking jobs in the private sector, a reason why there is still a concentration of corporate espionage consultancy around Langley, Virginia, USA. This was a period of private intelligence gathering. Many of the ideas about gathering large amounts of data on users grew out of the marketing field and were related to customer loyalty programs, bonus cards and in-depth customer segmentation.

My dissertation was about industrial espionage in trade negotiations. Negotiations are still a primary target for agents but the field has been vastly expanded. Just like then, companies today are still poor at detecting and stopping attacks, preferring to simply fire the alleged culprit hoping to avoid negative

publicity (Schultz, 2001, p. 202). There is always a fear that admission of breach may lead to loss of confidence and lower share price. So the stories seldom become public, if they are not leaked by state intelligence organizations or spread as anecdotes by retired executives at cocktail parties.

Spying on allies for economic gains has been normal practice within Europe for many years, especially ahead of major European summits (Corera, 2016, p. 361). German intelligence can detect increased activities before commercial negotiation with the Chinese. Most of the attacks are traced back to the same cities: Beijing, Shanghai and Guangzhou (Corera, 2016 p. 242). At other times, hacking attempts have come from Hainan, which is the headquarters of signals intelligence for the People's Liberation Army (PLA). Other attacks come from Chinese universities and may be just for practice. Western adversaries are engaged in many of the same practices.

For spies, the use of the computer is far safer and less risky than snooping around in person. When we copy from a personal computer instead of stealing a briefcase we do not leave a trace if we are good, so it's an attractive form of espionage. It's also difficult to separate good from bad guys on the internet, which makes the place a natural environment for deception schemes.

Our computers are faced with possible hacking (mainly fishing) attacks every day. This has become normal. Computers are simply not safe. Even though safe email services exist, like Phil Zimmermann's PrettyGoodPrivacy (PGP), created in 1991, which caused no end of panic in the US government and the US Naval Research Laboratory's TOR, companies are slow to adopt it, maybe because they find it difficult to use or are afraid that the messages cannot be opened by the receiver or will arrive much later (Schultz, 2001, p. 206).

Before we look to the literature and the discussion it's necessary to give some background to the field of economic and industrial espionage to describe current capabilities.

1.1 Definitions capabilities for economic and industrial espionage

Economic espionage (also *government espionage*) is a government's efforts to collect information, appropriate trade secrets, and steal knowledge (Nasheri, 2005). *Industrial espionage* is the same, but without direct government involvement. *Information warfare* (also *cyberwar*) on the internet, as conducted by the military, is a version of economic espionage where the primary aim is first of all to destroy vital infrastructure in another country, not to steal company secrets or help companies become more competitive.

Private companies gather their data either from the traces we make when we engage on their sites or by active searches on the internet, such as when we look up a name on a site. Governments gather their data by controlling the entry points where the internet is brought into a country, by setting up black boxes inside of telecom companies and by tapping data directly from the databases of private companies like Microsoft or Facebook by forcing them to build side doors (in the US this is controlled by the 2008 Foreign Intelligence Surveillance Act). FISA says the government has the right to collect any data that comes through your software program and that you are obliged to facilitate this gathering. They also get data through a system of information exchange with other countries. Private telecom, internet and software companies cooperate with their national intelligence organizations because they know they have to in the end, or because the government is a major customer or out of some feeling of patriotism. The public at large is unaware of these deals and forms of cooperation.

In the end, the internet is a physical infrastructure consisting of cables and routers. More than 90% of the world's data pass through fiber-optic cables (Corera, p. 306) and the US (most of the rest pass via other UKUSA member states). Foreign powers can now break into anything that is connected to the internet. With the help of traditional agents (carrying malware on a USB stick) they can also break into closed systems. Of concern to private organizations is that this knowledge is just as easily available to their competitors.

An important strategic advantage is related to who can supply the cables and internet infrastructure. Today there are only two companies that are suppliers of complete telecoms networks in the world: Huawei and Ericsson. The US has made a point of not letting Huawei in to the US due to allegations that it's a spying tool for the Chinese government. The only evidence so far is that the NSA has spied on Huawei since at least 2007 (Corera, 2016, p. 373). Huawei may soon

be the only major supplier that can set up and run a telecoms network from scratch if Ericsson is outcompeted, as is indicated by recent sales figures and economic results. We do not know what Huawei will be like in the future, once it has established its role as the dominant supplier.

All this raises a number of questions as to how companies can protect their secret information. The aim of this paper is to try to define a number of these questions for future research based on a literature review of scientific papers and books published during the past ten years (the research gap) followed by a lengthy discussion on some key issues.

