Management in Business Analytics: An Ego-Centric NetworkApproach

Correa Juan C (juan.correan@cesa.edu.co)
Colegio de Estudios Superiores de Administración
Arango Lukas
Colegio de Estudios Superiores de Administración
Díaz Hugo
Colegio de Estudios Superiores de Administración
Zárate Luis
Colegio de Estudios Superiores de Administración
Kure Karim
Colegio de Estudios Superiores de Administración
Huertas Carlos
Colegio de Estudios Superiores de Administración
Gomez Nicolas
Colegio de Estudios Superiores de Administración

Research Article

Keywords: Ego-centric network, Management, Business Analytics, Business Schools

Posted Date: April 11th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1527000/v1

Management in Business Analytics: An Ego-Centric Network Approach

* Juan C. Correa (https://orcid.org/0000-0002-0301-5641)
Lukas Arango,
Hugo Díaz,
Luis Zárate,
Karim Kure,
Carlos Huertas,
Nicolás Gomez

ABSTRACT

Managers know well the utility of business analytics for decision-making purposes. Nonetheless, quantitative scrutiny on the link between management and business analytics remains unexplored. We address this gap by combining bibliometric data collection techniques with text mining and ego-centric network analyses following reproducible research standards. Results show that only 12.33% of a total of 381 sampled documents from the Scopus database revealed an explicit link between the term "management" with the bigram "business analytics" and the size the ego-centric network proved to be almost a quarter of the size of the extensive network that represents all conceptual keyword co-occurrences in the literature. We argue that, in contrast to common wisdom, our results suggest that the link between business analytics and management remains incipient, and this has essential teaching implications for business schools aiming at including business analytics in their curricula.

* Corresponding author: Colegio de Estudios Superiores de Administración -CESA. Casa Echavarría - Diagonal 34 # 5A–23 Tercer Piso. Pbx: (57 1) 339 53 00 Email: juan.correan@cesa.edu.co, Personal Website: https://correajc.com/

Management in Business Analytics: An Ego-Centric Network Approach

ABSTRACT

Managers know well the utility of business analytics for decision-making purposes. Nonetheless, quantitative scrutiny on the link between management and business analytics remains unexplored. We address this gap by combining bibliometric data collection techniques with text mining and ego-centric network analyses following reproducible research standards. Results show that only 12.33% of a total of 381 sampled documents from the Scopus database revealed an explicit link between the term "management" with the bigram "business analytics" and the size the ego-centric network proved to be almost a quarter of the size of the extensive network that represents all conceptual keyword co-occurrences in the literature. We argue that, in contrast to common wisdom, our results suggest that the link between business analytics and management remains incipient, and this has essential teaching implications for business schools aiming at including business analytics in their curricula.

KEYWORDS

Ego-centric network; Management; Business Analytics; Business Schools

1. Introduction

Combining data analytics and management techniques opens a new dimension in business administration theory. The evolution of information technology is now well-prepared to analyze vast amounts of data in real-time (e.g., consumer transactions), coming from both structured and unstructured sources (e.g., photos, videos, social network interactions), in batch or streaming flows with volumes at the scale of Zettabytes (1 Zettabyte = 10^{21} bytes). Thus, a robust set of tools are available for the description, diagnostic, prediction, and prescription of business data for decision-making purposes in various industries such as restaurants (Correa et al., 2019), healthcare (Zolbanin, Delen, & Sharma, 2018), telecommunications (Kasap, Turan, Savran, Tektas-Sivrikaya, & Delen, 2018), tourism (Delen & Sirakaya, 2006), energy (Cayir Ervural, Zaim, Demirel, Aydin, & Delen, 2018), or education (Delen, 2010), to mention just a few.

The increasing number of textbooks (Griffel & Guetta, 2021) and articles (Williams & Elmore, 2021) teaching business analytics used in business schools reveals how these institutions face the old idea that "*managers don't code*" (Von Thile, Melzer, & Steiert, 2004). Two decades ago the distance separating managers from statisticians, engineers, or business analysts was described as an unfortunate gap (Kohavi, Rothleder, & Simoudis, 2002). Today, cases like Jeff Harris as a product associate manager in Google confirm a simple and yet powerful idea[1]: Organizations can create novel opportunities for business school graduates with some programming skills. The reason behind recruiting these professional profiles relies on the concept of boosting productivity among computer scientists coordinated by someone who understands technicalities while keeping the eyes on the business' goal.

Furthermore, as the data analysis for business decision making is a highly appreciated tool, the principle of garbage-in, garbage-out is still valid, since more data does no mean necessarily better data, and there are important considerations to be taken into account, as privacy, regulatory or compliance issues (Ajah & Nweke, 2019). Additionally, the upskilling and reskilling process associated with the adoption of new technologies applied for businesses is being valued across industries, as 94% of global business leaders reported that they expect employees to train themselves in new skills. However as this creates new opportunities to boost productivity it poses challenges as well, especially for emerging markets where access to tech education is not affordable to socially disadvantaged social groups (Hammer & Karmakar, 2021).

