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Contact to corresponding author: Arif Ibne Asad, asad@utb.cz

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Arif Ibne Asad
Tomas Bata University in Zlin, Czechia
orcid.org/0000-0001-8622-0941

Boris Popesko
Tomas Bata University in Zlin, Czechia
orcid.org/0000-0002-3590-7070

Brian Godman
University of Strathclyde, United Kingdom
orcid.org/0000-0001-6539-6972

Unraveling the internal drivers of pharmaceutical company performance in Europe: A DEMATEL analysis

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Abstract

Research background: Internal business factors are vital to how a company achieves its goals. The present study of internal drivers of pharmaceutical company performance is very insightful, as it has the potential to boost further competitiveness, it may allow health authority personnel to have guidelines to make strategic decisions, as well as inspire investor confidence, ensure regulatory compliance and performance benchmarking, and support talent acquisition and retention. In addition, it can identify the important internal factors that need to receive more priority.

Purpose of the article: The European pharmaceutical industry is currently facing multiple challenges. This paper aims to map the relative relationships among the internal factors that influence the business performance of pharmaceutical companies in Europe by using the DEMATEL approach.
Method: There are two phases of the present study, an extensive literature review and the use of the decision-making trial and evaluation laboratory (DEMATEL) technique. To identify the key internal drivers and their cause-and-effect relationship with pharmaceutical company performance in Europe, data from experts were obtained using the predesigned DEMATEL questionnaire.
Findings & value added: The extensive literature review from the Web of Science and Scopus databases found that seven internal factors are very demanding in the case of European pharmaceutical business performance. The main elements that have the highest impact on pharmaceutical business performance in Europe are human resources competencies, the information system, technological competitiveness, and the patent system. However, financial profitability, research and development competencies, alliances with other companies, and supply chain management are the factors that are affected more by other factors.
The study is the first attempt to identify the internal business performance of the pharmaceutical sector in Europe by working with pragmatic and perceptive decisions from pharmaceutical stakeholders in Europe.

Introduction

Internal business factors are vital to how a company achieves its goals. The internal business environment consists of factors within the company that influence the success and approach of operations; it includes a company's own strengths and weaknesses, as well as internal operations and resources (Sun, *et al*. 2013; Hassan *et al*., 2021) which are most suited to a highly knowledge-intensive industry such as pharmaceutical companies (Downs, & Velamuri, 2018, Styhre, 2002). Internal company characteristics such as the existing innovation culture, leadership qualities, internal research and development capabilities, motivation for innovation, and overall organizational continuing efficiency are also important (Pinto *et al*., 2023; Galende, & de la Fuente, 2003).

Pharmaceutical research is an expensive endeavor for drug manufacturers. Companies must protect their discoveries with patents due to the importance of financial investment in research projects (Ohana *et al*., 2004). As a research-intensive industry, pharmaceutical companies spend approximately 14–15% of their total revenue on research and development activities (R&D) (Downs & Velamuri, 2018). Additionally, the high cost of drug development has made a question about the affordability of drugs to the patients (Workman *et al*., 2017). Importantly, financial factors (Boldeanu &

Pugna, 2014; Boldeanu & Gheorghe, 2012) and human resource competency significantly impact pharmaceutical innovation (Bousalem & Aichouche, 2016). Internally, the desire to improve firm performance by developing more effectively and efficiently needs some other crucial drivers, such as a major driver is drug supply chain integration (Glenn Richey Jr. *et al*., 2009; Jaberidoost *et al*., 2013), which requires add value through competitive advantages for the pharmaceutical company (Moosivand *et al*., 2019). In addition, technological innovation is crucial for the competitiveness and growth of enterprises, regions, and countries (Hall & Bagchi-Sen, 2002). Therefore, pharmaceutical manufacturing technology is undoubtedly a crucial factor in the business (Gascón *et al*., 2017). Overall, the importance of internal factors for pharmaceutical companies cannot be denied.

The most powerful business drives are frequently those that originate from within the organization or from personal actions with a clear business objective, such as rebranding or expanding into new markets, as well as from personal career growth, resource utilization, and goal-setting. The current study is novel for both highly knowledge-intensive industries and pharmaceutical companies. As the current art of the studies is concerned with evaluating pharmaceutical inventory configurations in pharmaceutical supply chains and identifying the main factors influencing inventory levels (Hansen *et al*., 2023), the adoption of digital transformation (DT) in the pharmaceutical business is highly impacted by the high cost of developing new medications and the lengthy clinical approval processes, Tetteh *et al*. (2022). Moreover, according to Doloreux *et al*. (2016) and Subramanian and Bhattacharyya (2023), knowledge-intensive business services (KIBS) participation in R&D depends highly on internal resources. However, there is no comprehensive study that focuses on the overall internal factors that have been focused in the present study.

The aim of this paper is mapping to reflect the relative relationships among the internal factors that influence the business performance of pharmaceutical companies in Europe by using the DEMATEL approach. The DEMATEL method is useful to identify cause-effect chain components of a complex system of internal drivers of European pharmaceutical companies, such as business profitability, research and development competencies, human resources competencies, relationship development with alliances, information system, and technological competencies, supply chain management and patent system, and protections. Very few studies have been previously conducted on the DEMATEL approach to identify cause and effect drivers of pharmaceutical companies, such as those Kumar and Chandra (2022); Turan and Ozturkoglu (2022); Khan *et al*. (2023) who used DEMATEL to investigate the performance of the pharmaceutical industry's supply chain management, Sharma *et al*. (2022) used the DEMATEL approach to investigate the barriers to industry 5.0 adoption in German pharmaceutical experts, Singh *et al*. (2023) used the DEMATEL approach to identify post-implementation barriers of enterprise resource planning (ERP) system in pharmaceutical companies, and Tavana *et al*. (2015) used this method in measuring the financial performance of publicly held pharmaceutical companies. As a result, the DEMATEL is a proven method for identifying the cause-effect chain components of the internal factors influencing pharmaceutical companies, however, it has limited scopes in pharmaceutical business research.

The current study is distinctive in several ways. First, it investigates several internal factors of pharmaceutical companies, second, it focuses on all European pharmaceutical companies because there are several contemporary pharmaceutical challenges in the European pharmaceutical industry, such as issues with patent systems, R&D, health care systems, outsourcing and alliances, and supply chain management. Some recent studies focused on these issues individually, but not concurrently, such as Ciliberti *et al*. (2016) study on the internal R&D and innovation factor of the Italian pharmaceutical industry, Eva (2018) described the impact of new health technology expansion on healthcare spending growth in the Czech Republic, and the impact of internal workforce factors on pharmaceutical business in the UK is examined by Jolly *et al*. (2005). The research is divided into several sections. An extensive literature review on internal factors influencing the business performance of pharmaceutical companies in Europe and the DEMATEL method applied, where pharmaceutical experts are interviewed as respondents to evaluate the cause-effect factors of pharmaceutical business performance.

There are multiple core and sub-sections in the study. The study's introduction is included in the first section. The use of the DEMATEL approach to identify business performance indicators in the pharmaceutical industry, the necessity of conducting the study from a European perspective, and internal drivers of pharmaceutical company performance are covered in the literature review section. The third section focuses on the study's methodology; it covers the sample and research framework, the study's procedure, and the DEMATEL method's steps. The application of the DEMATEL approach to yield outcomes is covered in the fourth section. This includes classifying the cause-and-effect factors and identifying the major internal drivers of pharmaceutical business performance in Europe. The study's conclusions and a discussion are rounded out in the final sections.

Literature review

In this section of the literature review, researchers will examine papers on "factors influencing the business performance of pharmaceutical companies", identifying "internal and external factors for pharmaceutical business performance", and explain why this study will prioritize internal drivers over external drivers of pharmaceutical companies. Finally, this section will examine the literature in this area from a European pharmaceutical perspective and the application of the DEMATEL approach to identify business performance indicators in the pharmaceutical sector. The extensive literature review was conducted through Web of Science and Scopus databases.

Internal drivers of performance

The internal business environment (internal business environment) refers to the current business strategy, objectives, resources, procedures, organizational culture, and the value of the company as a whole. The company has influence over internal business determinants, which are elements that affect the company's performance and operational strategy. It is crucial to consider the external environment to identify prospective possibilities and risks outside of a company's operations. However, the key to a successful company is controlling the advantages of internal operations. Importantly, internal drivers have an impact on how the company's inventive process is set up (Galende & de la Fuente, 2003; Gaol *et al*., 2020).

