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The interdisciplinary curriculum alignment to enhance graduates' employability and universities' sustainability

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A R T I C L E I N F O

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A B S T R A C T

The employability of university graduates mainly depends upon the skillset they acquire through curriculum, subject specializations, and pedagogical practice. Contemporary analytical, big data-driven, and IT-based skills are imperative for supply chain graduates and business schools' sustainability. This study aims to provide directions and guidelines on the curriculum framework that offers an equilibrium of qualitative and quantitative skills for supply chain management graduates' employment and relative sustainability for universities. We utilized a three-pronged methodology to identify analytical, big data-driven, and IT-based skills. First, literature review was used to identify 18 criteria organized into 3 themes. Second, we conducted interpretive content analysis of the curricula of 38 Association to Advance Collegiate Schools of Business (AACSB) accredited supply chain management programs across the world. Third, in-depth interviews with 16 leading academics and industry experts were conducted to conclude the study and draw meaningful insights. Specific solutions aimed at combating the contemporary challenges and the implications of redesigning interdisciplinary curricula for students in specialized business programs – such as supply chains, logistics, and operations – are also offered. This research provides new insights to continuously improve interdisciplinary curricula, enhancing students' employability and contributing to universities' financial sustainability.

1. Introduction

Curriculum design, continuous improvement, and pedagogical practices have significant impacts on the learning outcomes and, eventually, the employability of university graduates (Gaweł et al., 2023). Yuen, Tan, and Loh (2022) surveyed 196 faculty members of the top ten leading universities in the field of maritime supply chain management and reported pedagogy and big data analytics as being part of the five core competencies of educators. Recently, the COVID-19 pandemic has abruptly changed the learning environment, making it necessary to redesign curricula, and to adapt teaching methodologies for effective online and blended formats

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(Dumulescu, Pop-Păcurar, & Necula, 2021). The transition from face-to-face offline to online education has coaxed teachers into amalgamating education technology in their teaching pedagogy. Li and Jiang (2021) reported that educational psychology is linked with the research trends found in a particular field, which are consequently reflected in the relative curricula and their redesign.

The Industry 4.0 era, marked by surging data, digitization, and automation, presents both opportunities and challenges. Massive data production across industries demands new solutions for data collection, storage, and analysis (Oesterreich & Teuteberg, 2016). Businesses are leveraging big data analytics to gain unique insights and improve financial and non-financial outcomes (Akhtar, Frynas, Mellahi, & Ullah, 2019). This highlights the growing need for graduates skilled in data science, a field with the potential to revolutionize various sectors (Tiberius, Weyland, & Mahto, 2023; Xu & Babaian, 2021). Data Science methods offer a variety of instruments to create economic and social value (Akhtar et al., 2019; Mikroyannidis, Domingue, Phethean, Beeston, & Simperl, 2017; Wang, Gunasekaran, Ngai, & Papadopoulos, 2016). Supply chains grapple with big data (tweets, feedback, etc.) and analytics (extensive applications of data mining and quantitative modeling) demanding data-savvy graduates who can extract actionable insights (Akhtar, Khan, Frynas, Tse, & Rao-Nicholson, 2018; Papadopoulos, Gunasekaran, Dubey, & Fosso Wamba, 2017).

Universities are adapting by offering more data analytics courses and programs (Schoenherr & Speier-Pero, 2015; Sollosy & McInerney, 2022). However, the challenge lies in creating truly interdisciplinary supply chain skills that combine computing, statistics, engineering, and operations research (fulfilling industry's need for designing and optimizing complex "supply networks"). Overcoming this challenge is difficult for academics, business schools, and students. The speed at which this field is evolving is another challenge making curriculum design difficult (Dey, 2024; Mikroyannidis et al., 2017). Moreover, gaining access to data analytics software is a constraint for universities, however, academic alliances are a cost-effective and efficient way to introduce commercial software into curricula (Angolia & Pagliari, 2018). Despite the rise in data analytics degrees, curricula need to evolve further to meet market demands (McLeod, Bliemel, & Jones, 2017). There is limited research on the role played by big data analytics in higher education (Chaurasia, Kodwani, Lachhwani, & Ketkar, 2018; McLeod et al., 2017; Sollosy & McInerney, 2022).

This study examines MSc Logistics & Supply Chain Management (L&SCM) programs, industry views on their fit with practice, and data-driven skills needed. It proposes a new curriculum framework for better graduate employability and long-term relevance. The study also identifies key academic challenges in implementing this framework. It contributes to existing research by evaluating L&SCM curriculum trends in leading universities; highlighting the under-researched area of big data integration in L&SCM programs; and identifying challenges in integrating big data and Industry 4.0 concepts. A threefold methodology was used to: identify themes from the literature; use those themes as criteria for content analysis of selected AACSB accredited L&SCM programs; and interviews experts and professionals to identify challenges in amalgamating big data analytics skills into the curriculum.

2. Literature review

2.1. Role of data analytics in logistics and supply chain curriculum

Immersive learning technologies (simulations, VR/AR, big data insights), reality technologies (e.g., virtual reality [VR], augmented reality [AR], and mixed reality [MR]), and RFID systems generate significant data (Wu, Tang, Tsang, & Chau, 2021). Curricula need to adapt to this data-driven world, with big data skills becoming crucial for business programs (Akhtar et al., 2019; Ballou, Heitger, & Stoel, 2018). Studies recommend incorporating big data analytics into various educational backgrounds (Asamoah, Sharda, Hassan Zadeh, & Kalgotra, 2017; Chaurasia et al., 2018; Voas & Laplante, 2017; Xu & Babaian, 2021). However, a gap exists in comprehensively analyzing how to integrate these elements into interdisciplinary logistics & supply chain programs for better graduate outcomes. This study addresses this research gap by examining how big data can enhance the curriculum of MSc L&SCM program for

Table 1
Top 10 master programs in supply chain management.

Rank	Eduniversal	QS Ranking
1	Masters in Supply Chain Management, MIT (USA)	Master's in Supply Chain Management, MIT USA
2	International Master in Digital Supply Chain Management, POLIMI (Italy)	Master of Supply Chain Management, Michigan Ross (USA)
3	International Corporate Master in Operations, CENTRUM PUCP (Peru)	Supply Chain Management MSc, Vienna University (Austria)
4	MBA in Global Supply chain and Logistics, Purdue University (USA)	MS in Supply Chain Management, Erasmus University (Netherlands)
5	ISLI - Global Supply Chain Management, KEDGE Business School (France)	MSc in Supply Chain & Purchasing Management, EMLyon Business School (France)
6	Maestria en Supply Chain Management, Universidad del Pacífico (Peru)	MS in Global Supply Chain Management, USC Marshall School of Business (USA)
7	Master's in Management - Major in Operations Management, Universidade Nova (Portugal)	MSc Operations, Projects & Supply Chain Management, Alliance Manchester Business School (UK)
8	Master of Global Supply Chain Management, Antwerp Management School (Belgium)	MSc in Operations and Supply Chain Management, Trinity Business School (Ireland)
9	Master Supply Chain Internationale, Université Paris (France)	International Master in Digital SCM – Operations, Procurement and Logistics, Politecnico di Milano (Italy)
10	MEMIT Master universitario in Economia e Management dei Trasporti, della Logistica e delle Infrastrutture Università Bocconi (Italy)	Master of Supply Chain Management, University of Washington Foster School of Business (USA)

Sources: (Eduniversal, 2024; QS Rankings, 2024) graduate employability. We review current curricula of leading universities using criteria found in the literature and propose a new framework integrating data science and big data analytics skills. This framework benefits both students (improved job prospects) and universities (higher rankings, student satisfaction). However, challenges exist for implementation.