Apart from these realities, other relevant events are taking place in the community of computer scientists and software developers but call for the participation of business school graduates. Zhou, Wang, Kamei, Hassan, & Ubayashi (2022) identified that almost 95% of open source projects face different difficulties to sustain their efforts

[1]see this video in Youtube: `https://youtu.be/11LozsUoWX4`

after the first year. By sampling 225 GitHub open source projects that received 54,889 donations with a total value of $2,537,281 through the Open Collective platform, they found two interesting results. First, corporate donors tend to donate more money than individual donors in a single donation. Nonetheless, in a collective, the total donation amount from individual donors is more than corporate donors, and they are more likely to redonate to the same collective compared to corporate donors. Second, non-engineering-related expenses take up to 54.0% of the total number of all expenses that are filtered against donation. In sum, Zhou et al. (2022) claimed the need to budget for a reasonable amount of non-engineering expenses (e.g., marketing and travel) for the sake of open source projects financial sustainability.

Until this point, it should be clear that the ties that link managers with business analytic technologies are well-known by professionals of several disciplines. As per Delen (2021) this link emerged as new topic for higher education institutions. The relevance of this topic relates to helping universities and business schools to become more real-world by bridging the gap between academic offerings and industry demands. As the number of jobs in analytics and data science far exceeds what universities offer, Delen (2021) claims that data analytics in business schools is especially challenging due to the less technical training that students have in a variety of business subjects. Following this reasoning, we wonder if such a connection is clear in the literature available for higher education purposes. And if so, how does the word "management" connect with the bigram term "business analytic." Despite the large number of articles focusing on the relationship between management and business analytic technologies, some insights from traditional and qualitative research tools are available in previous reviews (Power, Heavin, McDermott, & Daly, 2018). Our goal in this paper is different as it leverages reproducible research techniques (Peer, Biniossek, Betz, & Christian, 2022) to quantify the link between management and business analytics. A scrutiny of this relationship is relevant for several reasons. First, it will help business school professors understand the landscape that lies ahead for business school students in a more precise way. Second, it pinpoints a possible list of topics, concepts, methodologies, or technological approaches that should be part of the educational curriculum for both undergraduate and graduate levels. Finally, it might help identify novel opportunities for interdisciplinary team-building purposes. The remainder of this paper is organized as follows. The following section introduces the concept of Ego-network as an approach that will help us quantify the relationship between the term management and the bigram "business analytics." Then, the section of materials and method follows before the results. The manuscript finalizes by arguing the implication for teaching and managing interdisciplinary teams.

2. Ego-Centric Networks

According to Arnaboldi, Conti, La Gala, Passarella, & Pezzoni (2016), an ego-centric network is a particular type of graph that shows the relationships that a given individual node, termed ego, has with other nodes of the network, termed alters. An ego-centric network can be regarded as a sub-graph that can be retrieved from a larger graph. An analogy of a large network is the set of all international airports, and an ego-centric network is that of those airports with direct flights from and to the Atlanta International Airport. The ego-centric node in this case is the Atlanta International Airport, and the alters nodes are all other airports with direct connections to Atlanta. As per Newman (2010), studies of ego-centric networks do not reveal the structure of an entire network, and the analyst receives snapshots of small local regions of the network. An ego-centric network proves to be useful for understanding knowledge creation, usage, and evolution (Liang, Liu, Mao, & Lu, 2021). The statistical description of networks is possible through the calculation of several features such as those in the following list:

- **Network transitivity**: The transitivity or clustering coefficient of a network is an index that captures of the tendency of the nodes to cluster together. High transitivity means that the network contains communities or groups of nodes that are densely connected internally.
- **Network Size**: The size of a network reflects how many nodes belong to the network. The higher the size, the larger the network.
- **Network Density**: Describes the portion of the potential connections in a network that are actual connections. A "potential connection" is a connection that

could potentially exist between two "nodes" – regardless of whether or not it actually does.

- **Network Diameter**: This feature relates to the shortest distance between the two most distant nodes in the network. Once the shortest path length from every node to all other nodes is calculated, the diameter is the longest of all the calculated path lengths.
- **Average Path Length**: This feature relates to the average number of steps along the shortest paths for all possible pairs of network nodes. It is a measure of the efficiency of information or mass transport on a network.

These features are helpful to understand how visible is the term "*management*" inside the framework of a network composed by a non-empty set of conceptual terms related to business analytics. The essential ingredient in this aspect relates to defining a more extensive network that serves as a framework from which to compare and judge how frequently connected is an ego node (i.e., management) with its alters (i.e., business-analytics-related terms). In sum, we claim that an ego-centric network that takes the term *management* as the ego node helps visualize its connection with other nodes related to business analytics. Our methodological approach immediately described in the next section shows a suitable procedure that allows us to address our goal in this paper.