In pharmaceutical firms, business performance will be positively impacted by successful internal control, particularly good monitoring, knowledge, and tradition (Nguyen, 2021). Internal pharmaceutical factors, such as financial resources, R&D intensity, persistence in innovation, knowledge sharing with alliances, technology usage, and entrepreneurship, exhibit a significant influence on firm performance (Um *et al*., 2022). Table 1 found the seven internal factors that are discussed extensively in the literature of Web of Science and Scopus. Due to their direct influence on the future success of pharmaceutical companies, the seven internal criteria listed below are frequently considered significant for evaluating pharmaceutical business performance. The following subsections give a brief explanation of the final criteria or factors chosen and explained in Table 1.

Financial profitability (F1)

The first factor that pharmaceutical firms consider when making decisions about how to run or grow the business is their financial performance. Management's financial choices are in line with the shareholders' goals of maximizing wealth, which also includes the company's goal of maximizing profits (Boldeanu & Gheorghe, 2012; Enekwe *et al*., 2014). When the rate of return on total assets increases, pharmaceutical companies pay more attention to both operating efficiency, corporate social responsibility, and other internal factors (Chai *et al*., 2020).

Research and development competencies (F2)

The achievement of success in R&D activities and many characteristics of the company are positively and significantly correlated. Therefore, having an R&D department, having special incentive systems for the R&D staff, implementing innovative management practices in the R&D department, and the firm's patent policy are all variables that have a good impact on a larger organization (Mendigorri *et al*., 2016; Ling *et al*., 2018). As reported by Raghavendra *et al*. (2012), according to 72.7% of respondents, various internal issues related to the pharmaceutical sector, rather than external factors, are what influences how much money pharmaceutical companies spend on R&D.

The performance of a pharmaceutical company's business and its inventive culture are closely correlated. Various practices, including encouraging employee creativity, accepting and partnering with alliances for the collaborative development of technologies, and employee participation in the development of new drugs or therapies, can be used to address an innovative culture (Nazari & Ghasemzadeh, 2018; Araujo *et al*. 2022).

Additionally, pharmaceutical firms increasingly aim to produce environmentally friendly green products. Natural product-based drug discovery is being made possible by recent technological advancements. Notwithstanding, certain obstacles have been tackled and novel prospects have emerged in the field of natural products-based drug discovery. These include enhanced analytical instruments, genome mining and engineering strategies, and advancements in microbial culturing (Atanasov *et al*., 2021). To become more involved in cleaner production in the long run, the sector must foster process-orientated innovations and create an eco-friendly culture (Li & Hamblin, 2016).

Human resource competencies (F3)

The pharmaceutical industry relies extensively on qualified personnel in a variety of positions, such as sales representatives, regulatory specialists, researchers, scientists, and clinicians. Companies can improve their R&D capabilities, ensure high-quality product development, maintain regulatory compliance, and drive effective sales and marketing strategies by having competent and motivated staff. The retention, happiness, and future performance of employees are impacted by pharmaceutical governance. Furthermore, the intrinsic factors that best describe the motivation of sales teams are personal goals and acquired abilities (Ferreira, 2017; Ghauri, 2018; Pinto & Rastogi, 2022; Frank *et al*., 2023).

Internal capabilities of human resources team influence positively to enlarge, uphold, or control the power of parental pharmaceutical companies (Dadfar *et al*., 2010; Chai *et al*., 2020; Naeem *et al*., 2021). In addition, an internal procedure is established whereby the employment connection is explored and negotiated, so that all sides are satisfied with the outcome. For pharmaceutical businesses, it has a larger internal attribution to successful performance outcomes, but from this point of view, it also results in increased usage of surplus resources (Riantoputra, 2010; Luu *et al*., 2019; Jayamohan *et al*. 2024).

Corporate social responsibility (CSR) programs by the human resource team address social issues, but they can also improve customer trust and foster a sense of loyalty among customers by helping them identify with pharmacies (Riantoputra, 2010; Abbasi *et al*., 2023). Companies can prioritize advertisements above long-term initiatives even within CSR programs, emphasizing the necessity for global standards that are straightforward for businesses to effectively publish to gain market access to the medicines (Rocha *et al*., 2020). Additionally, the pharmaceutical industry has been under criticism for its negative image and for possibly altering clinical trial outcomes and prioritizing money over patients. CRS methods place these contemporary societal debates within the pharmaceutical industry's reputational agendas (Van den Bogaert *et al.*, 2018). However, the main structural barriers that support Big Pharma's corporate moral irresponsibility when it comes to the sale and distribution of necessary medications and vaccines during COVID-19 include the company's conflicts of interest, the regulatory framework that is becoming less strict, the company's aggressive and unethical lobbying, the money it provided to lawmakers who directly oversee the industry, and the absence of state intervention and regulation (Ballano, 2023).

In particular, HR metrics such as employee remuneration and training better describe how the company performed during a crisis such as the COVID-19 period, where human capital contributed to enhancing the performance of their companies in times of crisis (Mahssouni *et al*, 2022).

Alliances with other companies (F4)

Forming alliances has become a crucial decision for businesses looking to improve their competitive edge. The pharmaceutical company may benefit strategically from alliances and collaborations with other pharmaceutical companies, research facilities, academic institutions, or healthcare organizations. Alliances increase R&D capabilities, speed up product development, increase market competitiveness, and provide access to complementary knowledge, common resources, and wider market reach (Ombrosi *et al.*, 2019; Ortiz *et al.*, 2021). While new players benefit from the expertise of established players in commercializing novel technologies, conventional businesses use their partnerships with new entrants to adjust to technological advancements (Jiang *et al.*, 2022). Pharmaceutical companies tend to participate in mergers and acquisitions (M&A) due to the industry's high information demands and the ability of partners to share knowledge to grow their businesses (Timmins, 2019).

Information system and technology (F5)

Technology and information systems are becoming more and more integral internal factors for the pharmaceutical sector. How technology affects collaboration in strategic business processes, such as new product development (NPD), depends on the specific characteristics of the process.

Furthermore, a new dimension has been added to the healthcare sector with the employment of robots, artificial intelligence, and machine learning (Boddu *et al*., 2022).

Importantly, mismanagement of the pharmaceutical supply chain, including drug shortages, lack of coordination among healthcare stakeholders, product waste, and lack of demand information, can be resolved by integrating information between key stakeholders in the industry. Blockchain, a distributed digital ledger technology, is showing promise for resolving various supply chain management issues as it offers security, transparency and traceability (Alharthi *et al*., 2020). Production intelligence makes use of and closely integrates a variety of concepts and techniques currently used in drug manufacturing and therapy production (Estler & Ewen, 2011). Consequently, in order to deliver the value of competence in the technology and information systems that businesses employ in their business activities, an integrated system is required (Gaol *et al*., 2020).

Supply chain management (F6)

Effective and sustainable supply chain management is essential in a pharmaceutical company to guarantee on-time drug delivery, manage inventories, and maintain quality control (Wisniewski & Tundys, 2020; Donkor *et al*., 2022). According to Haque and Islam (2018), collaboration and knowledge-sharing techniques in the supply chain have a substantial impact on customer satisfaction, which in turn increases corporate competitiveness. It guarantees a high level of product quality and new product innovation in the highly educated pharmaceutical sector. Moreover, Companies might take up sustainable development initiatives as part of their own operations or in conjunction with other supply chain participants as part of sustainable supply chain management (Małys, 2023).

Due to the recent changes in supply chain management and the resulting complexity of the system (both offline and online), some stakeholders who act irresponsibly in the chain have faced penalties. For instance, Tenders impose monetary fines on suppliers for neglecting to fulfill their supply commitments (Jongh *et al*., 2021). However, if the fine is excessive, it will constrain pharmaceutical companies' financial actions (Zhang & Zhu, 2022).

In the EU, the issue of drug shortages has drawn a lot of public and political attention, as the pharmaceutical supply chain is still highly vulnerable after COVID-19 pandemic. Importantly, shortages have been recognized as a serious public health concern by the European Parliament and Council. The EU Pharmaceutical Strategy for Europe in 2020 also includes measures to guarantee the availability of medications throughout the EU and prevent shortages (Jongh *et al*., 2021).

The patent system (F7)

To preserve the creative strategies employed by pharmaceutical companies, patent protection is crucial. Drug patents help to recover financial outlays made during the research and development phase. Drug patents can defend against copyright allegations, because rivals can easily duplicate the development of a drug. However, the company's human resources have a role in determining which patents to keep or revoke. Pharmaceutical business performance deteriorates as a result of the default patent system (Asad & Popesko, 2023). In addition, important aspects of the conventional blockbuster model are exposed in light of the primary developments in the pharmaceutical industry that could negatively affect the model's efficacy, including the sharply rising costs of research and development, enormous patent cliffs, and increasing regulatory pressure on medicine prices (Bereznoy, 2022). Pharma companies began using access to medications as a strategy to boost their financial performance and public image in addition to improving pricing and active patent policy challenges (Rocha *et al*., 2020). Big Pharma is beginning to seem more and more like a private equity fund, producing profits for its investors based on monopolized information via intellectual property rights, capitalized future earnings potential, and increasing debt (Klinge *et al*., 2020).