2.2. Curriculum assessment criteria

The universities around the world that offer MSc Logistics and Supply Chain Management (L&SCM) programs (as mentioned in Table 1) have designed curricula/courses focusing on certain trends and practices prevalent in the industry. These practices can be considered assessment criteria to evaluate the existing literature or analyze the content on the alignment of curricula with the practices prevalent in the industry.

A number of researchers have used criteria approach to identify themes and use them as a criteria to further review the literature (Calma, Suder, & Kenworthy, 2024; Moazzam, Akhtar, Garnevska, & Marr, 2018; Tiberius et al., 2023). In this study, we adopted a criteria approach to identify 18 criteria from the literature, organized under three themes logistics management, data science, and modeling and simulation were used for content analysis of selected AACSB accredited MSc L&SCM curricula (see Table 2).

2.3. Themes in the curriculum of logistics and supply chain management

2.3.1. Logistics and supply chain management

Logistics management is an important part of SCM. It involves planning, implementing, and controlling the efficient and effective forward and reverse flow and storage of goods, services, and related information between the points of origin and consumption to meet customer requirements (CSMP, 2013). Logistics management mainly covers the transportation of goods and materials, their warehousing and storage, industrial packaging, handling, inventory control, order fulfillment, demand forecasting, production planning, and scheduling, procurement, customer service, facility location, returned goods handling, parts, and service support and salvage and scrap handling (Coyle et al., 2012). L&SCM graduates are often employed in roles such as logistics officer, procurement officer, inward goods/stock-taking supervisor, fleet manager, distribution manager, packaging and dispatch manager, outbound logistics officer, and freight officer, among others. Table 1 presents key focal areas of L&SCM curricula related to the logistics management stream. Several authors have used the term logistics itself (Akalin et al., 2016; Flöthmann & Hoberg, 2017; Schoenherr & Speier-Pero, 2015Schoenherr & Speier-Pero, 2015; Yew Wong et al., 2014), whereas others have split this term into its component parts, such as procurement, inventory and warehousing, transportation, operations management, manufacturing, distribution, ports and networks, finance and accounting and general business management (Akalin et al., 2016; Brajesh, 2016; Flöthmann & Hoberg, 2017; Schoenherr & Speier-Pero, 2015Schoenherr & Speier-Pero, 2015; Yew Wong et al., 2014).

Schoenherr and Speier-Pero (2015) surveyed 571 supply chain professionals and found that most of them applied analytics in

Table 2
Foundations for content analysis and literature for MS L & SCM curriculums.

Themes	Focus and domains	Studies
Logistics and supply chain management	Logistics and supply chain focused (LSCF)	(Akalin, Huang, & Willems, 2016; Flöthmann & Hoberg, 2017; Schoenherr & Speier-Pero, 2015Schoenherr & Speier-Pero, 2015; Yew Wong, B. Grant, Allan, & Jasiuvian, 2014)
	Procurement focused	(Akalin et al., 2016; Flöthmann & Hoberg, 2017; Schoenherr & Speier-Pero, 2015 Schoenherr & Speier-Pero, 2015)
	Inventory and warehousing focused	(Akalin et al., 2016; Flöthmann & Hoberg, 2017)
	Transportation-focused (TF)	Flöthmann and Hoberg (2017)
	Distribution-focused (DF)	Akalin et al. (2016)
	Ports and network focused (PNF)	Flöthmann and Hoberg (2017)
	Operations management focused (OMF)	(Flöthmann & Hoberg, 2017; Schoenherr & Speier-Pero, 2015Schoenherr & Speier-Pero, 2015; Yew Wong, Grant, D, Allan, & Jasiuvian, 2014)
	Finance/accounting integration (FAI)	(Brajesh, 2016; Flöthmann & Hoberg, 2017; Yew Wong et al., 2014)
	Manufacturing-focused (MF)	Flöthmann and Hoberg (2017)
	General business focus (GBF)	Yew Wong et al. (2014)
Data Science	SAP integration (SAPI)	(Angolia & Pagliari, 2018; Brajesh, 2016; McLeod et al., 2017; Sweeney, Campbell, & Mundy, 2010)
	Industry 4.0, (e.g., machine learning, IoTs, and engineering) focused (IF)	(Angolia & Pagliari, 2018; McLeod et al., 2017; Sackey & Bester, 2016; Umachandran, Jurcic, Ferdinand-James, Said, & Rashid, 2018)
	Data-driven integration (DI)	(Angolia & Pagliari, 2018; Brajesh, 2016; Flöthmann & Hoberg, 2017; McLeod et al., 2017; Schoenherr & Speier-Pero, 2015Schoenherr & Speier-Pero, 2015)
	Computer programming integration (CPI)	(Bernon & Mena, 2013; Voas & Laplante, 2017; Yeung, 2015)
	Statistical and mathematical integration (SMI)	(Angolia & Pagliari, 2018; Brajesh, 2016; McLeod et al., 2017; Schoenherr & Speier-Pero, 2015Schoenherr & Speier-Pero, 2015; Voas & Laplante, 2017)
	Analytics integration (AI)	(Angolia & Pagliari, 2018; McLeod et al., 2017; Schoenherr & Speier-Pero, 2015 Schoenherr & Speier-Pero, 2015)
	Logistics technology integration (LTI)	(Angolia & Pagliari, 2018; Bernon & Mena, 2013; Brajesh, 2016; Sweeney et al., 2010; Voas & Laplante, 2017)
Modeling and Simulation	Operations research focus (ORF)	(Akalin et al., 2016; Angolia & Pagliari, 2018; Bernon & Mena, 2013; Voas & Laplante, 2017)

supply chain-related functions—namely, logistics, operations management, and procurement—of the organizations for which they worked. Akalin et al. (2016) reviewed the core requirements of 447 business schools accredited by the Association to Advance Collegiate Schools of Business (AACSB)—which represented 87.6% of the 510 AACSB-accredited business schools in the US—and found that the vast majority of them offered operations management (OM) programs only as core courses. Flöthmann and Hoberg (2017) analyzed the profiles of 307 supply chain executives (SCEs) in terms of the various functions they performed in their organizations and found that most of them were involved in logistics, procurement, and production. Earlier, Yew Wong et al. (2014) had examined the curriculum design of L&SCM undergraduate courses offered by selected UK HEIs and compared them with employers' job requirements in the UK. They found that general management skills (such as management, finance/accounting, leadership, and HRM) were preferred, with basic knowledge of SCM subjects—namely, logistics, operations management, procurement, inventory and warehouse management, and distribution management. It is thus clear that analytics, along with domain knowledge, play a vital role in logistics and supply chains. As analytics are based on data, this points to data science aspects, leading to our second theme.