3. Materials and Methods

By following standard practices of bibliometric analyses (Aria & Cuccurullo, 2017), we used the Scopus database to conduct a strategic search of relevant documents that focus on business analytics and management. The bibliographic records of those documents match the following three query criteria.

- **Criterion 1**: Documents with "*business analytics*" in their title and "*management*" in the title, abstract, or keywords: `(TITLE("Business Analytics") AND TITLE-ABS-KEY ("Management"))`
- **Criterion 2**: Documents published in the *Journal of Business Analytics*:

`(ISSN(2573234x) OR ISSN(25732358))`

- **Criterion 3**: Documents published in the *International Journal of Business Analytics*: `(ISSN(23344547) OR ISSN (23344555))`

Following recommended practices of bibliometric studies (Serafin, Garcia-Vargas, Garcia-Chitiva, Caicedo, & Correra, 2019) on Sunday 06 March 2022 we downloaded in bibtex format the bibliographic records that met the criteria described above. Each criterion resulted in a single bibtex file and all three resulting files were compressed in a standard zip file, pre-processed in R (R Core Team, 2022) with the aid of the `bibliometrix` package and its biblioshiny function (Aria & Cuccurullo, 2017). A sample of 381 documents were included for further analyses. A warning note deserves consideration in this moment. We are aware that our information search strategy and its resulting sample is far from being exhaustive. Nonetheless, it can be regarded as a representative sample of the literature as it shows the records published in 133 sources, in the period between 2007 and 2022 by a total of 897 authors, of which 73 records represent single-authored documents. We set the raw data downloaded from Scopus as a standard tidy data frame in R (Wickham & Grolemund, 2017). From this data frame we structured the analyisis on each document abstract and its keywords, by employing some functionalities of the `quanteda` R package (Benoit et al., 2018). By applying standard bibliographic mapping of abstracts' keywords co-occurrences, we were able to quantify the size of the network of all 381 abstracts and its keywords, with the size of the ego-centric network ($n = 47$) that zooms in the connections between the term *management* with business-analytics-related terms. To maximize transparency and reproducibility, we developed a public GitHub repository where interested readers have access to supplemental material, data, and codes that can be cloned or downloaded. This repo will be available in case of positive acceptance of the current manuscript.

4. Results

We begin the analysis by estimating the size of the ego-centric network that represents the documents with explicit mentions of the term "*management*" with the bigram "*business analytics*." This ego-centric network resulted from a total of 47 documents out of the 381 documents sampled from the Scopus database. In other words, only 12.33% of the documents sampled revealed an explicit link between these terms. As a second detailed analysis, we focused on the documents' keywords co-occurrences; that is, the terms that tend to appear together. By considering each keyword as a node, the connection between two keywords represents their conceptual link in the literature. In Table 1 we compared the statistical features of both of our networks. In terms of size, the ego-centric network is almost a quarter of the extensive network (i.e., 313 keywords co-occurrences out of the 1,290 total of co-occurrences in the extensive network of reference). Compared with the extensive network, the ego-centric network proved to be four times denser; its transitivity was almost double, its diameter was almost its half, but their degree centralization and average path length tend to be quite similar.

Table 1. Network-based statistics of the ego-centric network as compared with the extensive network

Statistics	Extensive Network	Ego-Centric Network
Size	1290	313
Density	0.015	0.061
Transitivity	0.222	0.402
Diameter	5	3
Degree Centralization	0.543	0.596
Average Path Length	2.496	2.129

Figure 1 shows the extensive network of all 381 document. This network reveals three distinct clusters. The major cluster (red nodes) groups the main keywords analyzed combined with many different terms related to data analytics, such as *big data*, *data handling*, *information analysis*, and other analytics bigrams such as *advanced, business, data*. The second cluster (green nodes) reveals a more diverse set of applications among which *decision support systems*, *human resource management*, *text and data mining*, *statistics*, *machine learning*, *deep learning* tend to be connected with *sales*, *forecasting* and *life cycle*. The third cluster (blue nodes) shows how *knowledge management* connects with *information use*, *information systems*, *competition* and *competitive advantage*.

Upon graphing the ego-centric network (Figure 2), the graph shifts towards four distinct clusters. In the main cluster (red nodes), we noticed the emergence of a selected