2. METHOD

How does one perform research into economic and industrial espionage? Is it even possible? Most sources are based on interviews with employees of western intelligence services and will naturally be skewed in that direction, for example showing how they never engage in economic espionage themselves but try to stop it when it comes from other, unfriendly nations. The us-and-them rhetoric is strong in these sources (mainly books). All services systematically exaggerate the dangers coming from other countries to obtain larger budgets and employ more staff. The assumption here is that one party is predominantly good. Compared with current as well as historical events of aggression between states since the Second World War it's difficult to make this claim stick. Thus, this method can at best be seen as telling one side of the story. The companies themselves do everything in their power not to tell stories about when they are hacked or cheated as it is considered negative publicity.

When authors or researchers do get access to information about industrial espionage inside of companies they have typically had to sign hefty confidentiality agreements. Thus the names of real companies and people are hidden and the stories are one-sided.

One solution to these biases is to set up laboratory experiments where the subjects do not know what is being measured (contrived study setting). Laboratory experiments can be set up as a role play with case studies indicating different roles. The easiest way of running such experiments is with graduate students, but they are not representative of the population we are trying to measure. To strengthen the reliability of the findings such studies can be supported by running the games inside of real companies. A further layer of extending redundancies in method can be done by comparing these results with interviews of executives (Solberg Søilen, 2005). Using the laboratory experiment, a multiple cross-sectional study with constructs measured at multiple points in time and the use of different samples may be imagined. The method is far from perfect when it comes to eliminating biases but relatively good given the nature of the object studied.

When writing on a sensitive issue there is often a considerable delay in the empirical data presented: a story is often first leaked many years after an incident happened. Thus publications today typically reflect a reality that is no longer existent. The more technology that is involved in the problem statement the more prone the answers are to be outdated by the time of publication. In general, however, a number of research strategies are possible: experiments, survey research, observation and case studies.

For this paper a combination of literature review and discussion is chosen to try to define a *status quaestionis* for the field. The aim is to identify a series of new and interesting research problems. As such this paper may be seen as a first step in hypothetic-deductive research. The nature of the subject is more open for exploratory and descriptive research.

Web of Science renders 104 references on the topic of industrial espionage. Forty of these are articles, and, most (8) are written for the study of history. From these the author selected and read little more than two dozen articles based on their relevance for business studies. These and related topics are discussed and future studies defined.

3. LITERATURE REVIEW

Thorleuchter and Poel (2013) confirm that government and industrial espionage has become an increasing problem for governments and corporations. An article in the *Journal of Professional Engineering* (2007) describes how the international Bar Association has warned that businesses are more at risk than ever. This development has been facilitated by users having weak passwords for their systems, a problem identified more than fifteen years ago by Schultz, (2001) and still a major culprit. Thus there are several articles that confirm the existence, the degree and some of the causes of the problem. Other articles focus on solutions.

Lee (2015) attempts to show how criminal profiling can be used to prevent industrial

espionage. An empirical analysis from South Korea published by the National Intelligence Service (NIS) shows that leaks from big companies come from current employees and from ex-employees in 47.8% of the cases each. For small and medium sized companies the numbers are 5.1% and 71.8% respectively (p. 1693). This means that for small and medium sized companies the problem is basically ex-employees, but that in big companies there problem is evenly spread. It means that for small and medium sized companies the problem of leakages is so small that it may not require our attention. If this data is reliable and applicable to other countries the findings are of great interest.

Meyersson and Glitz (2016) are interviewed in HBR about a large empirical analysis done with data from the DDR during the period 1969-1989, which found that East Germany enjoyed significant economic returns from its government espionage. More interesting, the authors suggest that the DDR was so successful with industrial espionage that it may have crowded out standard forms of R&D (p. 30). For example the DDR was able to reverse engineer the IBM 360 in 1970 so that a company from Dresden was able to make 100 computers per year three years later (p. 31). The authors suggest that this strategy may lead to less R&D by a group's own efforts and therefore an industrial decline in the long run for nations faced with free competition. This raises a strategic question as to which countries, and maybe more interesting for business studies, which industries and companies, are to gain the most by espionage.

Economic and industrial espionage finds interest among a variety of schools of economics, and solutions are suggested using different scientific methods and approaches. For example Barrachina et al. (2014) make an elaborative attempt of a game theoretical approach to economic espionage that show in which case espionage can make the market more competitive.