One of the seven criteria is connected to the other, as shown by the extensive literature review. The purpose of this study is to use primary data to show this causal link.

The necessity of the study from a European perspective

The development, approval, and post-authorization monitoring of pharmaceuticals are handled under Europe's complete pharmaceutical system (European Commission, 2020). However, there are current challenges for the European pharmaceutical industry, including the default patent system, ineffective R&D, debate about the function of alliances, a lack of expertise in the European healthcare system, pharmaceutical supply chain management, and other issues. The lack of an adequate emergency infrastructure capable of handling the difficult logistical problems brought on by supply chain restrictions (European Parliament, 2021; Asad & Popesko, 2023). To discover the best policy measures, the pharmaceutical industry in Europe requires a comprehensive and integrated strategy that addresses the issues and eliminates obstacles. This strategy should operate across disciplines and regulatory competencies throughout the lifetime of medicines and medical technologies (European Commission, 2020).

According to a study by Schapranow *et al*. (2012), the pharmaceutical sectors in Europe and the United States have a growing need to build counterfeit detection systems, which is what drives the increased importance of RFID security. To examine messages and data flowing through the supply chain using RFID (radio frequency identification), a formal model is presented. Artificial intelligence (AI) may be able to provide people with better health care through more affordable and durable goods and services. In addition, it can make information, education, and training more accessible. It is enhancing our understanding of diseases, improving clinical trials, speeding up drug discovery, and improving diagnostic efficiency and accuracy. It can increase workplace safety by using robots to perform hazardous tasks and creating new job opportunities as AI-driven sectors develop and adapt (European Parliament, 2023).

"Innovative and Affordable Medicines" is listed as the top objective of the European pharmaceutical industry. Lack of research on Europe's health issues, such as antimicrobial resistance, rare diseases, and vaccines, as well as the challenges in the pharmaceutical system, may all be related to a variety of potential factors, such as the affordability of medicines due to high prices, potential unintended or detrimental consequences of incentives, and the lack of leverage of individual Member States in negotiations with industry (European Parliament, 2021). The seven criteria discussed in this study are also related to each other across Europe. The DEMATEL questionnaire, developed for this purpose, questioned pharmaceutical professionals throughout Europe. The operating effectiveness and internal elements are influenced by financial profitability, and the R&D and HR capabilities of a pharmaceutical firm also have an impact on patents, sales growth, partnerships, and technical advancement. Alliances, information and technology, supply chain, and patents are additional elements that are somehow related to or have an impact on other factors. As a result, from a European perspective, this study has significant implications for and is applicable to the current pharmaceutical landscape in Europe.

The application of the DEMATEL approach in identifying business performance indicators in the pharmaceutical sector

In Table 2, the implementation of the DEMATEL approach in the pharmaceutical business area has been illustrated. No prior research has identified the pharmaceutical business performance criteria using the DEMATEL technique. However, the majority of studies focus on supply chain issues or try to identify what makes a chain work well, such as De Campos *et al*. (2021); Meidute-Kavaliauskiene *et al*. (2021); Turan and Ozturkoglu (2022); Shafiee *et al*. (2022); Kayani *et al*. (2023); Kumar and Chandra (2022). Other partial factors of pharmaceutical business performance include adopting an export strategy for pharmaceuticals (Jassbi *et al*., 2021), evaluating the effectiveness of publicly traded pharmaceutical companies (Tavana *et al*., 2015), prioritizing medication management criteria (Izadpanah *et al*., 2022), and challenges and solutions for the pharmaceutical manufacturing sector (Sharma *et al*., 2022). The majority of the research has just been conducted between 2021 and 2023, thus there are several potentials for DEMATEL and comparable methodologies to contribute in this area.

Methods

This section provides an overview of the DEMATEL approach, data collection procedures, expert profiles, and the research strategy for the current study.

The DEMATEL method

The Decision-Making Trial and Evaluation Laboratory (DEMATEL) method has been used in practice to show how different criteria interact with each other and to identify the primary criteria that best capture the efficacy of various factors and attributes (Lee *et al*., 2013). The Science and Human Affairs Programme at the Battelle Memorial Institute in Geneva first developed the decision-making trial and evaluation laboratory (DEMATEL) method in 1972–1976 (Du & Zhou, 2019). The four steps that make up the original DEMATEL process are as follows.

First step: find the average matrix A.

Suppose that we have n factors to take into account and H experts willing to share their insights. Each stakeholder is asked to rate the impact they believe factor i has on factor j. This pairwise comparison of the i-th factor and the j-th factor provided by the k-th expert is indicated by the symbol $\mathbf{b}_{\mathbf{ij}}^{(\mathbf{k})}$. The ij factor function takes an integer scoring between 0 and 4, which corresponds to "No influence (0)," "Low influence (1)," "Medium influence (2)," "High influence (3)" and "Very high influence (4)," respectively.

The scores provided by each expert will create a nxn non-negative answer matrix with $\mathbf{B}^{(\mathbf{k})} = [\mathbf{b}_{\mathbf{ij}}^{(\mathbf{k})}]_{\mathbf{nxn}}$ and where 1≤K≤H. Therefore, $\mathbf{B}^{(\mathbf{1})}$, $\mathbf{B}^{(\mathbf{2})}$, …….,$\mathbf{B}^{(\mathbf{H})}$ are the experts' response matrices. Each answer matrix $\mathbf{B}^{(\mathbf{k})}$'s diagonal members are all set to zero, indicating that no impact is imparted on its own. The scores of the H experts can then be averaged to get the nxn average matrix A for all experts.

The average matrix:

$$\mathbf{A} = [\mathbf{a}_{\mathbf{ij}}]_{\mathbf{nxn}} = \frac{\mathbf{1}}{\mathbf{H}} \sum_{\mathbf{k=1}}^{\mathbf{H}} \mathbf{b}_{\mathbf{ij}}^{(\mathbf{k})},\ i, j = 1,2, \ldots, n \tag{1}$$

The initial direct relation matrix is a substitute for the average matrix A. The initial direct effects that a factor has on and obtains from other factors are displayed in matrix A. Drawing an impact map allows us to further illustrate the causal relationship between each pair of components in a system.

Second step: calculate the normalized initial direct-relation matrix D

Now, to obtain the normalized initial direct-relation matrix $\mathbf{D} = [\mathbf{d}_{\mathbf{ij}}]_{\mathbf{nxn}}$ from normalizing the average matrix A, let us suppose,

$$\mathbf{S} = \mathbf{max}\left(\max_{\mathbf{1 \le i \le n}} \sum_{\mathbf{j=1}}^{\mathbf{n}} \mathbf{a}_{\mathbf{ij}}, \max_{\mathbf{1 \le j \le n}} \sum_{\mathbf{i=1}}^{\mathbf{n}} \mathbf{a}_{\mathbf{ij}}\right) \tag{2}$$

Then,

$$\mathbf{D} = \frac{\mathbf{A}}{\mathbf{S}} \tag{3}$$

The entire direct effect that factor i has on other factors is represented by the sum of each row i of the matrix A, $\sum_{\mathbf{j=1}}^{\mathbf{n}} \mathbf{a_{ij}}$. Therefore, the largest overall direct influence of all factors is represented by $\max_{\mathbf{1 \le i \le n}} \sum_{\mathbf{j=1}}^{\mathbf{n}} \mathbf{a_{ij}}$. Similarly, the entire direct effect that factor j has on other factors is represented by the sum of each column j of the matrix A, $\sum_{\mathbf{i=1}}^{\mathbf{n}} \mathbf{a_{ij}}$. Therefore, the largest overall direct influence of all factors is represented by $\max_{\mathbf{1 \le j \le n}} \sum_{\mathbf{i=1}}^{\mathbf{n}} \mathbf{a_{ij}}$. Matrix D is created by dividing each element of A by the positive scalar S, which uses the greater of the two as the scaling factor. It should be noted that each matrix D element $\boldsymbol{d_{ij}}$ falls between zero and one.