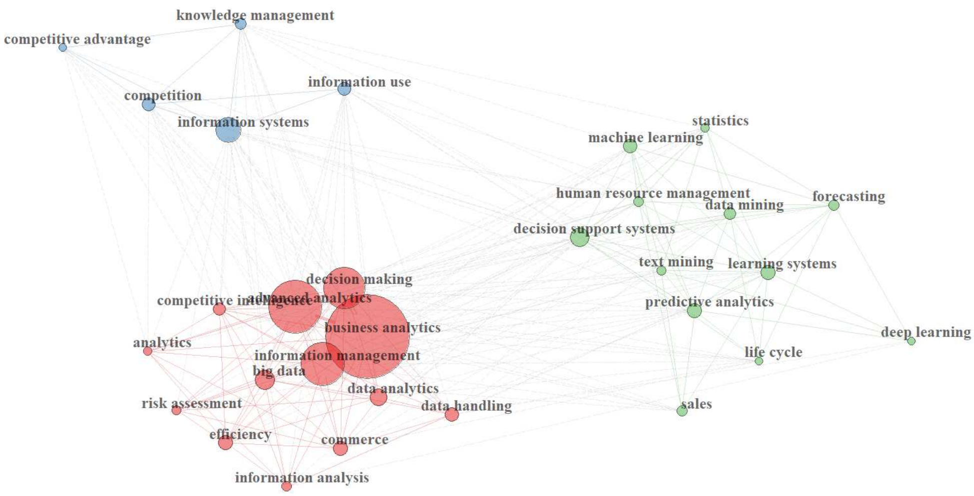

Figure 1. The Extensive Network of business analytics related terms with management

.

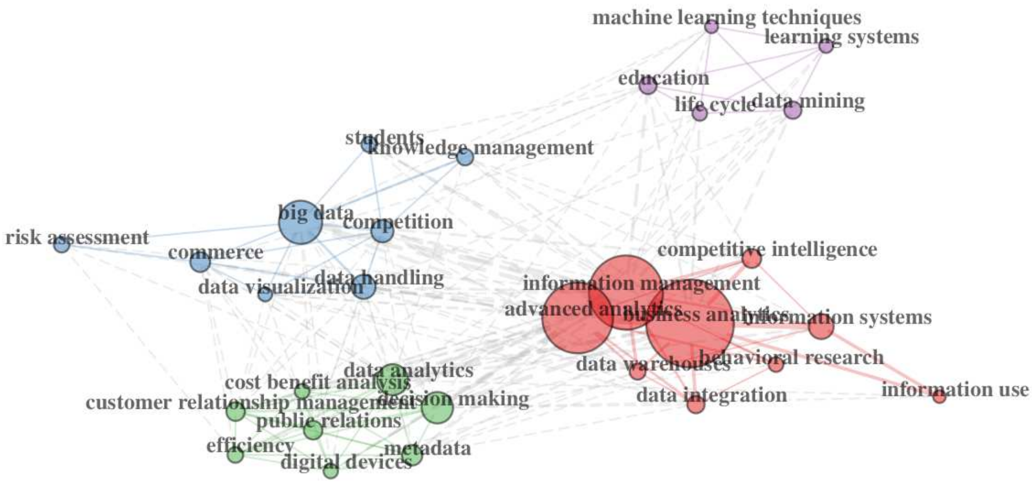

Figure 2. The Ego-Centric Network of business analytics related terms with management

.

group of keywords that relate to scientific and practical purposes. Here, terms such as *competitive intelligence*, *behavioral research*, *advanced analytics*, *data warehouse*, *data integration*, *information management*, *information systems*, and *data integration* reveal the most prominent nodes (i.e., their size is larger as compared with the size of all other nodes). The three smaller clusters once again seem to specialize towards specific orientations on different business applications or more specialized fields of data analytics. Interestingly, the term *education* emerged as a visible node in this network. In Figure 3 we compared once again the extensive network with the ego-centric network, but now the emphasis is on the academic collaboration between researchers and their affiliated countries.

Collaboration.png

Figure 3. Academic Collaboration: (A) from the Ego-centric Network, and (B) from the Extensive Network

.

Among the 47 documents that composed the ego-centric network, we were able to find the list of the top five most relevant authors in terms of number of published manuscripts (Akbas & Taj, 2018; Fadler & Legner, 2021; Grossmann, 2009; Grossmann & Moser, 2016; Naous, Schwarz, & Legner, 2017; Taj & Sanchez-Arias, 2019). This list is summarized in Table 2 although in the supplemental material, the reader can find the list of all 47 documents of the Ego-centric network (i.e., Egocentricnetwork.RData and Most_Local_Cited_Authors.xlsx).

Table 2. Top Five Relevant Authors

Author	Institution (Country)	Documents
Grossmann, W.	University of Vienna (Austria)	2
Legner, C.	Univesity of Lausanne (Switzerland)	2
Lin, J.	Siemens SISW (Germany)	2
Rohleder, C.	University of Applied Sciences Constance (Germany)	2
Taj, S.	Florida Polytechnic University (USA)	2

5. Discussion and Implications for Business Schools

This paper aimed at providing fresh insights on how the term "*management*" connects with the bigram "*business analytics*." Compared with previous endeavors that attempt to define business analytics from an empirical approach (Power et al., 2018), our framework revealed a quantitative endeavor that leverages the rigor of bibliometric studies (Aria & Cuccurullo, 2017) with text mining techniques (Benoit et al., 2018), and ego-centric network statistical visualization analyses (Newman, 2010). A caveat on this manuscript is worth mentioning at this point. Our methodological approach should be regarded as a topic-oriented description of one particular link that might be relevant for business schools and not for knowing in detail the current use of analytic data techniques for specific business sectors. In this regard, we are keenly aware of the presence of so many other relevant authors and topics that did not appear in our results. For example, the extensive work of professor Dursun Delen at Spears School of Business at Oklahoma State University might be an adequate reference for such a purpose (Delen & Demirkan, 2013; Delen, Hardgrave, & Sharda, 2007; Demirkan & Delen, 2013; Olson & Delen, 2008).