Another highly analytical paper is presented by Ferdinand and Simm (2007). They analyze industrial and economic espionage as a form of learning. For example Chinese students come to the West to learn as much as possible. The work of Ferdinand and Simm (2007) builds on Greve (1998), Kraatz (1998), and Baum et al. (2000), who describe how organizations learn from their competitors. Following the work of Bapuji and Crossan (2004) Ferdinand and Simm (2007) analyze espionage as a form of external learning (EL) without collaboration, what they also call larcenous learning (LL). This may be a fruitful approach as it gives insights into the motives of much industrial espionage. It is also a constructive conceptual way to avoid the complicated moral discussions which tend to go nowhere (not that they are not important).

As argued by Polanyi (1967), stealing knowledge may in itself be insufficient if we do not have the ability to apply it. Attempts of theft are therefore often followed by attempts to hire key personnel and make other prearrangements. Sometimes in history this has even come to include kidnapping (DeCamp, 1974, Cipolla, 1993). From a strategic perspective this means that espionage should not be seen as an isolated phenomenon, but as a plan for R&D that includes other elements in conjuncture. The question is what elements do you need in addition to the secret information? According to Cotte (2005) technological eve is a precondition for innovation and therefore also for efficient espionage, the importance of which the author considers to be exaggerated, almost a quasi-mythical phenomenon.

According to a study by Sivanesan (2011) agents are normally recruited from science and technology academia. Today preparations for identifying and locating potential agents are normally done on the internet. As an example, LinkedIn is frequently used for this purpose. An initial contact and follow ups are often made on this and similar sites. In the old days recruiting agents used to be a risky and time consuming exercise (instructions though classified ads in a newspaper, etc.). Intelligence services are patient and can spend months cultivating a relationship before they find a way to persuade the agent to hand over valuable information, but this is also a more costly process. Often agents contacted in this way do not know that they have been recruited as spies, but think they are part of a normal market research or consultancy job outsourced to some entity. Again the internet shows itself as an arena for deception. Universities are an especially attractive target, as they, by definition, contain a concentration of knowledge workers with access to cutting edge research. A question that arises is which countries are pointed out as economic spies in the literature? Sivanesan (2011) claims they come from Russia, China, and more generally from the Middle East, Asia and North Africa. Another approach is to define who has the capabilities to perform economic and industrial

espionage and assume that these are being or will be used sometimes in future, for example under another head of state.

New political leadership can lead to increased economic and industrial espionage. But the internet can also help a new group of politicians get elected. A reoccurring topic today is whether false information and disinformation threatens the political model of democracy. Companies operating on the internet pay little attention to if information is true for false. Instead they tend to put all focus on internet traffic; that is how many users they have. False stories are spread just as quickly as and sometimes even quicker than true stories. For example Facebook has been criticized for facilitating spreading false information as news during the last political election in the US between Hillary Clinton and Donald Trump. Agents of false news use Twitter and other networks to create fake accounts that spread untruths or inject fraudulent chatter into the conversation. Dictatorships have been known to create fake videos and images and upload them to YouTube and other websites in the hope that news organizations and the public will find them and mistake them for real (Silverman, 2012). The companies themselves refer back to the freedom of press and argue that censorship is not something they can or will engage in.

At the same time never before in the history of journalism have more people and organizations been engaged in fact checking and verification. Never before has it been so easy to expose an error, check a fact, crowdsource and bring technology to bear in the service of verification. A politician or public figure who publicly asserts a falsehood is likely to be called out by fact-checking organizations such as FactCheck.org.

The problem is that rumors and falsehoods spread just as quickly, if not faster than, facts. In many cases they prove more compelling, more convincing, and more are more clickable. This development threatens democratic values and the electoral outcome of political elections, the argument goes. Research by Nyhan and Reifer (2015) suggests the internet may be ineffective at reducing public misperceptions about controversial issues. That is, once a false perception has rooted itself it is difficult to correct it. Thus the argument of legislation for more restricted use of the internet against such practices becomes important not only to guarantee a higher degree of truth in the information that is spread but also for political stability. China and other countries that were early to regulate the internet see this as a victory for their approach.

From the above a number of issues are identified and presented as a discussion in the next section where the aim is to present a series of theses based on arguments.

4. DISCUSSION

By looking at the different cases of economic and industrial espionage used as examples in the literature through history some patterns become clear. The first is that those who engage in economics of industrial espionage are often the scientifically and industrially weaker party, the party that is learning or trying to catch up.