Third step: calculating the total relation matrix

Let, $\boldsymbol{D^m}$ is the power of the normalized initial direct-relation matrix D, which can be used to symbolize the effect of length m or the effect that spreads after (m-1) intermediates and is known as the m-indirect influence. We may calculate the overall influence or total relation by adding up $\mathbf{D}$, $\mathbf{D^2}$, $\mathbf{D^3}$,….., $\mathbf{D^\infty}$. It guarantees convergent solutions to the matrix inversion, similar to an absorbing Markov chain matrix. Therefore, $\lim_{m \to \propto} D^m = [0]_{n \times n}$, where $[0]_{n \times n}$ is the n×n null matrix. In the DEMATEL approach, it has been assumed that $\boldsymbol{D^m}$ would converge to a zero matrix and the total relation matrix can be obtained as follows:

$$T = \sum_{k=1}^{\propto} D^i = D + D^2 + D^3 + \cdots \ldots \ldots + D^m$$

$$= D(\mathbf{I} + D + D^2 + D^3 + \cdots \ldots \ldots + D^{m-1})$$

$$= D\,(\mathbf{I} - D)^{-1}(\mathbf{I} - D)\,(\mathbf{I} + D + D^2 + D^3 + \cdots \ldots \ldots + D^{m-1}) \tag{4}$$

$$= D\,(\mathbf{I} - D)^{-1}\,(\mathbf{I} - \mathbf{D^m})$$

$$= D\,(\mathbf{I} - D)^{-1}$$

$$\mathrm{T} = \mathrm{D}(\mathbf{I} - \mathrm{D})^{-1}$$

where, $\mathbf{I}$ is the identity matrix and T is the total relation matrix. Once T has been determined, we can define r and c as vectors nx1 vectors that represent the total sum of the rows and columns of T's relation matrix:

$$\mathbf{r} = [\mathbf{r_i}]_{\mathbf{nx1}} = (\textstyle\sum_{\mathbf{j=1}}^{\mathbf{n}} \mathbf{t_{ij}})_{\ \mathbf{nx1}} \quad (5)$$

$$\mathbf{c} = [\mathbf{c_j}]'_{\mathbf{1xn}} = (\textstyle\sum_{\mathbf{i=1}}^{\mathbf{n}} \mathbf{t_{ij}})'_{\ \mathbf{1xn}} \quad (6)$$

where, the superscript ′ denotes transpose.

Let $\mathbf{r_i}$ represent the total of the matrix T's i-th row. The overall effect of factor i on other factors, both directly and indirectly, is then displayed by $\mathbf{r_i}$. Let $\mathbf{c_j}$ stand for the T matrix's j-th column's sum. The overall effect, direct and indirect, that factor j has received from other factors is then shown by the expression $\mathbf{c_j}$. Therefore, when j = i, the sum $(\mathbf{r_i} + \mathbf{c_i})$ provides us with an index that represents the complete influence that the factor i has both given and received. In other words, $(\mathbf{r_i} + \mathbf{c_i})$ depicts the significance of the role factor i plays in the system measured by the sum of its effects, both delivered and received. Additionally, the difference $(\mathbf{r_i} - \mathbf{c_i})$ demonstrates the overall impact that each aspect has on the system. Factor i is a net causer (cause group) when $(\mathbf{r_i} - \mathbf{c_i})$ is positive, and a net receiver (effect group) when $(\mathbf{r_i} - \mathbf{c_i})$ is negative.

Fourth step: Set a threshold value and get the impact-relations map

Select a threshold value (α) to filter out any insignificant influence in the T matrix to adequately explain the structural relationship between the elements while maintaining the manageable complexity of a system. The decision-maker must choose a threshold value in order to lessen the complexity of the structural relation model implied by the matrix T, even if each factor of the matrix T gives information on how one element impacts another. The factors selected and displayed on an impact relation map (IRM) should only be those whose impact on the matrix T exceeds the threshold value.

Following the identification of the cause and effect factors, this phase is taken. where N represents the total number of elements in the entire relation matrix (T).

$$\boldsymbol{\alpha} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}[t_{ij}]}{N} \tag{7}$$

Data collection and sampling method

The purpose of our study is to use a DEMATEL analysis to unravel the internal drivers of pharmaceutical company performance in Europe. We develop the purposive sampling technique taking this objective into account. We made an effort to get in touch with the leading pharmaceutical companies in Europe by contacting their human resources departments. 200 respondents from companies, researchers, medication production managers, supply chain planners, sales analysts, and others were asked to respond. Finally, we received 15 observations along with the follow-up undertaken in the study. For some of these, data was collected through face-to-face interviews and the distribution of Google questionnaire forms. In January 2023, the data collection procedure began, and it lasted until June of the following year.

Due to the nature of the study, the data is collected using the expert sampling method, a particular kind of purpose sampling approach. The expertise of the respondents is one of the main factors considered when using purpose sampling to choose the type of sample units to include in the study. The quality of the experts is typically more significant than their quantity in nonrandom sampling approaches (Sabary *et al*., 2023). A total number of experts from Germany, Ukraine, and the Czech Republic responded that one factor influences others with a scale scoring between 0 and 4, which corresponds to "No influence (0)," "Low influence (1)," "Medium influence (2)," "High influence (3)," and "Very high influence (4)," respectively. The structure of the predesigned DEMATEL questionnaire is represented in Table 9, the seven factors, such as financial profitability, Research and development, human resources, alliances, information system and technology, supply chain management, and the patent system, responded by asking how much each factor influences. Additionally, the diagonal members are set to zero, indicating that no impact is imparted on its own.

Profile of the total sample for the study

The 15 respondents were from Germany, Ukraine, and the Czech Republic. The respondents have relatively advanced education levels; of the total respondents, 66.7% have doctorates in Pharmacoeconomics or related fields, and 33.3% have master's degrees or other equivalent degrees. Experts have a good deal of experience in the pharmaceutical industry. For example, 60% of them have ten years or more of experience. Other, 40% of the experts also have experience between 1 to 5 years in the related field. In terms of their current positions, experts have high-ranking resumes, including academicians, specialists in medical information management, lab managers, heads of national monitoring centers for drugs and addictions, quality control managers, supply chain planners, sales assistants, pharmacists in drug stores, retail, wholesale pharmaceutical marketing specialists, and others.

The industry or type of business where experts' fields or sectors are associated with the pharmaceutical industry is, respectively, over-the-counter (OTC) medicines (20%), regulated pharmaceuticals (20%), prescription-only medicines (13%) and others, such as biotech lab research, clinical trials, and R&D supports, which make up 46.7%, see details in Table 3.

Research framework of the study

In Figure 1, there are two phases of the present study, extensive literature review, and the use of the DEMATEL technique. The term "extensive literature review" refers to a compilation of articles, books, and other materials on internal business performance variables that affect pharmaceutical organizations as well as the literature in this field from a European pharmaceutical perspective. The Web of Science and Scopus are the databases used for the literature review. Publications were chosen for examination, and seven internal business performance criteria were ultimately chosen due to the emphasis placed on them. Additionally, articles on the application of the DEMATEL approach in identifying business performance indicators were reviewed in the literature review section.

The DEMATEL technique was used mainly in the second phase to collect data from pharmaceutical experts. In the beginning, as a warm-up question we asked experts about rating each of the seven factors and how much these are important for pharmaceutical business performance, on a scale of 1 to 5, with 5 being the most important, and 1 being the least important. Importantly, we gather the experts' opinions in a (7x7) matrix form in response to the influence of a single component on others. We calculate an average matrix or direct relation matrix (A) from the information, and calculate the normalized initial matrix (D). Following the techniques of DEMATEL, we estimate the total relation-matrix (T) and the sum of rows and columns of matrix (T) to identify the cause and effect factors of the model. After setting the threshold value (α), we construct an impact relation map (IRM). A threshold value Alpha (α) is specified in order to achieve casual interactions between variables in a scenario. The average value of the complete relation matrix is used to calculate this value. The values of each relation matrix are then compared to the Alpha value. The causal relations are indicated by the total relation matrix that has a higher value for two or more elements than Alpha. The calculation was done through the Microsoft Excel software.

Result

Identification of key internal drivers of pharmaceutical company performance in Europe

On a scale of 1 to 5, with 5 being extremely important and extremely unimportant, we asked respondents to rate the importance of various dimensions related to measuring the role of the following factors in pharmaceutical business performance. That means, we aimed to sort out the crucial internal elements for pharmaceutical business performance based on the following scale: 5 = extremely important, 4 = important, 3 = normal, 2 = unimportant, 1 = extremely unimportant (Kumar *et al.*, 2018). The scale is used to identify the comparative importance of the factors, while it is different from the DEMATEL matrix scale, which had been described in the result section of the DEMATEL analysis.

From the perspective of experts, very few people believe that any component is irrelevant or seriously irrelevant. Supply chain and patent protection were only rated as the least significant by a small number of specialists, but since there were only 1–2 of them, we may disregard this ranking in our research. Figure 2 of the radar diagram shows that financial profitability was rated an important factor by the majority of the respondents (47%), who also thought it was extremely important (40%) and had a normal influence on the firm (13%). Significantly, 7 experts (47%) rated R&D competencies as of the utmost importance, giving them a score of 5. Additionally, 4 people (27%) believe that it is important for the success of the pharmaceutical industry. The same number of people believe that it has a typical impact on the viability of the pharmaceutical business.