Apart from previous ideas, we can highlight several implications for business schools. Given the increasing relevance of teaching business analytics for the next generation of managers, business schools should work closely with human resources professionals to identify skill development opportunities (Almgerbi, De Mauro, Kahlawi, & Poggioni, 2021). Business schools in general, and professors, in particular, should embrace an exploratory attitude and an open-mind orientation when choosing their teaching material. While traditional textbooks focusing on professional tools such as Python (Molin, 2021) or R (Wickham & Grolemund, 2017) permeate most of data science curricula in other professional programs (e.g., computer science), the specific audience in business schools classrooms might require the use of textbooks with comics (Biecek, Kozak, & Zawada, 2022) that introduce the use of repositories (e.g., GitHub) or references that illustrate business data analytics with low-code emphasis (De Mauro, 2021). Regardless of the chosen software, professors should follow existent recommendations on how to structure business analytics courses with hands-on teaching experiences (Delen, 2021). Identifying business-oriented data sets available in data repositories such as Harvard Dataverse, Kaggle, Mendeley Data, re3data, Google Data Search, OSF, datadryad, or dataone.org is vital for enriching practical exercises in classes. Using these data sets with reproducible research standards (Peer et al., 2022) might help students assimilate how-to specifics on data analyses more smoothly. This paper illustrates these standards by sharing its public repository with interested readers, as described in the materials and methods section.

6. Conclusion

According to Delen (2021), the popularity of data analytics-related courses has grown with hundreds of higher education programs worldwide, and the growing demand from employers drives this interest. This manuscript extends this claim by illustrating data-driven analyses that reflect some of the topics that link the term management with the bigram "business analytics." We concur with Delen that most enterprises face a mindset change in deviating from intuition-driven decision-making to embrace a more contemporary, evidence-based decision-making at all organizational levels. We hope to have contributed to the education of the next generation of managers in a globalized context and inspired professors to embrace another teaching perspective in this endeavor.

7. Conflicts of interest

We declare that we have no conflicts of interest.

8. Human Participants and/or Animals

The current research has not involved human participants or animals and relied on bibliometric records.

9. Informed consent

Not apply.

10. Funding

We declare that this research has not received any funding.

11. Authors contribution

J.C. conceived the study. K.K., C.H., L.Z., H.D., L.A. collected the data. J.C. and N.G. cured, pre-processed and analyzed the data. N.G. and J.C. prepared figures 1-3. All authors reviewed the manuscript.

References

Ajah, I., & Nweke, H. (2019). Big data and business analytics: Trends, platforms, success factors and applications. *Big Data and Cognitive Computing*, *3*(2), 1-30.

Akbas, M., & Taj, S. (2018). Intelligent mobility concentration for undergraduate students in data science and business analytics. In (Vol. 2018, p. 1233-1241).

Almgerbi, M., De Mauro, A., Kahlawi, A., & Poggioni, V. (2021). A systematic review of data analytics job requirements and online-courses. *Journal of Computer Information Systems*, 1–13.

Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, *11*(4), 959–975.

Arnaboldi, V., Conti, M., La Gala, M., Passarella, A., & Pezzoni, F. (2016). Ego network structure in online social networks and its impact on information diffusion. *Computer Communications*, *76*, 26–41.

Benoit, K., Watanabe, K., Wang, H., Nulty, P., Obeng, A., Müller, S., & Matsuo, A. (2018). quanteda: An R package for the quantitative analysis of textual data. *Journal of Open Source Software*, *3*(30), 774.

Biecek, P., Kozak, A., & Zawada, A. (2022). *The hitchhiker guide to responsible machine learning*. Warsaw, Poland: Scientific Foundation.

Cayir Ervural, B., Zaim, S., Demirel, O., Aydin, Z., & Delen, D. (2018). An anp and fuzzy topsis-based swot analysis for turkey's energy planning. *Renewable and Sustainable Energy Reviews*, *82*, 1538-1550.

Correa, J. C., Garzón, W., Brooker, P., Sakarkar, G., Carranza, S. A., Yunado, L., & Rincón, A. (2019). Evaluation of collaborative consumption of food delivery services through web mining techniques. *Journal of Retailing and Consumer Services*, *46*, 45–50.

Delen, D. (2010). A comparative analysis of machine learning techniques for student retention management. *Decision Support Systems*, *49*(4), 498-506.

Delen, D. (2021). Better practices for teaching business analytics. *OR/MS Today*, *Issue on Innovative Education*, 38-43.

Delen, D., & Demirkan, H. (2013). Data, information and analytics as services. *Decision Support Systems*, *55*(1), 359-363.