2.3.2. Data science

Companies are generating and collecting data exponentially. Therefore, there is an ongoing struggle to develop the expertise needed to aggregate, analyze, and, more importantly, provide actionable insights for strategic decision-making. The demand for data analysts or data scientists has outpaced their supply. The job descriptions found in this area include data analyst, data scientist, insight analyst, analytics consultant, predictive analyst, big data analyst, demand planner, and business intelligence officer, among others. Data science has evolved as an interdisciplinary area that deals with the use of scientific methods aimed at extracting knowledge and insights from structured and unstructured data. This area can be further divided into two categories—namely, information systems and big data. Information systems involve software such as enterprise resource planning (ERP) systems, which are widely used by businesses for collaborative planning and real-time information sharing through electronic data interchange (EDI) and radio-frequency identification (RFID) systems. These systems have dashboards for each echelon of a supply chain in which each of them functions. On the one hand, these systems integrate the various nodes of a supply chain while, on the other, they produce huge amounts of unstructured and raw data—called big data—which are characterized by volume, velocity, variety, and value.

Extracting useful insights from big data for real-time decision-making is a challenging task for supply chain managers. Researchers have brought forward several terminologies to comprehend the requirements of curricula on big data. Table 2 presents these focal areas: SAP, Industry 4.0/engineering/machine learning, data-driven supply chains/logistics, computer programming, statistical and mathematical analysis, data analytics, and logistics technologies. Industry 4.0 benefits from the physical infrastructure of industrial automation made possible by cyberspace and the Internet of things (Umachandran et al., 2018). Businesses are increasingly adopting logistics technologies such as industry 4.0, cloud computing, the Internet of things (IoT), artificial intelligence (AI), and machine learning (ML) to transform their business models, innovate and develop B2B and B2C links. The IoT—which involves sensors, devices, computing power, etc. (the 'things') connected to the Internet—has digitalized the supply chains in a true sense (Voas & Laplante, 2017). Developing and frequently updating content on this theme, which accounts for a major part of aligning MSc L&SCM curricula with industry requirements, is detrimental to improving the employability of SCM professionals. Additionally, Generative artificial intelligence (GAI, e.g., ChatGPT) challenges management educators and simultaneously provides transformational resources (Lim et al., 2023).

There is a need for Industry 4.0 and its related logistics technologies to be taught in classrooms. McLeod et al. (2017) explored the demand for big data and analytics curricula in the context of the SAP University Alliances program and found a substantial shift toward curricula focused on big data and analytics. The teaching of L&SCM courses with a team-based logistics simulation operating on a live commercial-software application (SAP ERP) is a pedagogy better suited for a more in-depth understanding of the transportation and logistics aspects of supply chain management (Angolia & Pagliari, 2018). The IoT presents a wide range of issues around which L&SCM curricula should be built (Voas & Laplante, 2017). Finally, the emphasis of curricula has shifted to data-driven functions and cyber-physical systems (Sackey & Bester, 2016).

2.3.3. Modeling and simulation

Modeling and simulation in the field of L&SCM involve solving real-life business problems with the help of mathematical models and simulating problems in the classroom in order to improve the students' problem-solving skills. Mathematical models are divided into two categories: deterministic and stochastic or probabilistic. Researchers have used mathematical models to solve problems or optimize resource utilization at various levels across the supply chain including product development, demand planning, forecasting, production planning and scheduling, capacity planning, procurement, inventory management, warehouse operations, process layout, assembly line balancing, queuing problems, transportation problems, distribution planning, and reverse logistics.

2.3.4. Big data analytics, skills, and value creation

The term 'big data' was originally derived from the business intelligence literature; in turn, this is linked with artificial intelligence, which has been used since the 1950s (Chen, Chiang, & Storey, 2012). Big data are defined as the outcome of a combination of modern technology and mathematical/statistical techniques, which enable the production and processing of large datasets. Such data cannot be handled by traditional technology or conventional mathematical/statistical techniques. Thus, big data analytics is the process of analyzing big data and gaining insights (APICS, 2012), which are the fundaments to understanding contemporary supply chain operations (e.g., detecting buying patterns, automotive decision-making for inventory management, and policymaking). Big data presents various characteristics including variety (e.g., webpages; social media, such as tweets, emails, online reviews, photos, and videos; and sensors), value, volume, velocity (i.e. the speed of the data flows), variability (i.e. unstructured raw data formats), and complexity (multifaceted datasets) pose serious challenges for modern supply chain graduates and need specific skills in product analytics that can create business value (Chen et al., 2012; Erevelles, Fukawa, & Swayne, 2015; Katal, Wazid, & Goudar, 2013; Schoenherr & Speier-Pero, 2015Schoenherr & Speier-Pero, 2015).

Business value creation should be characterized by dynamic perspectives, in terms of both financial and non-financial performance measures. Researchers (e.g., Jones, Tefe, & Appiah-Opoku, 2013; Merad, Dechy, Serir, Grabisch, & Marcel, 2013) have proposed that true business value creation can be created by contributing to performance dimensions such as service quality, product quality, enduring supply chain relationships, reduced environmental impacts, increased profits and share values, and market growth. Business value is thus defined as a combination of these financial and non-financial measures (Jones et al., 2013; Merad et al., 2013).

Analytical skills, big data implementations, and business value creation have frequently been used as buzzwords, but rigorous academic studies and empirical findings are only just emerging (Schoenherr & Speier-Pero, 2015Schoenherr & Speier-Pero, 2015). For instance, big data and analytics have recently enabled local Wal-Marts to stock appropriate quantities of relevant items during hurricane periods. By using big data and analytics, their supply chain data-savvy managers saved out-of-stock sales, increased profits, and maintained customer satisfaction, which are the key aspects of their business value creation. Similarly, supply chain and operational managers from MegaTelCo have been using big data to decide which customers should be offered incentives. This has helped the company to retain customers and to increase their satisfaction (Provost & Fawcett, 2013).

Numerous studies highlight that data-savvy supply chain graduates and managers need relevant knowledge and prerequisite skills in multiple domains such as operations management, statistics, mathematics, and computing (e.g.,Barton & Court, 2012; Davenport & Patil, 2012; Schoenherr & Speier-Pero, 2015Schoenherr & Speier-Pero, 2015). However, they do not necessarily need to be mathematicians, statisticians, or computer scientists, as some of the best data-savvy managers come from the operations management, supply chain, and general business domains (Davenport & Patil, 2012). The real business value creation lies in big data and analytics, which depend on skilled supply chain managers in possession of numerous characteristics, including the ability to.

- Identify business opportunities and the factors affecting business value creation, optimize performance models, understand statistics, and align models with business value creation (Barton & Court, 2012).
- Write programming codes, communicate verbally and visually, investigate problems, and test hypotheses thanks to strong backgrounds in mathematics, statistics, engineering, and computer science (Davenport & Patil, 2012).
- Combine the application of quantitative (machine learning techniques, statistics, mathematics, and programming) and qualitative methods (exploring business opportunities and risks) to forecast, develop simulation and optimization models for performance optimization, understand and apply accounting principles (accounting analytics), understand marketing opportunities, analyze and link data with business value creation and decision making and detect patterns (Schoenherr & Speier-Pero, 2015).

To analyze big data and create business value, supply chain data scientists/analysts use various data mining skills and machine learning techniques such as classification, clustering, regression, association, and network analyses (Chen et al., 2012). These skills and techniques are based on popular algorithms including neural networks for prediction, multivariate statistical techniques, heuristic search, and genetic algorithms for optimization have also been applied to business value creation and can be found in some contemporary business school curricula (Chen et al., 2012).