At the turn of the 19th century the USA was the student. In 1811 an American by the name of Francis Cabot Lowell almost singlehandedly stole the knowledge of how to build a textile industry from Britain (Mendell, 2003). England a few generations earlier wanted to learn how to make their own tea instead of buying it from China. In 1789 Robert Fortune smuggled thousands of tea plants and seeds to Darjeeling in British imperial India. Also the French stole secrets from China. The process of making true porcelain was also stolen from the Chinese and introduced in Europe by Père Francois Xavier d'Entrecolles (Bergier, 1975). The Jesuit travelled to China in 1698 and the theft can be seen in letters dated 1712 and 1722 (Bergier, 1977). For early self-educated industrialists travelling was the standard way of learning. Actually, learning by travelling has been a well-used method for acquiring a competitive advantage throughout history (Solberg Søilen, 2016). A classic is Charlers Dupin's six volume "voyages dans la Grande-Bretagne (1821-22). In the late 1960s and early 1970s when the Japanese were trying to gain a competitive advantage, a government sponsored system of industrial espionage was set up through The Japanese External Trade Organization (JETRO) partially funded by the government. JETRO train people to look for new technologies (Fialka, 1997). Japan is one of the few well documented cases of a country that was systematically spied upon by the US, especially before and during trade negotiations (Solberg Søilen, 2005). American disrespect for the privacy of Japanese citizens and companies makes an interesting case as both the US and Japan are dependent on good relations in Asia to counter Chinese dominance in the region. It may be because the US considers Japan to be

the weaker part and that they are entitled to treat Japan in this way due to atrocities committed by Japanese soldiers during the Second World War. Japan has few alternatives to American cooperation as they have not even apologized for the atrocities they committed in China during the same war.

Today it is not the Japanese as much as Chinese who fill the role of student in many industries in countries like England and the US. One of the well-known examples of Chinese espionage is Tenhong Lee from Taiwan (also called the glue man) who worked in an American company making glue-based products. He performed industrial espionage for a Taiwanese competitor (Ferdinand and Simm, 2007). One of the reasons the case is well know is that it went to court where we learned about the complex motives behind Lee's actions.

Thus we have come full circle when it comes to industrial espionage within a few centuries and there is nothing to suggest that these alternating roles of who stand to profit from spying and who stand to lose will remain static. Instead we may assume that this will continue to change with the alternations in the competitive advantage of nations, unless a better set of international laws and agreements can be established.

4.1 The moral dimension and regulations

Are economic and industrial espionage theft? Or, is it simply learning, as some of the literature suggests? Larcenous learning (LL) is adapted in organizations and countries in early stages of development. It's a rational strategy as it is faster than developing your own R&D capabilities, and it's also cheaper. Can economic and industrial espionage be justified when one considers that many of those companies holding secrets are monopolies and that the spread of industries to new countries helps fight poverty and prepares the way for a large middle class in those countries? Throughout history it can be shown how industrial espionage has helped fight poverty. China is only the latest example, bringing 500 million people from the poor classes to the middle class. How much is due to economic and industrial espionage is difficult to say, but we can assume that it has had a positive effect. Learning countries often start by making cheap copies of established brands and products. As their sales increase they are able to improve the quality of their products which again raises the possibility of charging a higher price. This is the way for Japan, China and all of the four Asian Tigers. In addition we have seen that research also suggests that certain forms of espionage can make the market more effective. When the information system (IS) quality is the private information of the entrant, the incumbent is better off with an IS of high expected precision while the entrant benefits from one of high quality (Barrachina et al., 2014, p. 127). There are several arguments for why economic espionage is improving both markets and societies. We suggest here that economic and industrial espionage can be seen as a form of *involuntarily sharing,* which can be good on the macro scale but is devastating on the micro scale. For the individual company and the country where that company is taxed, economic and industrial espionage is an economic loss. It is a crime and it is an intrusion on individual life.

All nations try to protect their own secrets by making laws that protect them, laws that are difficult to enforce outside of their own sovereign territory. There are no written rules in espionage between countries and foreign services, at best an understanding and form of balance. For some offenses there is a logic of guaranteed retaliation, a bit à la Mutual Assured Destruction (MAD) to use a parallel from the Cold War. We see this in examples of cyberwarfare. Moral and legal questions should be discussed further within the framework of moral philosophy and the study of international law. It is a dangerous moment for man when we accept the premises that stealing and treason are just the way of the world. It may be a part of human nature, it most certainly is a part of our history and as shown here it can have positive effects on the macro level, but agreements about conduct are necessary and countries can show political will by standing behind international laws and agreements.