Delen, D., Hardgrave, B., & Sharda, R. (2007). Rfid for better supply-chain management through enhanced information visibility. *Production and Operations Management*, *16*(5), 613-624.

Delen, D., & Sirakaya, E. (2006). Determining the efficacy of data-mining methods in predicting gaming ballot outcomes. *Journal of Hospitality and Tourism Research*, *30*(3), 313-332.

De Mauro, A. (2021). *Data Analytics Made Easy*. Birmingham, UK: Packt.

Demirkan, H., & Delen, D. (2013). Leveraging the capabilities of service-oriented decision support systems: Putting analytics and big data in cloud. *Decision Support Systems*, *55*(1), 412-421.

Fadler, M., & Legner, C. (2021). Data ownership revisited: clarifying data accountabilities in times of big data and analytics. *Journal of Business Analytics*.

Griffel, M., & Guetta, D. (2021). *Python for MBAs.* New York: Columbia University Press.

Grossmann, W. (2009). Data integration for business analytics: A conceptual approach. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *5914 LNAI*, 122-133.

Grossmann, W., & Moser, C. (2016). Big data-integration and cleansing environment for business analytics with dice. In M. J. Karagiannis D. Mayr H. (Ed.), *Domain-specific conceptual modeling: Concepts, methods and tools* (p. 103-123). Cham: Springer.

Hammer, A., & Karmakar, S. (2021). Automation, AI and the Future of Work in India. *Employee Relations*, *43*(6), 1327 – 1341.

Kasap, N., Turan, H., Savran, H., Tektas-Sivrikaya, B., & Delen, D. (2018). Provider selection and task allocation in telecommunications with qos degradation policy. *Annals of Operations Research*, *263*(1-2), 311-337.

Kohavi, R., Rothleder, N., & Simoudis, E. (2002). Emerging trends in business analytics. *Communications of the ACM*, *45*(8), 45-48.

Liang, Z., Liu, F., Mao, J., & Lu, K. (2021). A knowledge representation model for studying knowledge creation, usage, and evolution. In K. Toeppe, H. Yan, & S. K. W. Chu (Eds.), *Diversity, divergence, dialogue* (pp. 97–111). Cham: Springer International Publishing.

Molin, S. (2021). *Hands-On Data Analysis with Pandas* (2nd ed.). Birmingham: UK: Pakt Publishing.

Naous, D., Schwarz, J., & Legner, C. (2017). Analytics as a service: Cloud computing and the transformation of business analytics business models and ecosystems. In (p. 487-501).

Newman, M. E. J. (2010). *Networks: An introduction.* Oxford University Press.

Olson, D., & Delen, D. (2008). *Advanced data mining techniques.*

Peer, L., Biniossek, C., Betz, D., & Christian, T.-M. (2022). Reproducible research publication workflow: A canonical workflow framework and fair digital object approach to quality research output. *Data Intelligence*, 1–14.

Power, D., Heavin, C., McDermott, J., & Daly, M. (2018). Defining business analytics: an empirical approach. *Journal of Business Analytics*, *1*(1), 40-53.

R Core Team. (2022). R: A language and environment for statistical computing [Computer software manual]. Vienna, Austria. Retrieved from `https://www.R-project.org/`

Serafin, M. J., Garcia-Vargas, G. R., Garcia-Chitiva, M. P., Caicedo, M. I., & Correra, J. C. (2019). Cyberbehavior: A bibliometric analysis. *Annual Review Cyber-Therapy and Telemedicine*, *17*, 17–24.

Taj, S., & Sanchez-Arias, R. (2019). Innovative undergraduate degree programs in data science and business analytics. In (Vol. 2019, p. 2059-2060).

Von Thile, A., Melzer, I., & Steiert, H.-P. (2004). Managers don't code: making web services middleware applicable for end-users. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *3250*, 139-151.

Wickham, H., & Grolemund, G. (2017). *R for Data Science*. New York: O'Reilly.

Williams, B., & Elmore, R. (2021). Teaching business analytics during the covid-19 pandemic: A tale of two courses. *Communications of the Association for Information Systems*, *48*(1), 1.

Zhou, J., Wang, S., Kamei, Y., Hassan, A. E., & Ubayashi, N. (2022). Studying donations and their expenses in open source projects: a case study of github projects collecting donations through open collectives. *Empirical Software Engineering*, *27*(1), 1–38.

Zolbanin, H., Delen, D., & Sharma, S. (2018). The strategic value of big data analytics in health care policy-making. *International Journal of e-Business Research*, *14*(3), 20-33.