A majority of experts (40% or 6 experts) believed that other factors, such as human resource competencies, alliances with other companies, information system and technological competencies, supply chain management, and patent system and protections, were also crucial for pharmaceutical business performance, scoring 4 out of 5, see in Figure 1.

The results from the DEMATEL analysis

We sent 200 people from several European nations, including Germany, France, Italy, the Netherlands, Norway, Ukraine, the Czech Republic and Poland, to the DEMATEL questionnaire (Table 9) to identify the key internal drivers of pharmaceutical company performance in Europe. Finally, we received questionnaire responses from 15 respondents (experts) from Germany, Ukraine, and the Czech Republic. For DEMATEL analysis, a sample size of five to twenty can be considered sufficient (Kumar *et al*., 2018). Moreover, Sabry *et al*. (2023) state that DEMATEL can be conducted with five respondents, including decision-makers. Kabak *et al*. (2016) used DEMATEL to conduct 36 expert interviews.

Importantly, experts rated the seven preidentified internal elements that affect the business performance of pharmaceutical companies in Europe on a scale of 0 to 4. The decision of each expert is then arranged in a (7x7) matrix. Experts opined in response to the influence of a single component on others, where diagonal members are all set to zero, indicating that no impact is imparted on its own. As we have 15 experts in total, therefore, we symbolize each expert matrix in a unique character such as X1, X2, X3 ... X15. The fifteen matrices are shown in Table 4.

Of the four stages of the DEMATEL approach, the determination of the average matrix (A) is the first. Once all the expert data has been collected, we will average all the matrices, which will display the mean of all the experts. Table 5 shows the average matrix (A) of the 15 matrices.

In Step 2, we calculate the normalized initial direct-relation matrix D. Equations 2 and 3 are used to calculate the normalized matrix, and the results are shown in Table 6. That means, first we sum up each row and column, and the maximum number from both is 20.0, which we divide by each element of the average matrix (A), Table 5.

In Step 3, it is necessary to derive the total relation matrix (T). It can be constructed through the identity matrix (I) and direct relation matrix (D). Applying equation (4), we get the following Table 7, the total relation matrix (T). This means that the inverse of the difference between the identity matrix (I) and direct relation matrix (D) is multiplied by the direct relation matrix (D). In the total relation matrix, we calculate the sum of the row $\boldsymbol{r_i}$ and the sum of the column $\boldsymbol{c_i}$.

Finally, setting a threshold value and getting the impact-relations map (IRM) are the final stage formulations. The threshold value is calculated by following the identification of the cause and effect where N represents the total number of elements in the entire relation matrix (T).

$$\boldsymbol{\alpha} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}[t_{ij}]}{N} = \frac{\mathbf{34.68003}}{\mathbf{49}} = \mathbf{0.707756} \quad (8)$$

Only values greater than the threshold's alpha were retained and used to create the impact relation map (IRM) in Figure 3 according to the DEMATEL method. These values in matrix T have been indicated with an asterisk (*) for clarification. To locate the elements of a complex system's cause-and-effect chain, DEMATEL is regarded as an efficient technique. This technique not only uses matrices to turn dependency links into a cause-and-effect group, but also uses impact relation diagrams to identify key elements in complicated structural systems. To build an impact-relation map, the values of (r+c) and (r-c) were obtained. These values illustrate how a single factor affects other ones. Those with positive values (r-c) make up the positively influenced group. Simply said, the criteria in this category have the greatest influence on the other criteria and the least influence on them and are assigned a higher priority and called causer. Here, we display these requirements as shadow objects. Similarly, the group that is negatively impacted has a negative (r-c) value when compared to the other criteria. This is called the effect group, and the included factors of this group are more influenced by other factors, and those have lower priority. Here, we display these requirements as non-shadowed objects (Rouhani *et al*., 2014; Sabary *et al*., 2023; Sabary & Ključnikov, 2023).

The results from Table 8 illustrate that human resources competencies (F3), information system and technological competencies (F5), and the patent system and Protections (F7) are the causers. This indicates that these causer factors significantly impact the other factors. On the other hand, financial profitability (F1), research and development competencies (F2), alliances with other companies (F4), and supply chain management (F6) are the factors in the effect group, which are more affected by other factors. Importantly, the present study implies that human resources competencies (F3) have the highest value from (r-c), and it is 0.876398. On the other hand, the other two causers information system and technological competencies (F5), and the patent system and Protections (F7) are keeping comparatively lower values, respectively 0.069501 and 0.112831. Consequently, it can be said that human resources have a stronger impact on other factors in the pharmaceutical business performance, as it can directly play a significant role in patent protection, prudent information, and technological competence, as well as contribute highly to sustaining financial profit through innovation and R&D activities. Alternatively, financial profitability has the least value (-0.4038) in the analysis, which means that it has the lowest influence in the DEMATEL model.

Taking into account the values of r + c, one can specify how to prioritize a factor. According to Sabary *et al*. (2023), the relationship between the criterion and other criteria is indicated by the symbol r + c. Financial profitability (F1), research and development competencies (F2), and human resources competencies (F3) are the three highest prioritized factors in the study with (r+c) values of 11.23859, 10.86019, and 9.68773, respectively. Therefore, once it has completed its business activities, a pharmaceutical company focuses on these three internal characteristics. In the event of improved company success, the decision is made to prioritize these elements. On the other hand, alliances with other companies (F4), information system and technological competencies (F5), and supply chain management (F6) have the lowest (r+c) values, such as 9.551977, 9.546421, and 8.908776. It shows that, compared to other factors, all three of these factors are given the least weight when making decisions about how to improve business performance.

The black arrows in Figure 3 indicate the direction of cause and effect, and the small circles in Figure 3 show where the criteria are located based on the values of (r + c) and (r -c) as coordinates (r + c, r - c). The most significant evaluation criterion among the seven internal factors is financial profitability, which has the highest r + c value (11. 23859), while supply chain management has the lowest r + c value (8.908776). According to (r+c), F1> F2 > F3 > F7 > F4 > F5 > F6 can be used to order the seven components in terms of importance. The (r-c) criteria, on the other hand, are divided into two categories, namely, causes and effects. In the analysis, human resources have a stronger impact on other factors in the pharmaceutical business performance and financial profitability has the lowest influence on the DEMATEL model. As pharmaceutical companies have a higher priority on social responsibility in public health and R&D innovation for drug and therapy development, financial profitability often has less influence on other factors.

Discussion

The discussion section has been divided into two parts, such as a comparative perspective for previous research and business implications.

A comparative perspective for previous research

The major elements that have the greatest impact on pharmaceutical business performance in Europe are human resources competencies, the information system and technological competencies, and the patent system and protections. Previous studies also support these arguments, such as the study from De Campos *et al*. (2021), which illustrated that human resource management, teamwork, information technology, infrastructure, policy effectiveness, and end-of-life management practices are essential to the successful implementation of the Brazilian pharmaceutical care process. Singh *et al* (2023) studied the challenges of the pharmaceutical resource planning system and found that unreliable information, an ineffective mechanism, and lack of training should be listed as the three biggest obstacles. Sharma *et al*. (2022) conducted research on challenges and solutions to moving towards Industry 5.0 in the pharmaceutical manufacturing sector in Germany. The most significant barrier to Industry 5.0 adoption is discovered related to information and technological factors, which is to be "linking virtual reality " and it belongs to a causal group, which denotes its influence on other barriers. For German businesses, "Measures for better connectivity with patients" are crucial to ensuring secure communication and protecting patient data.

However, financial profitability, research and development competencies, alliances with other companies, and supply chain management are the factors that are affected more by other factors.

The DEMATEL approach is used to determine how publicly traded pharmaceutical businesses are related to each other, Tavana *et al*. (2015). According to the Kumar & Chandra (2022) study, transportation failure, a loss of human resources, and a loss of suppliers are potential risk factors that could result in vulnerabilities in the pharmaceutical sector, which overshadow a lack of medications, a decline in the quality of on-hand stock, and a loss of sales or revenue.