If we are to catch agents we must know what motivates them. The "glue man" was motivated by ego and power not money, and he also suffered from divided loyalties, as he wanted to help both companies. To assume that agents simply look for the money then is an oversimplified view of reality which can make us look in the wrong directions. If companies can better understand the agents' motives they can also more easily stop them, or persuade

them to act differently. Risk profiles can be identified in any company. Even the term agent needs to be broken down into subcategories as it has been suggested that most industrial espionage is carried through by employees already employed or leaving a company (in large companies). They may or may not be working with a foreign state or a competitor. Many employees simply take information because it is easy and they know it is valuable, but without knowing what they will do with it. Others, like Mr. Martin who worked for Booz Allen Hamilton, major contractor to the NSA, knew what to do with it before he was caught, but had not made the contact with competitors yet. It was the opportunity, or the occasion, that made him a thief. Thus we can speak about the following motives in economic and industrial espionage: the employee who *needs money*, has *split loyalties*, *leaves angry*, the *occasional thieve* and the *professional spy*. For cases of economic espionage where foreign states are involved in hacking the situation is different and clearer. Most spies here have a monthly salary. They are employed by the state to spy and are simply doing their job. Others are contractors or sub-suppliers. We must assume that fewer spies are motivated by political conviction today as the political divide (ideologies) between countries play a less significant role, but this may of course change.

A general problem in the literature, as briefly discussed in the methods, is the one-sidedness of the perspectives presented, especially when it comes to dealing out blame. When a book on industrial espionage is written in the UK today, then everyone else is considered to be the bad guys, for example the Chinese and Russians. The people interviewed in these books (and more worryingly, the author) want us to believe that the world's largest surveillance systems developed in the Western world are never used aggressively, but put in place only to defend our information and freedom. The same sources that are interviewed have no reservations about lying to elected politician in our national assemblies, and not only in the US. Leakages by Edward Snowden and others have confirmed suspicion. For example, the heads of American intelligence have all been caught lying before the Senate about spying on Americans. Obama lied when he said that PRISM was only used to spy on foreigners (or he too was seriously misled, which is not less worrying). PRISM showed that state organizations have a side door to the software we buy and how private data that is gathered about us on the internet is used. Snowden showed that the US is a major aggressor.

After these leakages much of the trust between state and citizens was broken, to say nothing about the trust between the American state and other nationals. After a series of unjustified wars in the Middle East, America is now close to moral bankruptcy in the sphere of international politics, discredited from outside and more worryingly from within. That is not a good thing for world stability.

A major problem with much of the existing literature on economic espionage is not only the one-sidedness but also the obvious extent of "moralism", blatant and uncritical condemnation of what other countries are doing. For example it is said that only China and Russia are engaged in economic espionage, how it was China who pioneered the use of computer espionage to target Western companies for economic gain or we are given excuses such as that the difference between intelligence and information is less clearly defined in China. Another approach is to recognize that all major services are engaged in economic and industrial espionage, but that some are more active than others. We may assume that countries that have the most to gain by economic espionage are more active and that those espionage capabilities that are being built will be used. There is no evidence that suggests otherwise.

Stories of moral superiority are spread to strengthen the conviction that one side has the moral high ground. Once citizens are convinced that their own state has that high ground they can do all sort of things and get away with it, like engaging in economic espionage or starting wars. The intelligence apparatus is part of this logic that spread stories of us-and-them, also for their own advantage to get larger intelligence budgets.

Experience so far has shown that good books on economic and industrial espionage are based more on leaked sources than on interviews with people under oath who have signed secrecy papers. We should always listen to the executive or politician who has nothing to lose, who has been fired or suffered from injustice. In the quest for objective information Open Source will continue to play an important role here.

Technology is both an opportunity for better information and a threat to the same development as we have seen. Going from

surveilling our computers to mobile phones is a great leap for intelligence organizations and private organizations alike. We can now follow people (targets/customers) in real time. For example with the help of beacons we can see when a customer is in the store and what he looks at. This information can later be used to send highly targeted advertising. The same technology can be used to gather information about terrorists' whereabouts.

For intelligence organizations planting bugs in homes was always risky. Now we carry those bugs around with us all of the time and our microphones and video cameras can be tuned on and operated remotely by others. As a species we have taken a major step into *the total surveillance state,* so it is surprising that more citizens are not reacting. The reason for why more are not reacting should be studied by psychologists.

The increase in false information is a product of this new technology. As we have seen it now spreads rapidly on the internet and is difficult to correct. Voters are willing to disregard more serious and objective news sites when they make up their mind about whom to vote for and why. At the same time it has never been easier to find good and reliable information. The problem is that correct information takes so much training and demand that we are more critical as readers. This has put a new layer of responsibility on our learning institutions which they have not been able to handle so far. If we as societies do not develop a more critical ability towards what is published on the internet then manipulators will get the upper hand. We have been there before in history, when demagogues ruled and it never ended well. That in itself is a reason to regulate publications on the internet. How this is different from censorship is a challenge for scholars to show before policies are decided and implemented. The principle of freedom of press works only as long as there is someone responsible and is therefore a poor parallel for the world of the internet. It seems clear that a solution will have to include more legislation, policing and enforcement.