Figures

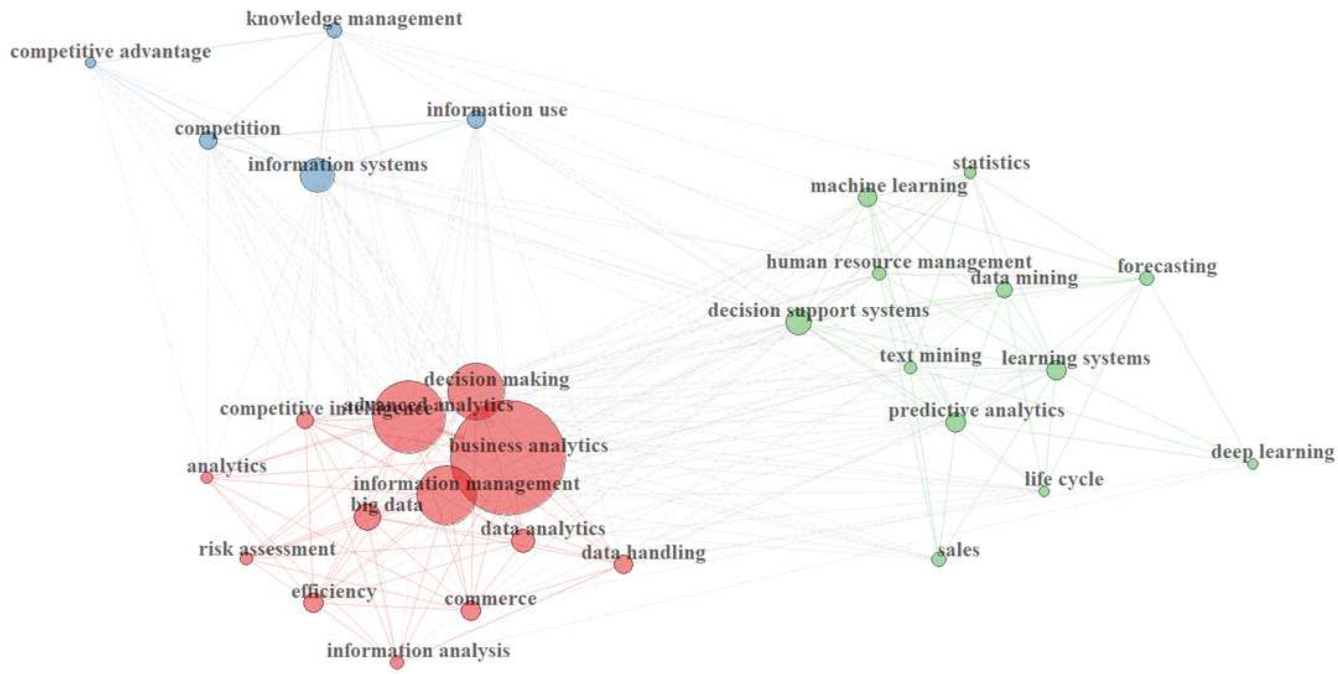

Figure 1

The Extensive Network of business analytics related terms with management

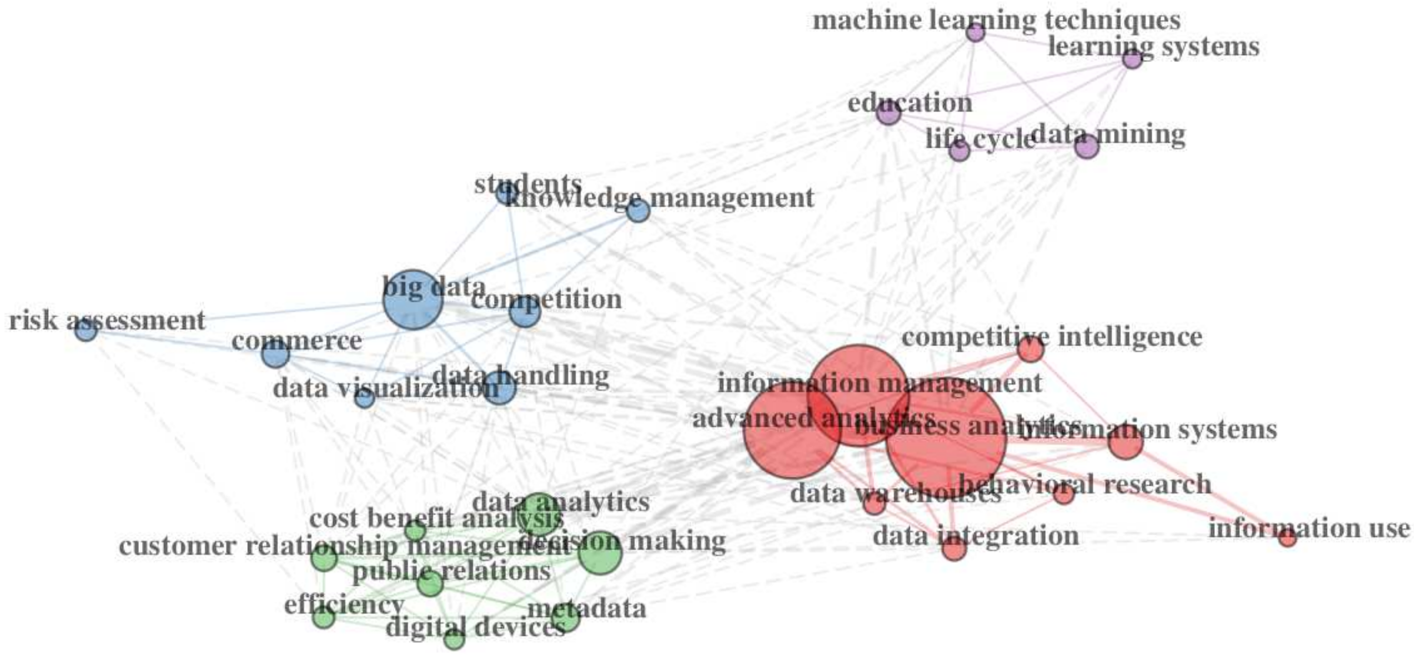

Figure 2