Many research investigations that employ the DEMATEL technique have been conducted on supply chain management issues in the pharmaceutical industry. In the present study, it is a factor in the effect group that is more influenced by other factors, which are evidenced in the studies, Meidute-Kavaliauskiene *et al*. (2021) illustrated that lean innovation practices in the pharmaceutical supply chain were more dependent on technology expertise. To prevent errors along the chain, it is also critical to comprehend the connections between all the facilities, tools, equipment, and materials required. Shafiee *et al*. (2022) added that highly influential hazards in the supply chain that are easily influenced by other risk factors include the perishability of items, unpleasant working conditions, supply-side risks, and work hours. Furthermore, Kayani *et al*. (2023) studied sustainability and resilient supplier selection criteria and the results found that the sustainability criteria were product price, past performance, innovative capability, and information disclosure rank. Importantly, Mahdiraji *et al*. (2022) analyzed findings and showed that the biggest obstacles are a lack of financial support and a shift towards digital technology. The requirements for secure storage of drugs and medical equipment, as well as providing a practical mechanism for reporting and controlling pharmaceutical errors, were investigated and tested for effectiveness by Izadpanah *et al*. in 2020. They affected the extra components: the influence was greater on ongoing drug and medical equipment evaluation than on independent factors or criteria.

Business implications

The Web of Science and Scopus databases yielded very few prior research articles on the internal issues affecting the pharmaceutical industry. The paper by Hansen *et al*. (2023) establishes an approach for evaluating inventory configurations in pharmaceutical supply chains and identifies the main factors influencing inventory levels. The case study demonstrated that internal considerations dominated when making decisions about inventory management, even if external and downstream supply chain elements were acknowledged as crucial to pursuing inventory reduction strategies. Production strategy, replenishment policies, production flexibility, order quantity, order size, capacity utilization, production lead time and lead time variance, and space set aside for inventory are some drivers that affect the manufacturing of the final product and the company's characteristics. Importantly, the adoption of digital transformation (DT) in the pharmaceutical business is highly impacted by both internal and external variables, as per the findings of Tetteh *et al*. (2022). One of the many internal variables driving DT is the high cost of developing new medications and the lengthy clinical approval processes.

One of the most important things that allows businesses to collect data, produce knowledge, and innovate is research and development (R&D). Particularly, knowledge-intensive business services (KIBS) participate in R&D, which relates to internal resources or transparency in the establishments (Doloreux *et al*., 2016). Organizational reconfigurations that enable intentional inflow and outflow of ideas and knowledge between internal firm resources and external stakeholders, anchored by the goals of the research-intensive firm, are found to be a prerequisite for the implementation of sustainable practices (Subramanian & Bhattacharyya, 2023).

Conclusions

The European pharmaceutical industry is currently facing a number of challenges. The aim of this paper is mapping to reflect the relative relationships among the internal factors that influence the business performance of pharmaceutical companies in Europe by using the DEMATEL approach. The extensive literature review from the Web of Science and Scopus databases has found that seven internal factors are very demanding in the case of European pharmaceutical business performance, such as financial profitability, research and development (R&D) competencies, human resource competencies, alliances with other companies, information system and technological companies, supply chain management and the patent system. The main elements that have the highest impact on pharmaceutical business performance in Europe are human resources competencies, the information system, technological competitiveness, and the patent system.

However, financial profitability, research and development competencies, alliances with other companies, and supply chain management are the factors that are affected more by other factors. The current study is distinctive in that it examines a number of factors of internal pharmaceutical companies — a comprehensive investigation that the researchers have not yet completed — and concentrates on all European pharmaceutical companies due to the fact that the European pharmaceutical industry is currently facing a number of challenges.

The present study of internal drivers of pharmaceutical company performance is very insightful, as it has the potential to boost further competitiveness, the health authority personnel can have guidelines to make strategic decisions, inspire investor confidence, ensure regulatory compliance and performance benchmarking, and support talent acquisition and retention. The social consequences of examining the internal performance drivers of pharmaceutical companies in Europe include increased access to healthcare care, advances in medical research, improved patient safety, and quality assurance.

The current study is distinctive in that it examines a number of factors of internal pharmaceutical companies — a comprehensive investigation that the researchers have not yet completed — and concentrates on all European pharmaceutical companies due to the fact that the European pharmaceutical industry is currently facing a number of challenges. Because the pharmaceutical industry relies heavily on knowledge and human resources for pharmaceutical research and business development, policymakers should be able to identify this important internal factor and give it more priority. This is because the more resourceful a company is with its human resources, the more likely it is to succeed in the future.

Internal variables are essential in influencing the competitiveness and performance of organizations in knowledge-intensive industries. Consistent innovation is based on internal elements including skilled resources, R&D investment, an innovative culture, and efficient knowledge management. The development of human capital, decent work and economic growth, innovation, building strong IT infrastructure, and other goals are closely linked to the internal factors that are critical for long-term sustainability in knowledge-intensive industries.

Since the pharmaceutical industry is a fairly closed sector, the fundamental constraint of the study is the difficulty in acquiring the data from the specialists. However, we were able to collect data from experts who were willing to participate in the interview and were from Germany, Ukraine, and the Czech Republic. It is a limitation of the study that we received low respondents for the study. However, further research can be done for a comparative analysis to get opinions from experts in North American and Asian countries like the United States and India where drug manufacturing companies are growing and competitive globally, as the DEMATEL approach is a very new method in pharmaceutical business performance analysis.

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Annex

Table 1. Internal factors influencing pharmaceutical business performance

Factors	Author(s)
Financial profitability (F1)	Boldeanu & Gheorghe (2012), Enekwe *et al.* (2014) Chai *et al.* (2020).
Research and development competencies (F2)	Raghavendra *et al.* (2012); Li & Hamblin (2016); Mendigorri *et al.* (2016); Ling *et al.* (2018); Atanasov *et al.* (2021); Araujo *et al.* (2022).
Human Resource Competencies (F3)	Riantoputra, (2010); Dadfar *et al.* (2010); Ferreira (2017); Ghauri, (2018); Van den Bogaert *et al.* (2018); Luu *et al.* (2019); Chai *et al.* (2020); Rocha *et al.* (2020). Naeem *et al.* (2021); Mahssouni *et al.* (2022); Pinto, & Rastogi (2022); Jayamohan *et al.* (2024); Abbasi *et al.* (2023); Frank *et al.* (2023), Ballano (2023).
Alliances with other companies (F4)	Ombrosi *et al.* (2019); Timmins (2019); Ortiz *et al.* (2021), Jiang *et al.* (2022).
Information System and Technological Companies (F5)	Estler & Ewen (2011); Bala *et al.* (2017); Alharthi *et al.* (2020); Gaol *et al.* (2020); Boddu *et al.* (2022).
Supply chain management (F6)	Haque & Islam (2018); Wisniewski & Tundys (2020); Jongh *et al.* (2021) Zhang & Zhu (2022), Donkor *et al.* (2022), Małys (2023).
The patent system (F7)	Rocha *et al.* (2020); Klinge *et al.* (2020); Bereznoy (2022); Asad & Popesko (2023)

Table 2. Implementation of DEMATEL-based approach in the pharmaceutical business area

Author (s)	Methods	Concerned issue
Jassbi et al. (2021); Kumar & Chandra (2022).	Fuzzy DEMATEL	adopt strategy of pharmaceutical export, resilience in the generic drug supply chain.
De Campos *et al.* (2021); Meidute-Kavaliauskiene *et al.* (2021)	A grey-DEMATEL approach	Backward logistics in the drug delivery process, Pharmaceutical Supply.
Singh *et al.* (2023); Tavana *et al.* (2015). Izadpanah *et al.* (2022).	DEMATEL-based ANP	Challenges in pharma enterprise resource planning, evaluating the efficiency of publicly traded pharmaceutical firms; Prioritising Medication Management Criteria.
Turan & Ozturkoglu (2022); Shafiee *et al.* (2022).	DEMATEL approach	obstacles to the pharmaceutical industry's execution of a sustainable cold supply chain, challenges to networks of supply chains for perishable products during the COVID-19 outbreak.
Sharma *et al.* (2022).	AHP-ELECTRE-DEMATEL Approach	Challenges and solutions for the German pharmaceutical manufacturing sector.
Kayani *et al.* (2023)	Fuzzy multicriteria decision making (MCDM) techniques	Sustainable and resilient supplier selection and order allocation.

Table 3. Profile of the sample experts

Category	Specification	Frequency	Percentage (%)	Country
Education level	Master or equivalent	5	33.3	Germany, Ukraine, Czech Republic
	PhD or Doctoral	10	66.7	
Work experience	between 1 to 2 years	1	6.7	
	between 2 to 5 years	3	20	
	between 5 to 10 years	2	13.3	
	10 years or more	9	60	
Type of business undertaken by the company	Over-the-counter (OTC) medications	3	20.0	
	Prescription-only medicines	2	13.3	
	controlled drugs.	3	20.0	
	Others	7	46.7	
Experts' current work title	Head of research centre for national drug monitoring, Research Assistants in biotechnological laboratory, Quality control manager, Pharmacists in drug store, Lab Manager, Pharmaceutical academicians, Retail and wholesale pharmaceutical marketing specialists, Supply Chain Planner, Specialist in medical information management, Sales assistant.			
Name of the company and institutions	GSK, Danylo Halytsky Lviv National Medical University, Lviv, Ukraine, Zaporozhye State Medical University, Zaporizhzhia, Yuria-Pharm, National Monitoring Centre for Drugs and Addictions in Czech Republic, Viatris, LLC BIOTESTLAB, BENU lékárna, principal investigator at Dpt of Addiction of the 1st Medical Faculty of the Charles university.			