Techniques derived from machine learning (e.g., cluster analysis, classification, regression, and association), optimization (e.g., stochastic and classification optimization), network analysis (e.g., social network and social media analysis), visualization methods, and signal processing have numerous business applications that proficiently contribute to factors connected to business value creation. For instance, Professor Hal Varian (University of California, Berkeley, and Google Chief Economist) believes that machine learning techniques, statistics, interactive visualization, and database management are the key areas for modern supply chain data scientists (Chen et al., 2012). Particularly, the use of inferential statistics (e.g., prediction, causality analysis, and comparisons of buying patterns) and programming skills (e.g., R, Matlab, SQL, and MapReduce) have become imperative for automated business processes, contributing to business value creation (Cohen, Dolan, Dunlap, Hellerstein, & Welton, 2009). Supply chain data scientists equipped with such skills use algorithms to analyze sensor data sourced from manufacturing lines and reduce waste and avoid costly human errors, ultimately creating business value.

Similarly, retailers and beverage companies use sentiment analysis to understand customer behaviors, as expressed on social media. Also, the integration of daily weather forecast data (e.g., temperature, rainfall, and hours of sunshine) helps companies to create business value by cutting extra costs on demand and inventory-planning processes (Brown, Chui, & Manyika, 2011). Organizations use data mining techniques to predict sales and profits. For instance, decision trees are used to predict which customers are likely to discontinue utilizing products or services, ultimately affecting sales and profits. Similarly, basket analysis is used in retail stores to identify combinations of products regularly bought by customers. This enables operations managers to lay out shelves in ways that induce customers to buy related products when they see them together (e.g., milk with tea, butter with bread, and fruits with vegetables). This not only increases their sales but also contributes to customer satisfaction, relationship management, and loyalty, jointly contributing to business value creation (Anderson, Jolly, & Fairhurst, 2007; Lantz, 2013). Such analytical applications are based on skills and business knowledge (e.g., machine learning, network analysis, and statistical and optimization techniques suited to visualize patterns and understand big data to create business value) that define effective supply chain data scientists.

A comparison of the above arguments with the curricula highlighted in Table 1 clearly highlights that leading universities in the field of Logistics and Supply Chain Management need to reconsider their curricula. The review of contemporary literature hints at the need for defining specific criteria for assessing the alignment of existing curricula with graduate's employability and market trends. Moreover, there is a dearth of literature on best practices to align curricula with university's long term sustainable development goals.

3. Methodology

3.1. Data collection procedures

We adopted a qualitative methodology which was executed in three phases. In first phase, a systematic review of literature was conducted to identify 18 criteria as mentioned in Table 2 (Moazzam et al., 2018). In the second phase, we applied those criteria to evaluate selected Logistics and SCM curricula to identify the various skillset themes expected by the industry from supply chain graduates (Hermann & Bossle, 2020). For this purpose, 38 AACSB-accredited universities from five geographic regions—namely, the Americas, Europe, Asia-Pacific, and Africa-Middle East—were selected by visiting their websites and searching whether they offered a master's degree in Logistics and SCM under that exact moniker or slight variations of it. Only those universities that were found to offer such programs were included in the study. In the third phase, the views, and experiences of 16 experts from United Kingdom were collected through semi-structured interviews, integrated them to draw meaningful insights, and suggest best practices to align curriculum with the contemporary needs of industry as well as sustainable development of the degree awarding institution. As the topic had not hitherto been explored and is emerging (Schoenherr & Speier-Pero, 2015Schoenherr & Speier-Pero, 2015; Wamba, Akter, Edwards, Chopin, & Gnanzou, 2015), interviews were appropriate to explore the research domain and address the research objectives. Fig. 1 summarizes the methodology in a flow diagram.

3.2. Methods of data analysis

Stemming from the deductive and abductive approaches adopted by methodological experts (Creswell, 2013; Hair, Bush, & Ortinau, 2000; Neuman, 2005), a combination of literature review, interpretive content analysis, and expert interviews was found to be suited to this research. Criteria approach has been used by various researchers to benchmark and/or assess alignment of a framework or methodology with strategic objectives (Moazzam et al., 2018). We apply criteria approach in the first phase to identify criteria from the literature. In the second phase interpretive content analysis (ICA) was used to identify various concepts and themes implicitly found in the content (Drisko & Maschi, 2016). ICA is a subjective technique that uses researcher generated summaries and interpretations rather than word count or any other quantitative technique (Drisko & Maschi, 2016). For this purpose, detailed lists of courses, course content, and course learning outcomes were reviewed against each code in Appendix-A, to evaluate the level of data integration found in the selected degree programs.

In the third phase, in-depth interviews were conducted to investigate why the inclusion of big data and analytical content in supply chain courses is vital and how big data analytics skills contribute to business value creation. A total of 16 interviews were tape-recorded and transcribed, with each lasting 45–60 min. A reflective diary method was utilized to take detailed notes. Immediately after the interviews, informal conversations were held to check whether the respondents had anything else to add. During these conversations, the consistency of the respondents' answers was also checked by repeating some of the questions asked during the interviews. At all stages of the study researchers ensured the reliability and validity of the data by overcoming researcher and respondent bias. Additionally, to maintain the quality of the original data, direct quotes/original exchanges are frequently referred to in the finding section (Gubrium, 2012).

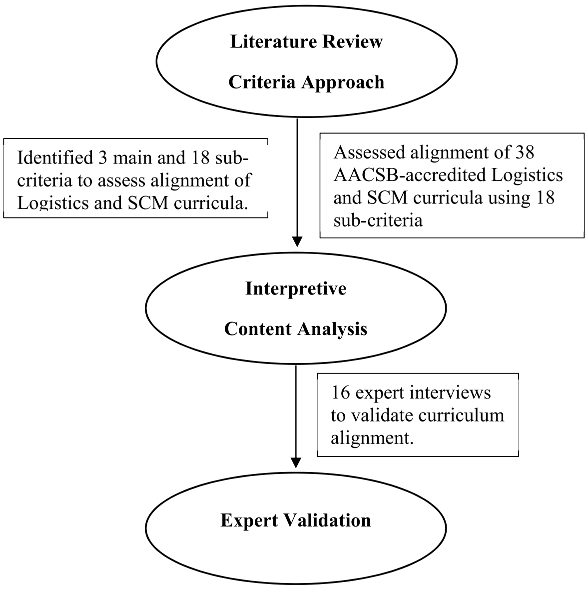

Fig. 1. Summary steps of proposed methodology.
Source: Author's own description

4. Results

4.1. Interpretative content analysis

Interpretative content analysis of 38 AACSB-accredited Logistics and SCM programs selected from leading universities around the world is presented in Appendix-A. These degree programs were reviewed against the criteria mentioned in Table 2. This analysis included universities located in the following regions: Asia-Pacific (16), Europe (10), Americas (8), and Africa-Middle East (4). The level of integration of data-driven skills found in the selected curricula increases from left to right in Appendix-A. The Université Laval, HEC Montreal, Massachusetts Institute of Technology, Purdue University, and Michigan State University were found to show a higher level of integration of the subject skills. In Europe, the University of Manchester, Cranfield University, Imperial College London, Lancaster University, Aarhus University, and Copenhagen Business School were found to exhibit higher levels of integration toward big data analytics, stochastic modeling, simulation, and optimization skills.