The Ego-Centric Network of business analytics related terms with management

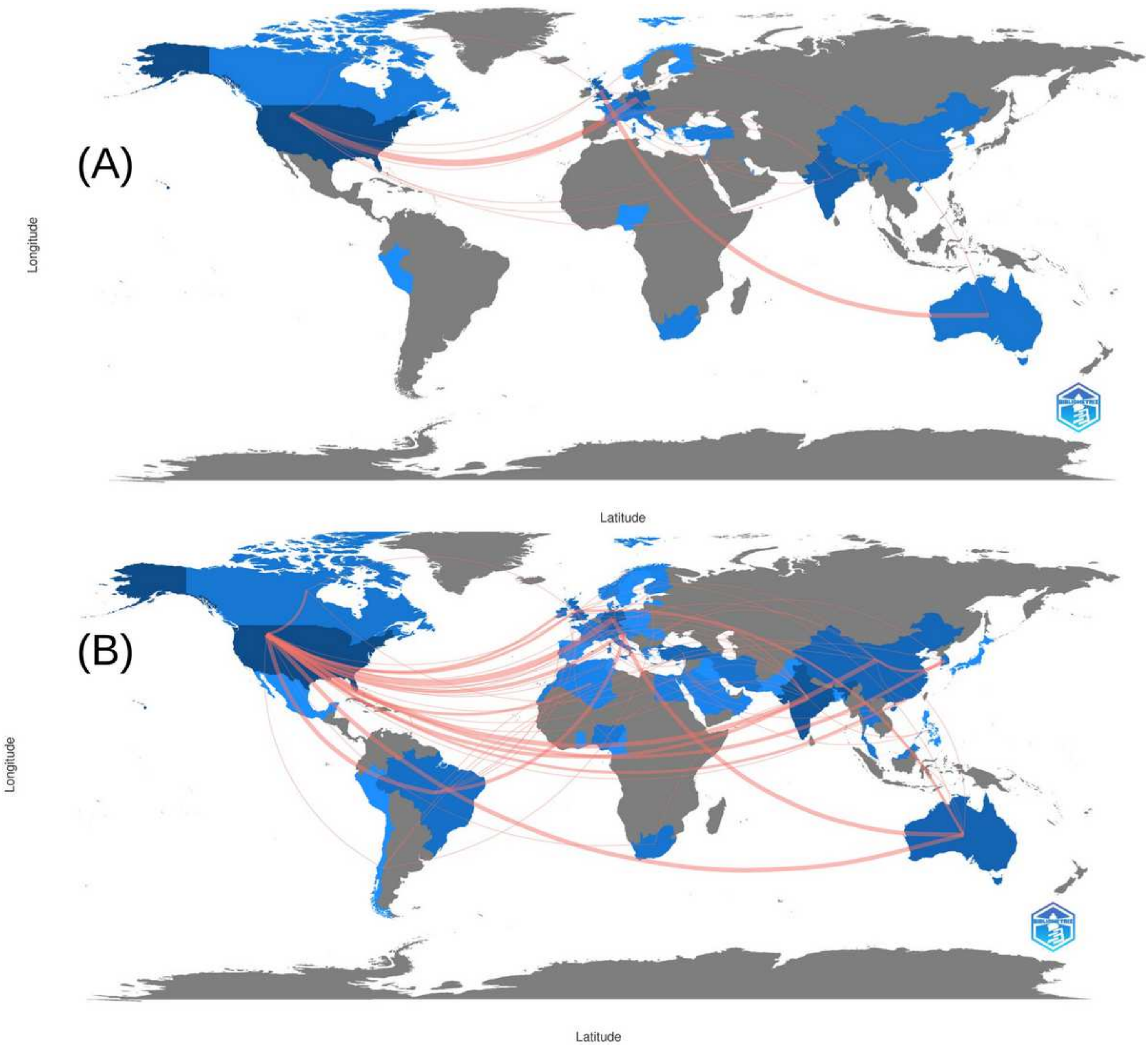

Figure 3

Academic Collaboration: (A) from the Ego-centric Network, and (B) from the Extensive Network