Our companies are just as vulnerable as the general public to misinformation and internet attacks. They don't normally know when they are being attacked, when a part of their own network traffic is due to intrusions. Foreign states continuously look for intelligence in connection with companies' mergers and acquisitions activity, joint venture intentions, and strategies. Companies surveille each other or their customers like when auction houses look for signs that art collectors are getting older and may be willing to sell. Criminals try different scams to get access to credit cards and other valuables. In the end they are only protected by the expertise they have developed within their own organization.

4.2 Cyberwars and challenges faced by government institutions for signal intelligence

In 2014 Sony Corporation was attacked to the point where servers and computers were all cleaned of data. The company had to pay its employees in paper checks and there was no contingency plan. In this case the company got some help, at least afterwards. A few months later the NSA shut down the entire internet and mobile phone data in North Korea for a short time as a direct retaliation. Cyberwar is a threat that can strike any private organization, not only suppliers of infrastructure, but any company that infuriates another country or its rulers. Moreover the companies attacked do not know if they are been harmed because of something they have done or something they could have done as many attacks are mere exercises. These exercises can be initiated by a foreign country's intelligence apparatus, but may also come from universities, even from within their own country.

Economic and industrial espionage over the internet (preventing it, and even carrying it out) is the business of signals intelligence (SINGINT). In the US this means the National Security Agency (NSA), in England the GCHQ and in Sweden the FRA.

Information warfare has become very real. The Cyberarmy is to the 21st century what the air force was to the 20th century. It is now the fourth army group next to the army, navy, and air force. As a consequence militaries all over the world are building their own cyber-armies, some of them like Iran after having suffered from massive attacks by other countries (US, Israel and UK primarily).

The US, England and Israel showed that they can take control of a country's nuclear facilities even in a closed computer system not connected to the internet by getting an agent to put in a simple USB drive with an operation known as "Olympic Games", but better known after the name given to the malware: Styxnet.

What they did not foresee was that this triggered a massive response by Iran. Iran answered with two major attacks, one against Aramco and another against American banks. In 2012 Iran took down the computer network of the Saudi oil giant Aramco for 8 days. A few weeks after they showed they can take down customer services offered by the Bank of America (Corera, p. 280-1). This led to an American-Iranian deal of de-escalation that left Israel infuriated and the UK uncertain that they should have entered the cooperation in the first place, according to Corera's sources.

Cyberwar and cyber armies are a reality after Styxnet, and this and similar codes have since spread to many countries. A problem is that we do not know the extent of other countries' capabilities for cyber warfare as they have not been fully tested. In a worst case scenario countries and companies must assume that all they do online can be stolen and stopped if they do not have a vigorous security system in place, which also takes into account the possibility that an employee may be used as a vehicle, even involuntarily. Needless to say this degree of security is hardly found in any organization.

The problem with cyberattacks is that it's difficult to know who is attacking you, whether it's your own state, another state or another company.

Michael Hayden defined the types of attackers as states, criminals and a third groups consisting of "hactivists", "anarchists" and "nihilists" (Corera, p. 301).

During the last American presidential election we witnessed how Russian intelligence was able to influence the outcome of the election by hacking the email account of Clinton's campaign manager and leaking the information, bluntly exposing the Clinton campaign's strategies but also portraying the candidate and her staff as cynical and unconcerned about voters' interests. The real damage of these intrusions is still being evaluated. Their significance is still difficult to oversee aside from the obvious fact that they may have helped Donald Trump win the American presidential election. On one side there is nothing new with these intrusions. Both Russia and the US have been interfering in other countries' elections for more than a century, as other great powers have done before them. However, this may be the first time Russia has succeeded with such an operation in the US and the first time the US got a taste of some of its own medicine, after having meddled systematically in political election all over the world since the Second World War.

Hacking is all about getting access to source code, so the attacker can identify how a system is made and where the weaknesses or hacking opportunities are. Hindering spying is about checking the source code for backdoors, which can be used by foreign governments. For example Microsoft has to show at least some of the code for its products to be sold in China as China knows that Microsoft is obliged through American law to alter their software to allow for American spying.

These episodes are often portrayed as a conflict between states and private companies, like when Facebook's Mark Zuckerberg lashed out against the American president for PRISM. In reality many private technology companies live in a form of symbiosis with national intelligence organizations. They exchange employees/expertise and do business with each other. Both are also in much the same business, in the information industry, where the primary aim is the gathering and exploitation of data. They also cooperate.