In the Asia-Pacific region, 11 out of 16 programs were found to have medium-to-high levels of data-intensive skills integration, whereas the universities in the Africa-Middle East were found to be less focused on data analytics skills in their L&SCM curricula. Notably, while the University of Hull was found to be focused on L&SCM and to integrate some aspects of modeling/optimization, other universities, such as the Lancaster Management School, were found to provide triangulated skills (i.e., L&SCM knowledge, data mining and analytics, and relevant C++ and SAS computer programming skills). This development was strongly intersected with contemporary supply chain operations, which are inundated with data and analytics connected with computing programming skills. However, big data-related skills were found to not have still been fully integrated, thus presenting opportunities for the creation of greater business value through software tools such as R, Python, SQL, Tableau, and Power BI.

4.2. Expert interviews

The characteristics of the 10 industry and six academia interviewees are shown in Table 3. To maintain confidentiality, they are referred to by their job titles and not their real names.

The links between the extant curricula and industrial practices were also explored in the interviews. A huge gap was found to exist between university courses and industrial practices, with the former being more theory oriented. The Head of SC Analytics highlighted this gap by saying:

"*MSc L&SCM courses are more theory-based, even when universities and colleges naively claim that their courses focus on experiential learning … when first I started in the industry, my managing director asked me to quantify our performance and identify the gaps for further improvement, it was very challenging … I did not know how to do so, and I thus studied all the definitions of logistics and supply chain management or maximum case studies, but that did not help either. He finally sent me for a training course … three months with the Inventory and Forecasting department and three months with an accountant. In this regard, the relevant forecasting theories helped me, but I had to do a short course in accounting to understand the basics. Applied forecasting techniques were also very much quant-based … some important concepts taught in universities are very good and they seem more imbalanced.*"

What do you mean by imbalanced?

"*I mean that they are not very much associated with real practices, where new business operations heavily rely on computers … anyway, after the training period, I was able to apply some theories I studied in MSc L&SCM, but it still took me ages to learn the required computing, accounting analytics, and inventory modeling, I wish I had been taught these.*"

(Head of Analytics)

"*I think that courses need to adopt modern practices and strike a balance between theories, computing, and quantitative skills based on the fundamentals of math and statistics*."

Any examples of these skills?

"*Yes, we store a lot of data for analytics, but our graduates are unable to glean insights from them. So, I think modeling and programming skills could help. We normally use SAP and, for us, modeling and analytical skills are important in ERP systems, though skills in open-source*

Table 3
Research participants' characteristics.

Job titles and characteristics	Education and experience
4 Head of SC analytics	MSc L & SCM, and BSc in operation research (10 years of experience)
3 SC data scientist/analyst	MSc in business analytics, BA SCM (5 years of experience)
3 IT and analytic consultant	Masters in analytics and BSc in computer science (5 years industrial and 5 years consulting experience
3 Professors of operation research and analytics	Ph.D. in operation research and data science
3 Senior lecturers in SC analytics	Ph.D. in operation management and analytics
Retailer, FMCG	More than 20 years old
Import and export for retailers, food	More than 30 years old
Consulting	More than 25 years old
Universities (business schools, 2)	More than 100 years old
Employees >250	–
Turnover (£m) > 50	–

software can help as well [e.g. R, Python, SQL to understand data structures]*, which I am now getting from free open source courses available online, such as Coursera and edX.*" (Head of Analytics)

Analytically oriented degrees seemed to be more correlated with industrial practices, the SC data scientist/analyst expresses his view on this:

"One of the main benefits of the skills I learned during my MSc in business analytics was to explore data using the R software, it also helped me in building forecasting models and detecting customer buying behaviors at work, though I feel I could be better if I had had more courses in operation research as well, because a lot of our problems are based on optimizing techniques. For example, we are trying to reduce our transportation distances covered each day, an ongoing project. My manager asked me to work with the transportation manager to bring the project to a successful conclusion, but I felt I lacked the required math/operational research skills. Ultimately, we had to get help from an external consultant".

(SC data scientist/analyst)

"*We often have lots of clients from the industry asking for different jobs; in particular, data mining, optimization, and programming/writing algorithm/coding tasks are among the top requests … I think it is very hard to include all these skills in one business course unless it is a 3–4 four-year degree one … it might be possible if universities change their fundamental business courses.*"

What do you mean by fundamental courses?

"*I mean, if they can include such courses at the undergraduate level, then they can produce some ideal candidates for supply chain analytics, which is needed for modern businesses*".

(IT and analytic consultant)

The following paragraphs investigate contemporary analytical, data-driven, and computer-based industrial skills, consequently proposing the design of new curricula.

"*The business operations are no longer traditional, new digital-based operations require sold skills, not only effective communication or an understanding of supply chain operations.*"

Sold skills?

"*Skills that are more applied and business operations-linked … for example, forecasting skills and using computer software to forecast … Excel/R could be an example, if students can learn these during their courses. Also, data mining is becoming almost compulsory because of IT advancements, and these data must be used by SC analysts/scientists to get better insights in regard to exploring internal and external business opportunities. Data extraction skills* [e.g. SQL and text analytics] *could be useful because lots of businesses are web-based and linked globally.*"

(SC data scientist/analyst)

"*I think the basic concept of supply chain management, logistics, transportation, and operations management, where they can learn about TQM, Six Sigma, principles of waste and sustainability, performance measurement, inventory management, transportation networks, procurement. But the balance with quantitative and computing skills is very important for modern business operations. My personal experience is*

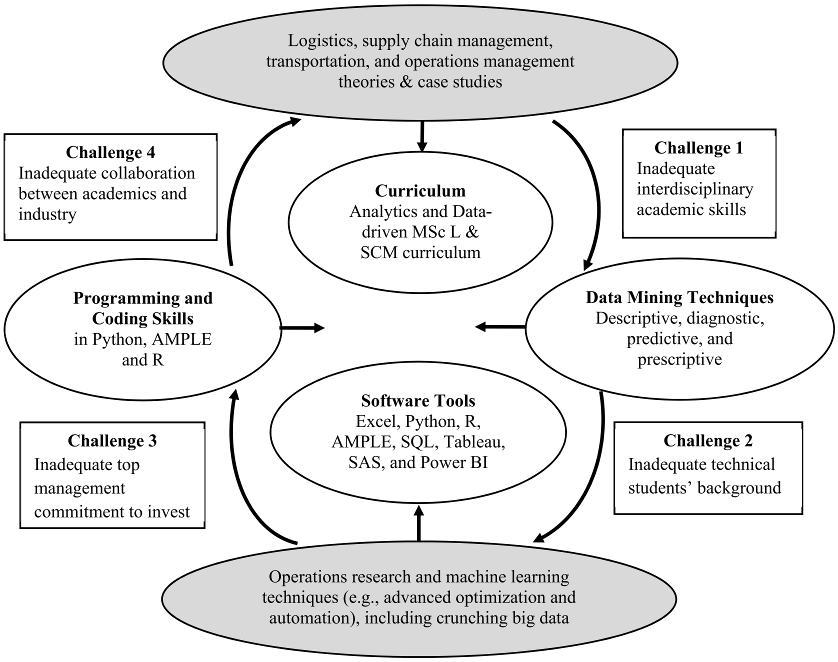

Fig. 2. Proposed curriculum for modern analytics and data-driven Logistics and SCM programs.
Source: Author's own illustration

that the students who have more tangible operational skills—such as optimization techniques, algorithms, and programming [e.g., Python]—*could get more interviews and responses for their jobs. General theories are good, but it is very hard to get a job without solid skills.*"

(Professor of operation research and analytics)

"*I have integrated a lot of information management and data mining skills in my courses to make them more practical. Recently, when I was teaching supply chain network analytics, lots of students showed great interest and appreciated network analytics they learned during the course.*"

(Senior lecturer in SC analytics)

"Analytics strongly interconnect with machine learning techniques. For example, we constantly monitor customers' buying patterns using Basket Analysis in R, and then we also look at weather forecast data and integrate it with buying patterns. In this regard, an external consultant helps us and he also provides training on pushing ads on our website and on looking at which customer wants what … I am not sure how exactly he does this, but he uses click-stream data; if customers click on a specific product, then that product is advertised on their social media sites. However, we use only aggregated data because of confidentiality issues."

