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Additional information and an imprint – p. 69

CONTENTS

From the Editorial Committee	5
Ewelina AUGUSTYNOWICZ: Is the tax wedge in Poland non-linear?	7
Amira BENACHOUR, Lamine TARHLISSIA: The microeconomic determinants of the performance of large companies: case of Algerian companies	15
Olufemi A. OGUNKOYA, Banjo A. HASSAN, Oluwatobi E. SOREMEKUN, Moshood A. OGUNDELE: The impact of technological innovation on firm performance in Nigeria Consolidated Breweries PLC	31
Anna TATARCZAK: Mapping the landscape of artificial intelligence in supply chain management: a bibliometric analysis	43
Adam WEINERT, Robert BANAS': Analysis of the functions of project management information systems – traditional approach	59
Additional information	69

From the Editorial Committee

We are giving you the next Vol. 29, No. 1(2024) issue of the Quarterly of the Faculty of Management of the Rzeszow University of Technology entitled "Modern Management Review".

The primary objective of the Quarterly is to promote publishing of the results of scientific research within economic and social issues in economics, law, finance, management, marketing, logistics, as well as politics, corporate history and social sciences.

Our aim is also to raise the merits and the international position of the Quarterly published by our Faculty. That is why we provided foreign Scientific Council, as well as an international team of Reviewers to increase the value of the scientific publications.

The works placed in this issue include many assumptions and decisions, theoretical solutions as well as research results, analyses, comparisons and reflections of the Authors.

We would like to thank all those who contributed to the issue of the Quarterly and we hope that you will enjoy reading this issue.

With compliments
Editorial Committee

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Ewelina AUGUSTYNOWICZ¹

IS THE TAX WEDGE IN POLAND NON-LINEAR?

The article attempts to answer the question posed in the title – is the tax wedge in Poland non-linear? The aim of the article is to present changes in the size of the tax wedge with the increase in gross pay, and to examine whether there is a pay threshold beyond which the size of the tax wedge decreases. In the course of the research, the impact of gross pay on the size of the tax wedge was compared. The study also attempts to indicate the gross pay, beyond which the size of the tax wedge increases again.

A hypothesis was formulated that there is a pay threshold beyond which the tax wedge loses its linear character. The comparative analysis of the size of the tax wedge was carried out on twenty-three variants of gross pay. The results show that after exceeding the gross pay of PLN 20,100, the tax wedge loses its linear character.

Keywords: tax wedge, gross pay, cost-per-hire.

1. INTRODUCTION

Employment and the related remuneration can be considered on three levels: from the employer's perspective, the key aspect is the total cost of employing an employee, i.e. gross pay with mandatory markups; from the employee's perspective, the most important is the net pay, i.e. the amount the employee will receive from the employer, usually to a bank account; on the other hand, from the state's perspective, the significant amount is the total budget contribution, i.e. the collision of the perspectives of the employer and the employee. This value, which is the sum of taxes and contributions paid by the employee and the employer, is called the tax wedge (Szaban, 2016). Thus, the tax wedge is the difference between the total cost of employing an employee and the net pay that the employee receives (Polarczyk, 2007). Although the name suggests that it is the sum of tax burdens, it takes into account all burdens, in particular contributions. In Poland, the term “tax and contribution wedge” may be used, however, it is a colloquial term. In this study, the tax wedge is understood as the total burden of all levies, in particular taxes and contributions. In comparative analyses, the tax wedge is presented as its percentage share in the total cost of employment (Polarczyk 2008). The size of the tax wedge affects decisions regarding the employment of employees; employers indicate employment costs as the biggest barrier to running a business in Poland (ZPP, 2020). Although the tax wedge is progressive (Wojciuk,

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Dziemianowicz, 2017), there are legal solutions in the Polish tax system that may cause a decrease in the tax wedge despite an increase in remuneration.

The aim of the article is therefore to present changes in the size of the tax wedge with an increase in gross pays and to examine whether there is a pay threshold beyond which the tax wedge decreases. The study will also attempt to indicate the gross pay, beyond which the size of the tax wedge increases again. A hypothesis was formulated that there is a salary threshold beyond which the tax wedge loses its linear character.

The established research objective required the use of the following research methods: critical analysis of the literature and legal acts, as well as a comparative analysis. The article has been divided into two parts. In the first, on the basis of the literature on the subject and legal acts, the factors shaping the tax wedge were characterized. The second part presents the results of a comparative analysis of the size of the tax wedge, depending on the gross pay.