Table 4. Experts' opinion in the form of matrices

$$X1 = \begin{bmatrix} 0 & 4 & 1 & 2 & 4 & 3 & 3 \\ 4 & 0 & 1 & 4 & 4 & 3 & 1 \\ 4 & 4 & 0 & 3 & 3 & 4 & 1 \\ 3 & 3 & 1 & 0 & 2 & 2 & 4 \\ 3 & 3 & 1 & 4 & 0 & 3 & 1 \\ 3 & 0 & 0 & 0 & 4 & 0 & 0 \\ 2 & 4 & 3 & 3 & 4 & 4 & 0 \end{bmatrix} \quad X2 = \begin{bmatrix} 0 & 3 & 3 & 4 & 3 & 4 & 3 \\ 3 & 0 & 3 & 2 & 4 & 3 & 3 \\ 4 & 4 & 0 & 3 & 4 & 3 & 3 \\ 4 & 3 & 3 & 0 & 3 & 2 & 2 \\ 3 & 4 & 3 & 2 & 0 & 4 & 3 \\ 4 & 2 & 2 & 2 & 3 & 0 & 2 \\ 3 & 3 & 2 & 3 & 3 & 2 & 0 \end{bmatrix} \quad X3 = \begin{bmatrix} 0 & 4 & 4 & 3 & 4 & 3 & 4 \\ 4 & 0 & 2 & 2 & 3 & 3 & 3 \\ 4 & 3 & 0 & 3 & 2 & 3 & 3 \\ 2 & 2 & 2 & 0 & 2 & 3 & 3 \\ 3 & 3 & 3 & 3 & 0 & 2 & 2 \\ 3 & 3 & 3 & 3 & 3 & 0 & 2 \\ 3 & 3 & 3 & 3 & 2 & 3 & 0 \end{bmatrix}$$

$$X4 = \begin{bmatrix} 0 & 2 & 2 & 2 & 3 & 2 & 2 \\ 3 & 0 & 1 & 2 & 3 & 1 & 2 \\ 3 & 2 & 0 & 2 & 2 & 2 & 2 \\ 2 & 2 & 2 & 0 & 1 & 2 & 1 \\ 3 & 3 & 2 & 2 & 0 & 1 & 2 \\ 3 & 1 & 2 & 2 & 1 & 0 & 1 \\ 2 & 2 & 2 & 1 & 2 & 1 & 0 \end{bmatrix} \quad X5 = \begin{bmatrix} 0 & 4 & 4 & 3 & 4 & 3 & 4 \\ 4 & 0 & 4 & 3 & 3 & 2 & 3 \\ 4 & 4 & 0 & 3 & 4 & 4 & 4 \\ 3 & 3 & 3 & 0 & 3 & 3 & 3 \\ 3 & 4 & 3 & 3 & 0 & 2 & 4 \\ 3 & 3 & 3 & 3 & 3 & 0 & 3 \\ 4 & 4 & 3 & 3 & 3 & 3 & 0 \end{bmatrix} \quad X6 = \begin{bmatrix} 0 & 4 & 4 & 3 & 4 & 3 & 4 \\ 4 & 0 & 3 & 3 & 3 & 2 & 2 \\ 4 & 3 & 0 & 3 & 3 & 2 & 3 \\ 2 & 3 & 3 & 0 & 2 & 2 & 3 \\ 3 & 4 & 2 & 3 & 0 & 2 & 3 \\ 3 & 2 & 2 & 3 & 2 & 0 & 2 \\ 3 & 3 & 3 & 3 & 2 & 2 & 0 \end{bmatrix}$$

Table 4. Continued

$$X7 = \begin{bmatrix} 0 & 4 & 3 & 3 & 4 & 3 & 3 \\ 4 & 0 & 4 & 4 & 4 & 4 & 4 \\ 4 & 4 & 0 & 4 & 4 & 4 & 4 \\ 3 & 4 & 3 & 0 & 3 & 3 & 3 \\ 3 & 4 & 3 & 2 & 0 & 3 & 3 \\ 4 & 3 & 3 & 3 & 3 & 0 & 3 \\ 4 & 3 & 3 & 3 & 4 & 3 & 0 \end{bmatrix} \quad X8 = \begin{bmatrix} 0 & 3 & 2 & 3 & 4 & 3 & 4 \\ 4 & 0 & 3 & 3 & 3 & 4 & 3 \\ 3 & 3 & 0 & 3 & 3 & 4 & 4 \\ 4 & 3 & 4 & 0 & 3 & 3 & 3 \\ 4 & 4 & 3 & 3 & 0 & 4 & 3 \\ 4 & 3 & 3 & 3 & 3 & 0 & 4 \\ 4 & 4 & 3 & 3 & 2 & 3 & 0 \end{bmatrix} \quad X9 = \begin{bmatrix} 0 & 4 & 2 & 3 & 3 & 2 & 2 \\ 3 & 0 & 2 & 4 & 2 & 2 & 4 \\ 3 & 3 & 0 & 2 & 2 & 2 & 2 \\ 3 & 4 & 1 & 0 & 1 & 2 & 2 \\ 3 & 3 & 1 & 1 & 0 & 3 & 2 \\ 3 & 1 & 1 & 2 & 1 & 0 & 1 \\ 4 & 4 & 2 & 3 & 1 & 1 & 0 \end{bmatrix}$$

$$X10 = \begin{bmatrix} 0 & 4 & 3 & 3 & 2 & 3 & 2 \\ 4 & 0 & 3 & 4 & 3 & 1 & 3 \\ 3 & 4 & 0 & 3 & 2 & 3 & 2 \\ 4 & 4 & 3 & 0 & 1 & 2 & 2 \\ 3 & 2 & 2 & 1 & 0 & 1 & 1 \\ 3 & 2 & 2 & 1 & 2 & 0 & 2 \\ 2 & 2 & 2 & 2 & 2 & 2 & 0 \end{bmatrix} \quad X11 = \begin{bmatrix} 0 & 3 & 2 & 2 & 2 & 2 & 2 \\ 4 & 0 & 2 & 2 & 2 & 2 & 3 \\ 3 & 3 & 0 & 2 & 2 & 2 & 2 \\ 2 & 2 & 1 & 0 & 2 & 1 & 2 \\ 3 & 2 & 2 & 2 & 0 & 2 & 2 \\ 2 & 1 & 1 & 1 & 1 & 0 & 1 \\ 3 & 3 & 2 & 2 & 2 & 1 & 0 \end{bmatrix} \quad X12 = \begin{bmatrix} 0 & 3 & 3 & 3 & 4 & 3 & 3 \\ 4 & 0 & 4 & 4 & 3 & 2 & 3 \\ 4 & 4 & 0 & 3 & 3 & 2 & 3 \\ 3 & 3 & 3 & 0 & 3 & 3 & 3 \\ 4 & 4 & 3 & 4 & 0 & 4 & 4 \\ 4 & 3 & 2 & 3 & 3 & 0 & 3 \\ 3 & 2 & 2 & 3 & 3 & 2 & 0 \end{bmatrix}$$

$$X13 = \begin{bmatrix} 0 & 4 & 4 & 3 & 3 & 4 & 4 \\ 4 & 0 & 4 & 4 & 4 & 4 & 4 \\ 3 & 2 & 0 & 4 & 2 & 2 & 2 \\ 2 & 2 & 2 & 0 & 2 & 2 & 2 \\ 4 & 4 & 4 & 4 & 0 & 4 & 4 \\ 4 & 4 & 3 & 4 & 4 & 0 & 3 \\ 4 & 4 & 2 & 3 & 3 & 3 & 0 \end{bmatrix} \quad X14 = \begin{bmatrix} 0 & 3 & 2 & 2 & 3 & 4 & 2 \\ 4 & 0 & 1 & 3 & 2 & 4 & 4 \\ 4 & 4 & 0 & 2 & 2 & 3 & 3 \\ 4 & 4 & 2 & 0 & 1 & 2 & 3 \\ 2 & 2 & 1 & 2 & 0 & 1 & 0 \\ 4 & 4 & 1 & 2 & 1 & 0 & 2 \\ 4 & 4 & 0 & 3 & 0 & 0 & 0 \end{bmatrix} \quad X15 = \begin{bmatrix} 0 & 4 & 3 & 4 & 2 & 3 & 2 \\ 4 & 0 & 3 & 4 & 2 & 2 & 3 \\ 3 & 2 & 0 & 2 & 2 & 2 & 3 \\ 4 & 4 & 3 & 0 & 2 & 2 & 3 \\ 3 & 2 & 1 & 1 & 0 & 2 & 2 \\ 2 & 1 & 2 & 2 & 1 & 0 & 1 \\ 4 & 4 & 3 & 3 & 2 & 2 & 0 \end{bmatrix}$$