(SC data scientist/analyst)

"*Optimization techniques, statistical business process control* [e.g., control charts]*, simulation, visualization, machine learning, data analytics/mining computer programming and coding skills could be very useful for industries, general supply chain/logistics/transportation theories do not help much. This sounds like computing or operation research-oriented courses, but it is not, because modern supply chain operations need them if SC graduates cannot get them, and we have to hire people from other fields to do supply chain analyst jobs. For supply chain analysts, we need more analytical skills and data-driven backgrounds.*"

(Head of SC analytics)

The above arguments suggest that, to cope with modern supply chain operations rooted in data and in a digitally connected world, modern supply chain graduates need balanced backgrounds that can be achieved by following the proposed curriculum framework in Fig. 2, because supply chain industrial practices revolve around these domains, as supported by the findings.

4.3. Key academic challenges and implications regarding the proposed curriculum framework

The industrial opportunities for required skills were highlighted in the literature review and interpretive content analysis. This mainly addressed how skills can create business value. Also, some industrial challenges were highlighted (e.g., a shortage of data-driven skills and the need to provide extensive training to supply chain graduates, who are not equipped with the right skill sets), This section specifically looks at key academic challenges to develop the proposed curriculum framework for modern MSc L&SCM graduates.

Our research showed that the extant MSc L&SCM curricula are not well integrated with the required industrial skills. The professor of operations research and analytics asked how. The above model was explained, to which he replied,

"*I agree with your research, however … look, this is very complicated. First of all, I accept that the curricula need changes to adapt to modern industrial practices. However, we face various challenges such as student backgrounds and the hiring of relevant staff. Let me explain these to you one by one. We have students with different backgrounds; some are mathematically proficient, and others are good at computing. Most come from general business backgrounds, and it is very challenging for them to cope with such a demanding course. I think they should develop fundamental backgrounds in computing/mathematics/statistics in their undergraduate courses. The MSc L&SCM course could then be more advanced, intergrading some data mining skills, coding practices, and operations research techniques. Operations research techniques rooted in a mathematical background are the basics needed to solve logistics/supply chain/transportation problems. For instance, traveling salesman problems and linear programming play a key role in supply chain operations*."

(Professor of operations research and analytics)

"*Regarding staff issues and their skills, it is very hard to find suitable multiple skilled business academics; they are normally equipped with either general business backgrounds or operations research/statistics/mathematics. Finding academics with backgrounds in multiple fields is not easy, so business schools must pay a lot to hire for different fields. Also, cultural change is an obstacle too. Many professors and seniors have established theoretical-based curricula, and they would not be happy to integrate skills such as computing programming and statistics, although these are fundamental to modern business operations. I think we can train our academics as well, but one must be very ambitious to learn multiple skills, and those who did their studies before the computer age would not be happy to implement such policies.*"

(Professor of operation research and analytics)

"*The key challenge I often face is that, when I try to teach advanced-level operations research, students cannot cope and they ask for basics, which means they do not have an adequate background in data analytics. For example, last year, I had many comments from the students that the SC Analytics course is too technical. I did a bit of research, and these comments were from those students who came from the general business domain. On the other hand, many quant students loved the course and commented that it was very practice oriented. I think we need to integrate fundamentals at the undergraduate level.*"

(Senior lecturer in SC analytics)

"*Undoubtedly, analytics are a key part of businesses and we have been integrating relevant content, but the business school is generally slow* *in this regard, as resources and top management commitments are low. Information management using specific techniques* [e.g., text mining/pattern detection] *should be part of logistics and supply chain curricula*".

(Senior lecturer in SC analytics)

"*We often observe that universities do not have sufficient resources to equip themselves with computers. Ideally, each technical course* [e.g., analytics, data mining, writing algorithms, and coding] *should be practiced on computers, but the students do not have that opportunity because of a lack of resources. I think governments should provide more* funds *for infrastructure that is fully installed, with the required software and computers.*"

(Senior lecturer in SC analytics)

"*Big data and analytics courses are particularly important for supply chain operations and information management; ultimately for knowledge discovery … because such operations are more digitally connected and are exponentially producing data that can produce insights for business opportunities.*"

(Senior lecturer in SC analytics)

"*Though it is challenging, you have developed a very good model, I think this could be the future of our MSc L&SCM graduates, but its effectiveness depends on how much relevant background students get in their undergraduate courses … basically, this curriculum framework would be ideal if its structure could be also integrated into BSc L&SCM courses; then, our graduates will be more in demand like computer scientists … cross disciplinary collaborations between academics themselves and industry are challenging, as most of them are not interested or do not see any mutual benefits*."

Senior lecturer in SC analytics)

5. Discussion

For this study, selected L&SCM curricula and their links with industrial practices were reviewed. Consequently, a new curriculum framework integrating the skills required for contemporary business operations was proposed. Also, key opportunities and challenges were highlighted. The research revealed a significant gap between the theory and practice of L&SCM in relation to industry 4.0 and its technologies. The courses were found to be more theory-based and imbalanced, with graduates being unable to glean insights from the large amounts of stored data. Asamoah et al. (2017) emphasized the interaction of theory and principles with practice through their application in course exercises, projects, and lab assignments. This could offer more reflective practice suited to achieving a better understanding of the concepts being taught. Additionally, the proposed curriculum framework was designed in relation to the data science expectations of EU industrial sectors, providing industry-standard scenarios and tools (Mikroyannidis et al., 2017).

To cope with modern supply chain operations, which are rooted in data and in a digitally connected world, a new curriculum framework was proposed with a focus on programming and coding techniques, data mining, and operation research skills. This is important because, according to (Landry, Pardue, Daigle, & Longenecker, 2013) the disparity between the existing curricula and the number of program credit hours serve as a call to action for the creation of model curricula for business analytics. These skills are of the utmost importance for business graduates to succeed in the challenging practical world; they are because they offer learners experience with the data science tools customarily employed in the industry and their specific sector (Mikroyannidis et al., 2017). Google's chief economist explained that, while data are abundant and widely available, '*what is scarce is the ability to extract wisdom from them*' (Parks, Ceccucci, & McCarthy, 2018). This highlights the criticality of business analytics in preparing organizations to solve 21st Century business challenges (Landry et al., 2013), particularly those linked to industry 4.0 (Fatorachian & Kazemi, 2018; Mikroyannidis et al., 2017; Oesterreich & Teuteberg, 2016). The provision of such practical tools provides an appreciation of the operational challenges linked to L&SCM, in addition to the capabilities of information systems suited to provide cross-functional data for decision-making (Angolia & Pagliari, 2018).