2. FACTORS SHAPING THE TAX WEDGE

The size of the tax wedge is influenced in particular by taxes and contributions paid on employees' salaries; some of them are financed by the employer, and some are taken from the employee's salary. The type of individual contributions, their amount and share in their financing by the parties to the employment relationship is presented in table 1. The basis on which the so-called social contributions (retirement, disability, sickness and accident) and contributions to special-purpose funds (employment fund and solidarity fund) are calculated is the gross pay. On the other hand, the basis for the health contribution is the gross pay net of social contributions.

Table 1. Amount of respective contributions

Contribution type	Financed by the employee	Financed by the employer
Retirement	9.76%	9.76%
Disability	1.5%	6.5%
Accident	-	1.67% ²
Sickness	2.45%	-
Health	9%	-
Employment fund and solidarity fund	-	2.45%

Source: Own elaboration on the basis of Act of 13.10.1998 on social insurance system (i.e. Journal of Laws of 2022, item 1009 as amended); Act of 27.08.2004 on health care services financed from public funds (i.e. Journal of Laws of 2022, item 64 as amended); Act of 13.07.2006 on the protection of employee claims in the event of the employer's insolvency (i.e. Journal of Laws of 2020, item 7 as amended); Act of 20.04.2004 r. on employment promotion and labor market institutions (i.e. Journal of Laws of 2022, item 690 as amended).

² The percentage rate of the accident contribution is not fixed and depends on several factors, in the case of entrepreneurs employing less than 10 employees, it is 50% of the highest interest rate set for a given contribution year for activity groups. From April 1, 2021, it is 1.67% (50% of the highest premium – 3.33% for service activities supporting mining and quarrying) in accordance with the Regulation of the Ministry of Family and Social Policy of 16.03.2021 amending the regulation on differentiation of the rate percentage social security contribution for accidents at work and occupational diseases, depending on occupational hazards and their effects (Journal of Laws of 2021, item 489).

Income tax is another category, after contributions, which strongly influences the size of the tax wedge. In Poland, taxation of individuals is progressive, which means that the income tax burden increases with the increase in income (Deresz, Podstawka, 2017). Since 2009, the Polish tax system has provided for two tax thresholds. In 2023, for the tax base³ not exceeding PLN 120,000, the income tax is 12%, after exceeding this limit, the tax rate increases to 32% (Act, 1991, Article 27 section 1). Only the surplus above PLN 120,000 is taxed at the rate of 32%. Depending on the gross pay, the share of the tax wedge in the cost of employment increases. Basically, the tax wedge is progressive, which results from the fact that there are solutions in Poland that increase taxation along with the increase in income. These solutions are the presence of the second tax threshold and the solidarity levy. In addition, the tax-free amount affects the progressivity of the income tax. The aforementioned solidarity levy is de facto an additional tax burden on the basis of the third tax threshold functioning before 2009 (Kijanka, Kowalska-Musiał, 2020). The amount of tax under the solidarity levy is 4%, and the taxable amount is the surplus over PLN 1,000,000 of the tax base (Act, 1991, Article 30h, paragraphs 1 and 2). On the other hand, the free amount reduces the tax value. Taxpayers whose annual income does not exceed PLN 30,000 do not pay income tax. However, for other taxpayers, the amount of PLN 30,000 is also tax-free, due to the amount reducing the tax (Act, 1991, Article 27(1)). If the employee submits the PIT-2 statement to the employer, his monthly income tax advance may be reduced by 1/12 of the free amount. Failure to submit the PIT-2 declaration does not mean the loss of the exemption, the free amount will be settled in the annual tax return. Thanks to this construction of the regulations, the tax wedge increases with the increase in income and is of a progressive nature. However, in Poland there is a certain paradox, due to which the tax wedge may, contrary to appearances, lose its linear character. It is a provision specifying the maximum annual basis for the calculation of contributions for retirement and disability insurance.

The retirement insurance contribution, also called the old age risk insurance (Szczepański, 2014), is charged to both parties of the employment relationship in the amount of 9.76%. The total burden of the retirement contribution is therefore 19.52%. Adding to this the total amount of the disability contribution (1.5% for the employee and 6.5% for the employer), the total amount of the old age risk contribution and the disability contribution amounts to 27.52%. And although retirement and disability contributions are intended, after reaching the retirement age or in connection with incapacity for further work, to ensure the maintenance of a standard of living similar to that during the period of professional activity (Golinowska, 2014), the Polish retirement and disability system allows for it only up to a certain level. The Act on the Social Insurance System contains a limitation that the annual basis for calculating the retirement and disability contributions may not exceed "thirty times the projected average monthly salary in the national economy for a given calendar year" (Act, 1998, Article 19(1)). After exceeding the specified annual basis, these contributions cease to be paid. In 2023, this limit is PLN 208,050 (Announcement, 2022). The lack of contributions, the total amount of which is over 27%, has a significant impact on the formation of the tax wedge and may result in its decrease.