In the first half of 2014 Google received 15,000 government request for user data from different countries. They complied in 65% of the cases (Corera, p. 380). Social media and Google are themselves in the spying business, selling private information to companies for advertising. The main difference is that it is done by consent (at least formally, but no one reads the fine print) and that customers can opt-out. Further research should aim to show the extent to which this cooperation is done.

For those citizens fearing a total surveillance state, it is sometimes argued that intelligence organization are selling security. The privacy debate exists but is not strong today. Instead states do what they can and lie about the rest. For example they claim that they are not surveilling their own citizens, but in reality they cannot separate this data from other foreign data. Instead all is collected. The NSA are wiretapping the whole world and we as world citizens are to believe that this is for our own best interest as America will protect us all. It is a hard sell today. The major reason why other nations and their elites comply is that the NSA is also sharing a part of this information, with other countries like Germany and France that do not have the same technological capabilities. The intelligence that is passed on by the NSA to other countries is sometimes invaluable for catching terrorists.

Sometimes the intelligence is passed on as part of intelligence swaps (getting access to data the other party does not have) and sometimes it is simply goodwill. Of course they only swap between friends. It would be of interest to know what other countries think about these issues and the extent to which new intelligence alliances are formed.

The NSA was the result of a need for a more centralized intelligence system after the disaster of Pearl Harbor and failings in the Korean War (Corera, 2016, p. 51). In the shadow of what President Eisenhower called the 'military-industrial complex', there emerged a spy-industrial complex centered in Washington, DC and northern California. By the early 1960s, over 50,000 Americans were involved in signals intelligence (Corera, p. 62-64). Today the US has a total dominance of the infrastructure of the internet. Bluffdale Ohio is the strategy to gather and save it all, every piece of digital trace a person leaves; not only surfing, but financial records, tickets, photos, chats, phone calls and GPS data.

The major security risk with this project is that it is done by non-military and private contractors. At the NSA less than 50% of staff today is military and much has been out sourced to a few big contractors of which Booz Allen Hamilton is the best known. It was the employer of Edward Snowden and more recently Harold Thomas Martin. Spy-hunting has been outsourced to private firms and private employees are receiving top security clearance:

"Booz Allen is one of five corporations that together employ nearly 80 percent of the private-sector employees contracted to work for US spy and surveillance agencies. Booz itself deploys an intelligence workforce of 12,000 personnel with security clearances, a figure I found is equivalent to nearly 27 percent of the 45,000 contractors employed in US civilian and military intelligence" (Shorrock, 2016).

Martin was recently arrested, suspected of taking the highly classified source code developed by the agency to break into computer systems of adversaries like Russia, China, Iran and North Korea.

We started the introduction of this paper by saying that governments were lagging far behind in technology. Today governments have built up their technological abilities, but these rely heavily on private contractors. This has given rise to a new problem and a new level of risk.

What is more worrying for businesses is that it is just as easy and natural and often more lucrative for the same NSA staff to take on assignments for a private company, and the risk is not exclusive to the US. The same competence is found among IT consultants in many countries around the world.

Companies will need to push for more security and encryption. In extreme cases it has meant going back to the typewriter and holding meetings while going for a walk in the park. For that which cannot be protected it means companies should not write it down, at least not on anything that is connected to the internet. This is a radically different world from the one I started to study only a decade ago when I wrote a dissertation on industrial espionage.

5. FUTURE STUDIES

It would be interesting to see if findings from the National Intelligence Service (NIS) referred to in Lee (2015) about who leaks (employees, former employees) and in what size companies (small, medium and large) are applicable to countries other than South Korea. If they are, spy catchers' attention at small and medium sized companies can be put mainly on ex-employees and mainly larger and multinational companies need focus on leakage among current employees.

Based on Meyersson and Glitz (2016) study of the DDR it would be of interest to define which countries and which industries and companies are better served by espionage economically.

Following from Polanyi (1967) we want to know what else an organization needs to acquire to become competitive besides the secret information and hiring key personnel who know how to use it. There is capital and the material component as in the case of the Iranian nuclear project, but other ingredients may have been overlooked that are essential for making use of the secret information that the organization has come across. In other words, it seems too narrow to only focus on the information itself when we want to understand the process by which secret information is turned into a competitive advantage. One suggestion is made by Cotte (2005), namely technological eve. How is technological eve performed effectively? What besides reengineering, buying the products of competitors and picking them apart to find out how each part is made and how it brings value to the end-product, are essential for this

operation? In the French literature there has been a keen focus on eve more in general ("*veille*") during the past decade. In Sweden universities still give courses in "*omvärldsanalys*", meaning "surrounding world analysis".