Several different challenges were identified—including students' backgrounds, the lack of basic background knowledge/technical skills, the lack of relevant staff, changing staff attitudes to incorporate technical skills, the lack collaborations between academics as well with industry, and the lack of resources at universities. Researchers have identified the skills and backgrounds needed by both students and teachers to join the program as a challenge and have proposed the technical skills background needed to be eligible to join the program. While Chaurasia et al. (2018) noted that, as students differ in their preferences, interests, backgrounds, and even goals for learning, there is an urgent need for user profiling through big data analytics. This could provide individual students or groups thereof with personalized learning environments suited to maximize learning effectiveness and efficiency.

In relation to the resource scarcity challenge, different departments (IT/Statistics/Mathematics) and other assets need to align with institutional strategic goals in order to satisfy the growing data analysis demand and create student satisfaction and employability and real business value. Changing the existing curricula could be challenging. Many HEIs lack an overall understanding of how big data can significantly improve and optimize operations and strategy, and consequently see little value in pursuing big data initiatives (Chaurasia et al., 2018). This results in HEIs resisting any implications presented by big data and industry 4.0 to business schools. However, engaging instructors in curriculum design could help to reduce this resistance to change. This is particularly important because, if academia is to provide better business analytics curricula to support decision-making, there is a need for the development of new analytical materials and pedagogy (Akhtar et al., 2019; Wang et al., 2016).

6. Conclusion

In conclusion, from the literature review, interpretive content analysis, and the interview findings, it can be observed how supply chain graduates need to be equipped with big data, analytics, operations research techniques, computing skills, and relevant knowledge so that they may apply them to create better business value. Without the integration of such techniques/skills in L&SCM curricula, students' soft skills (communication and leadership) are not very useful for practitioners as they have to provide them with intensive training aimed at gaining technical skills. Thus, business schools should focus on balanced curricula.

Although some business schools are developing and adapting to new industry trends, machine learning techniques and algorithm aspects are still missing despite their strong presence in supply chain operations. Thus, curricula suited for future supply chain graduates could be defined by striking a balance between an understanding of supply chain/logistics/transportation theories (qualitative), statistical applications (e.g., data quality detection and getting insights for business value creation), operations research (linear programming for transportation and inventory optimization), computer programming (C++, R, Python, SAS, Tableau, Power BI, AMPLE), big data analytics (text analytics for detecting service quality improvement, big data visualization for supply chain networks and network analytics to detect key supply chain operations for sustainability) and machine learning techniques (e.g., customer pattern detection). The umbrella domains for these techniques are highlighted in Fig. 2.

7. Theoretical and practical implications

This study has several theoretical and practical implications. Its relevance resides in the fact that it sought the input of both academicians and practitioners to highlight the need for big-data analytics in the field of L&SCM and to identify the potential steps to be undertaken to overcome the challenges they face. Its findings may also significantly help HEI administrators to identify the key steps to be undertaken to resolve the industrial challenges faced by university graduates. Furthermore, those faculty members interested in creating or furthering their L&SCM programs in order to include big data and analytics will find practical information, materials, and suggestions, as well as a research and curriculum development agenda. Additionally, if the findings of this study are heeded, they could significantly help universities to tap into the data-driven business world, which impacts the way organizations function and both they and their employees think, work, communicate, and interact. HEIs and business organizations need to engage in conversations aimed at developing current and future professionals. This study's contributions provide educators and organizations with a means to measure and monitor attitudes toward big data.

Statement of conflict of interest

There is no conflict of interests, and all authors approved the paper to be published.

CRediT authorship contribution statement

Pervaiz Akhtar: Writing – original draft, Methodology, Formal analysis, Conceptualization. **Muhammad Moazzam:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Aniqa Ashraf:** Writing – review & editing, Visualization, Validation. **Muhammad Naveed Khan:** Writing – review & editing, Visualization, Validation.

Data availability

We used all data in the manuscript submitted

Appendix A. An Interpretive Content Analysis of Selected AACSB-Accredited Supply Chain Management Curricula

Universities	Degree Programs	Low-Medium Integration							Medium-High Level Integration								Remarks	
		LCHF	PF	TF	PNF	OMF	ORF	MF	GBF	ERPF	IF	DI	CPI	SI	AI	LTI	FAI	Main focus and skills (tangible techniques taught) linked with the industries
Americas (8)																		
Massachusetts Institute of Technology, USA	Masters in SCM		✓			✓						✓			✓	✓	✓	Main focus: mixed and a good balanced skills: communication, leadership, and some quantitative areas covered
Purdue University, USA	M.Sc. Global SCM	✓	✓				✓	✓				✓			✓		✓	Main focus: Analytics, OR, excellently balanced qualitative and quantitative skills skills: analytics, data mining, optimization, simulation, spreadsheets
Centrum Catolica, Peru	Masters in SCM					✓	✓	✓										Main focus: (22 months program) skills: optimization
Michigan State University, USA	MS SCM	✓	✓				✓	✓				✓		✓		✓		Main focus: logistics, SCM, and manufacturing (two years program) skills: Quantitative and statistical methods for decision-making.
Pennsylvania State University, USA	Master of SCM		✓			✓												Main focus: General supply chain management
Low-level data integration																		
Arizona State University, USA	Masters in SCM	✓	✓							✓								Main focus: SCM and general
Skills: Decision models, planning, and control																		
Low level of data integration																		
Universte Laval, Canada	MBA SCM	✓	✓			✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	The major focus is on the use of information systems and data analytics suggesting a medium to high-level data integration
HEC Montreal, Canada	MSc Global SCM	✓	✓				✓		✓	✓		✓	✓	✓	✓			Main focus: a balanced set of courses on general business, SCM, and quantitative and mathematical modeling
Europe (10)																		
The University of Manchester, UK	M.Sc. Operations, Project & SCM		✓				✓	✓				✓				✓		Main focus: main focus on SCM and general skills: ERP, data analytics, technology, simulation
Cranfield University, UK	M.Sc. Logistics & SCM	✓	✓			✓						✓				✓	✓	Main focus: SCM and quantitative skills skills: simulation, data mastering, accounting, analytics for SCM, six sigma techniques
University of Hull, UK	M.Sc. Logistics & SCM	✓	✓	✓		✓									✓	✓		Main focus: Logistics and SCM skills: inventory modeling and analytics
Imperial College London, UK	M.Sc. Business Analytics or MSc Transport	✓	✓			✓						✓	✓					Main focus: IT or transportation, some aspects of supply chains, operations/optimization, and forecasting
University of Kent, UK	M.Sc. Logistics & SCM	✓	✓	✓		✓									✓	✓		Main focus: logistics, supply chains, big data analytics and visualizations using R/PythonSkills: spreadsheet modeling, data mining, logistics modeling, and R/ Python programming, stochastic modeling,

(*continued on next page*)

(*continued*)