Table 5. Average matrix (A)

	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
F1	0	3.533333	2.8	2.866667	3.266667	3	2.933333
F2	3.8	0	2.666667	3.2	3	2.6	3
F3	3.533333	3.266667	0	2.8	2.666667	2.8	2.733333
F4	3	3.066667	2.4	0	2.066667	2.266667	2.6
F5	3.133333	3.2	2.266667	2.466667	0	2.533333	2.4
F6	3.266667	2.2	2	2.266667	2.333333	0	2
F7	3.266667	3.266667	2.333333	2.733333	2.333333	2.133333	0

Table 6. Normalised initial direct-relation matrix (D)

	F1	F2	F3	F4	F5	F6	F7
F1	0	0.176667	0.14	0.143333	0.163333	0.15	0.146667
F2	0.19	0	0.133333	0.16	0.15	0.13	0.15
F3	0.176667	0.163333	0	0.14	0.133333	0.14	0.136667
F4	0.15	0.153333	0.12	0	0.103333	0.113333	0.13
F5	0.156667	0.16	0.113333	0.123333	0	0.126667	0.12
F6	0.163333	0.11	0.1	0.113333	0.116667	0	0.1
F7	0.163333	0.163333	0.116667	0.136667	0.116667	0.106667	0

Table 7. The total relation matrix (T)

	F1	F2	F3	F4	F5	F6	F7	r_i
F1	0.775534*	0.878234*	0.709556*	0.777731*	0.772195*	0.746598*	0.757549*	5.417396
F2	0.932173*	0.725857*	0.702635	0.788048*	0.759746*	0.728971*	0.758138*	5.395567
F3	0.906624*	0.850571*	0.572764	0.759236*	0.734022*	0.724146*	0.734701*	5.282064
F4	0.796845*	0.758908*	0.612138	0.561308	0.637278	0.631631	0.656973	4.655081
F5	0.823719*	0.784241	0.623269	0.689218	0.561231	0.659733	0.666549	4.807961
F6	0.75295	0.675029	0.555528	0.617391	0.604425	0.487849	0.589186	4.282358
F7	0.833349	0.791783	0.629777	0.703964	0.669563	0.647489	0.563674	4.8396
c_i	5.821194	5.464623	4.405666	4.896896	4.73846	4.626418	4.726769	

Note: Only values greater than the threshold's alpha were retained and used to create the impact relation map (IRM) in Figure 4 according to the DEMATEL method. These values in matrix T have been indicated with an asterisk (*) for clarification.

Table 8. The attribute of causes and effects

Factors	ri	ci	ri+ci	Rank	ri-ci	Identification
F1	5.417396	5.821194	11.23859	1	-0.4038	Effect
F2	5.395567	5.464623	10.86019	2	-0.06906	Effect
F3	5.282064	4.405666	9.68773	3	0.876398	Cause
F4	4.655081	4.896896	9.551977	5	-0.24182	Effect
F5	4.807961	4.73846	9.546421	6	0.069501	Cause
F6	4.282358	4.626418	8.908776	7	-0.34406	Effect
F7	4.8396	4.726769	9.566369	4	0.112831	Cause

Table 9. The DEMATEL questionnaire

One factor affects other factors.	Compare the influence of one main factor over another																																		
	Financial Profitability					Research and Development					Human Resources					Alliances					Information system and technology					Supply chain management					The patent system				
	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0
Financial Profitability			0																																
Research and Development								0																											
Human Resources													0																						
Alliances																		0																	
Information system and technology																							0												
Supply chain management																												0							
The patent system																																	0		

Figure 1. Conceptual Framework of the Study

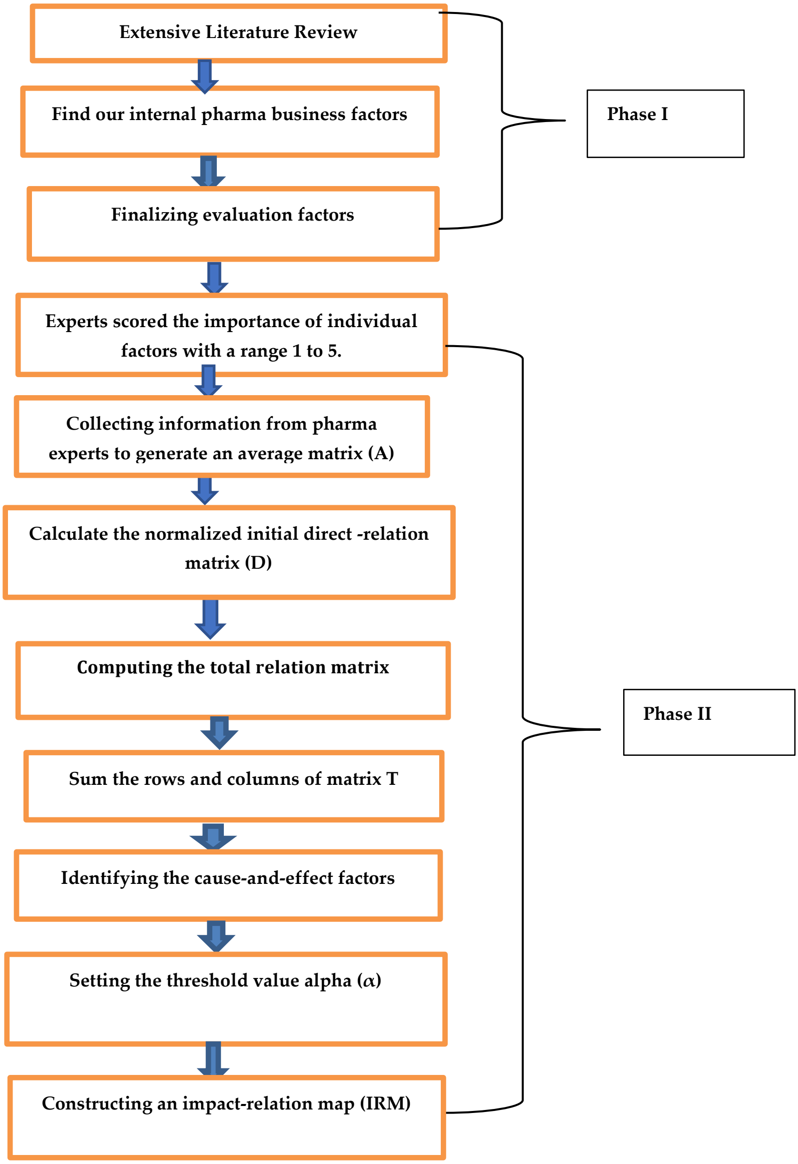

Figure 2. Radar diagram to compare the importance of each factor

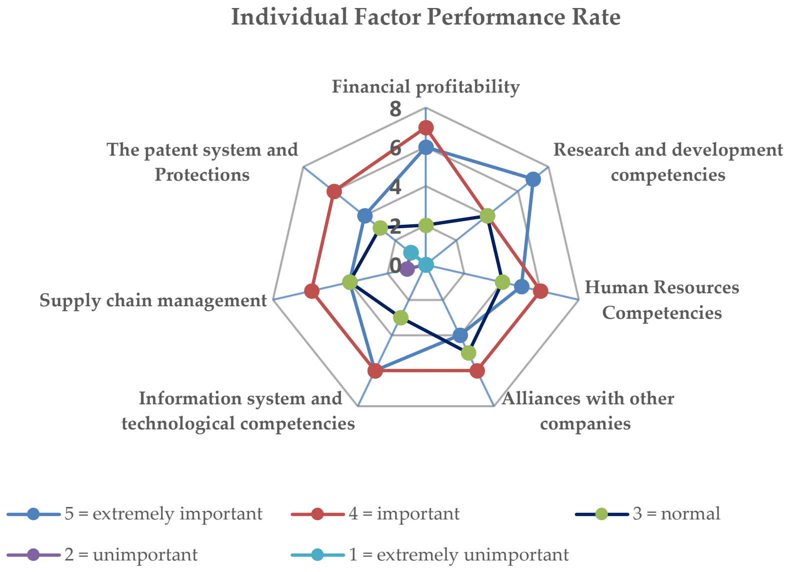

Figure 3. Impact relation map (IRM)