Building on the research of Sivanesan (2011) we want to know more about how spies are recruited from universities, but also what motivates them. How much of the information passed on is open source and published material? Academics on the cutting edge of a technical or natural science field can sometimes refrain from publishing to avoid coping and in order to prepare for patents.

Studies should continue from the research of Ferdinand and Simm (2007) that use external learning (EL) without collaboration, or larcenous learning (LL) to describe this process. It may be different in different cultures and the perception of LL may also be different. The difference between LL and EL, like attending a foreign university, may then be one of time: LL is fast while EL is slow. From a strategic perspective this raises the question of what mix is optimal for the competitive advantage of a rising nation, or any nation.

There is a need to gather data through interviews from non-Western intelligence organizations, like the Russians and Chinese, to balance and check the numerous stories coming from the Western world.

There is also a need to create case studies with individual stories of economic espionage. A number of these stories already exists in other forms and need to be extended. The great challenge in a case with two counterparts, two companies or countries, is to get the story from both sides.

From the discussion and syntheses it would be good if a historian could gather the examples we have of economic and industrial espionage through history and present them as unsentimentally as possible. A similar project for a broad discussion based in moral philosophy and international law does not exist either from what I can see. The consequences of cyberwarfare for companies are not sufficiently described and understood. More generally, the danger that the intelligence services can be used more intensively for economic espionage is real and should be addressed. How can companies protect themselves in this reality? How are state intelligence services going to solve the situation they have gotten into with the hiring of private contractors who leak information about us and how are internet companies going to convince customers that they are the good guys when they very much are locked into a symbiosis with the services, forced by law and otherwise persuaded to cooperate? Will we see new (national) systems of internet and will this make business less global and less efficient?

6. CONCLUDING REMARKS

Much has changed since I defended my doctoral thesis in industrial espionage at the University of Leipzig some ten years ago. We have moved from break-ins à la Watergate to theft by hacking. This period has also seen the beginning of cyberespionage even though the notion of information warfare was well known before. The conclusions of the empirical work in my thesis has stood the test of time and since then been confirmed regularly: companies do not disclose when they have been attacked as that only makes things worse. Instead they take the break-ins as a *fait accompli* and move on, unless they are the dominant player in the industry and the intruder is a smaller player, then they may decide to punish. The dissertation introduces the theory of *Diversification of Moral Risk* (DMR) built on the principle agent problem and the notion of portfolio risk diversification, showing how companies hire agents to perform actions they deem immoral to reduce the risk and consequences of being caught. For example oil companies outsource bribery to other companies to facilitate the handling of loading oil in high risk harbors. Weapons manufacturers hire other companies who hire other companies for their sales activities. Observations of these phenomena have only increased with new technology due to increased opportunities, lower risk of being caught and smaller consequences when caught.

Spying and snooping has become an activity that engages everyone today, on all levels. State intelligence organizations and internet and technology companies work much in symbiosis. For example Facebook is an indispensable starting point also for intelligence organizations that look for suspects as they will typically cross index our friends list with our financial transactions and flight itineraries over the past years. The same goes for individuals. A major motive for anyone to turn on Facebook is voyeurism, which is a form of snooping on people we know or even don't know but whose information we can get access to. We install cameras to keep track of

our kids and place trackers on our spouse's car. It is all part of the same phenomenon.

There is a risk that western intelligence organizations will turn to economic espionage to help their major corporations gain a competitive advantage as the technology and the facilities are already put in place. It very much depends on the country and who is head of state. The strategy of those countries who can afford to build these systems will be to catch it all and store it all, all data, and forever. The US is the first country to achieve this, but they are not going to be the only one. With the new complex at Bluffdale the US can not only search in all metadata, but also go down in detail and search all data (Deep Packet Inspections). Metadata is simply the best way to start a search because otherwise you would get too much. It is not where the search stops. This system is already giving the US an information advantage today, but responses are to be expected. China for one is bound to follow.

The internet, the ultimate symbol of freedom and knowledge, has become the ultimate surveillance tool. We as citizens have accepted walking around with a mobile phone, which is the spy's dream tool. Can the internet be recreated in its former self or was it naïve to think that the state would let it be uncontrolled? For companies it will have to mean a more encrypted reality.

No company secrets that are written electronically are safe unless protected by severe encryption. Very few companies have so far moved to safe encryption. Competitive industries must move to system awareness where employers have full control of what is downloaded to employees' computers. From the perspective of business studies we want to know what this costs and how it can be done. We also want to know about employees' reactions. Besides this we have suggested several new studies in the form of research gaps as summarized under the headline future studies.

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