Universities	Degree Programs	Low-Medium Integration							Medium-High Level Integration								Remarks	
		LCHF	PF	TF	PNF	OMF	ORF	MF	GBF	ERPF	IF	DI	CPI	SI	AI	LTI	FAI	Main focus and skills (tangible techniques taught) linked with the industries
																		optimization, simulation, big data analytics and visualizations using R/Python
Lancaster University, UK	M.Sc. Logistics & SCM	✓	✓			✓	✓			✓		✓	✓		✓	✓		Main focus: excellent balance of quantitative, qualitative, and computer skills skills: spreadsheet modeling, data mining, logistics modeling, C++ and SAS programming, stochastic modeling, optimization, analytics, simulation
Aarhus University, Denmark	Operations & SC Analytics			✓		✓	✓			✓	✓	✓	✓		✓			Main Focus: Big Data Analytics, ERP, and Stochastic modeling
Erasmus University, Netherlands	M.Sc. SCM	✓	✓		✓	✓										✓		Main focus: generic with a little focus on quantitative skills skills: simulation, forecasting
Kedge Business School, France	M.Sc. Global SCM	✓		✓		✓			✓									Main focus: Generic skills: SAP and general
Copenhagen Business School, Denmark	M.Sc. SCM		✓				✓					✓						Main focus: supply chain management (2 years program) skills: optimization, data mining
Asia-Pacific (16)																		
Hong Kong Ploy Technic University	Industrial Logistics Systems	✓		✓	✓	✓	✓	✓		✓		✓	✓	✓		✓		Main Focus: comprehensively covers all major functional silos of SCM and medium-level integration of ERP, data, and business intelligence
City University of Hong Kong	MSc Operations and SCM	✓	✓	✓		✓	✓			✓	✓	✓	✓		✓	✓		Predominantly a data analytics and computer programming intensive program.
Hong Kong University of Science & Technology	MS Global Operations					✓				✓		✓	✓		✓		✓	Operations and Supply Chain with a major focus on ERP and data analytics
Lingnan University Hong Kong	MS eBusiness and SCM									✓	✓	✓	✓		✓	✓		The program predominantly consists of ERP and data-intensive courses
Xi'an Jiaotong-Liverpool University, China	M.Sc. Operations & SCM	✓	✓			✓	✓		✓	✓	✓	✓	✓		✓		✓	Main Focus: A predominant focus on learning tools of data analytics, mathematical modeling, and simulations, the curriculum covers general business subjects as well.
Indian Institute of Management, Udaipur, India	MBA Global SCM	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓	✓			Two streams: one is to be completed from Udaipur and the second is a dual degree from Purdue University USA. Both Curricula offer a balanced set of courses in terms of data integration.
National University of Singapore	MS SCM	✓					✓			✓	✓	✓	✓	✓	✓	✓	✓	Main Focus: Strong focus on information systems, data visualization, and advanced data integration.
Curtin University, Australia	Master of SCM	✓	✓			✓	✓		✓	✓	✓			✓				The program is mainly general business focused with less focus on data integration
La Trobe University, Australia	MIM Supply Chain and Logistics	✓							✓						✓		✓	General business focus with specialized courses covering the supply chain and logistics concepts
Swinburne University Australia	Master of Supply Chain Innovation	✓		✓				✓		✓		✓	✓		✓	✓		The program incorporates medium to high-level content of information systems such as ERP and data analytics
The University of Melbourne	Master of SCM	✓	✓			✓				✓						✓		The program is designed for low to medium levels of ERP exposure and data integration

(*continued on next page*)

(*continued*)

Universities	Degree Programs	Low-Medium Integration							Medium-High Level Integration								Remarks	
		LCHF	PF	TF	PNF	OMF	ORF	MF	GBF	ERPF	IF	DI	CPI	SI	AI	LTI	FAI	Main focus and skills (tangible techniques taught) linked with the industries
University of South Australia	Master of Management SCM	✓	✓									✓			✓			A general business management program with a specialization in SCM mainly covering its components at low to medium-level data integration courses
University of Sydney	Master of Logistics & SCM	✓	✓	✓		✓						✓			✓			More focus on supply chain foundation and allied courses but less focus on ERP, Statistics, and big data-related courses.
University of Wollongong, Australia	Master of SCM	✓	✓			✓	✓			✓	✓	✓			✓	✓	✓	More a logistics systems and supply chain analytics oriented program, high level of data integration
Auckland University of Technology, New Zealand	Master of SCM	✓	✓			✓				✓		✓			✓		✓	A balanced program for gaining knowledge of the subject and learning skills in supply chain systems and data analytics. Medium to the high level of data integration
The University of Auckland, New Zealand	Master of SCM		✓			✓			✓			✓			✓		✓	Predominantly a general business-focused program with just one course on supply chain analytics
Africa and the Middle East (4)																		
University of Cape Town, South Africa	MBA Operations & SCM					✓			✓					✓			✓	General MBA with elective courses in operations and SCM as one stream. Low-level data integration and data analytics.
University of Stellenbosch, South Africa	M.Com, Logistics Management	✓												✓				Research intensive program with a statistical research focus
ESCA Ecole de Management, Morocco	Master in Purchasing & SCM	✓	✓	✓					✓					✓				Program with purchasing and supply chain focus, low-level emphasis on data-intensive skill development.
University of Dubai, UAE	MBA Operations & Logistics Management	✓	✓			✓			✓					✓			✓	General MBA with specialization in Operations and logistics, low level of integration of data analytics skills

The abbreviations used are: Logistics and SC focused (LSCF); Procurement focused (PF); Transportation focused (TF); Ports and network focused (PNF); Operations management focused (OMF); Operations research focus (ORF); Manufacturing focused (MF); General business focus (GBF); Enterprise Recourse Planning focused (ERPF); Industry 4.0 focused (IF); Data-driven integration (DI); Computer programming integration (CPI); Statistical integration (SI); Analytics integration (AI); Logistics technology integration (LTI); and Finance/accounting integration (FAI).
Note: Appendix-A has been prepared based on information available on the universities' websites. Also, MSc L & SCM courses (or the key content of LSCM in a program) in English are encompassed only.

Appendix B. Questionnaire for interviews

General questions about participants and companies

Please specify the industry in which you are working.
a) Wholesale b) Retailer c) Manufacturer d) Importer
e) Exporter d) other, please specify …. …
Please state the average number of employees in your company.
a) < 20 b) 20–49 c) 50–99 d) 100–250 d) > 250.
Please indicate the average annual turnover (in million UK£).
a) < £7 b) £8–26 c) £27–43 d) £44–50 e) >£50.
In which year your company was established?
Please state your formal level of education.
Have you got any specialized training/education in the following? If yes, please specify.
a) Logistics/supply chain management/transportation/operations management b) Analytics c) Data mining d) Operations Research – e.g. optimization, linear programming, etc (d computer programming – e.g. R, SAS, Python, etc
e) Other, please specify …. …
How many years of relevant work experience do you have?, …. please also specify your major area (s) of experience.
a) …. …. … b) …. ….. c) …. ….

Example of questions related to different areas/skills

What do you think about extant curriculums/courses universities teach in MSc L & SCM?
Are they very relevant to the required industrial skills? yes/no, any examples/why not …
What sort of development do you want to see in these courses? any examples …
What specific skills do you think are more important for supply chain graduates in terms of industrial practices? Any examples …
What sort of key challenges do you face with new supply chain graduates? Any example.
What sort of qualitative skills do you expect from a supply chain graduate?
What sort of quantitative skills do you expect from a supply chain graduate?
What sort of computing skills do you expect from a supply chain graduate?
What sort of key challenges do you face while teaching data-driven/computer-based/operation research courses to MSc L and SCM students?
Keeping modern industrial requirements, how MSc L & SCM curriculums can be improved?
What sort of courses do you think MSc L and SCM students should study?
How do you see the future of MSc L and SCM curriculums?

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