³ The taxpayer's income is subject to income tax, in the case of remuneration, the income is gross pay. Income tax is calculated on the basis of the tax base, which is basically income less social contributions and the so-called employee tax deductible costs – art. 26 sec. 1 and art. 22 sec. 2 of the Act of 26.07.1991 on personal income tax (i.e. Journal of Laws of 2022, item 2647, as amended).

Will the cessation of paying these contributions, despite the increase in the income tax rate, lead to a decrease in the tax wedge?

3. ANALYSIS OF THE TAX WEDGE NON-LINEARITY

In the comparative analysis, the following assumptions were made: the considered remuneration applies to a full-time employee under an employment contract. It was assumed that an employee works only under one employment relationship. The workplace is also in the town where the employee lives. The analysis omitted the use of any additional income tax reliefs and deductions, with the exception of the tax-free amount. It was also assumed that the employee is not a member of Employee Capital Plans. The analysis was carried out on an annual basis, because only this approach allows to correctly depict the tax wedge from the point of view of the occurrence of the second tax threshold and the limit of thirty times in retirement and disability contributions. Table 2 presents the results of the conducted analysis, indicating how the tax wedge is shaped in percentage terms for a given amount of gross monthly pay. Changes in the size of the tax wedge are also presented in chart 1.

Table 2. Tax wedge depending on the gross monthly pay

Monthly gross pay (PLN)	Gross pay per year (PLN)	Tax wedge (%)
3490,00	41 880,00	35.57
5000,00	60 000,00	37.94
7000,00	84 000,00	39.51
10 000,00	120 000,00	40.68
13 000,00	156 000,00	42.55
15 000,00	180 000,00	44.57
17 000,00	204 000,00	46.12
20 000,00	240 000,00	46.16
20 100,00	241 200,00	46.16
20 200,00	242 400,00	46.15
21 000,00	252 000,00	46.11
22 000,00	264 000,00	46.05
23 000,00	276 000,00	46.00
24 000,00	288 000,00	45.96
25 000,00	300 000,00	45.91
50 000,00	600 000,00	45.37
75 000,00	900 000,00	45.18
85 000,00	1 020 000,00	45.14
88 000,00	1 056 000,00	45.14
89 000,00	1 068 000,00	45.17
90 000,00	1 080 000,00	45.21
100 000,00	1 200 000,00	45.53
150 000,00	1 800 000,00	46.51

Source: Own study based on the Act on the social insurance system; the Act on health care services financed from public funds; the Act on personal income tax; Act on the protection of employee claims in the event of the employer's insolvency; the Act on employment promotion and labor market institutions.

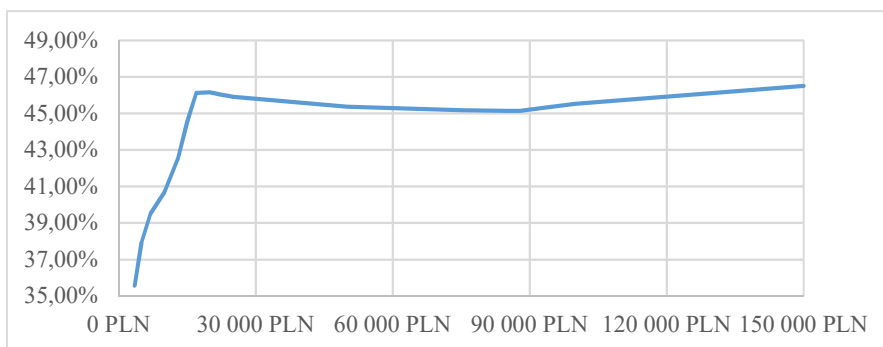


Chart 1. Tax wedge depending on the gross monthly pay

Source: Own study based on the Act on the social insurance system; the Act on health care services financed from public funds; the Act on personal income tax; Act on the protection of employee claims in the event of the employer's insolvency; the Act on employment promotion and labor market institutions.

By employing an employee whose gross pay is at the level of the minimum wage as of January 1, 2023 – PLN 3,490 – the tax wedge will be 35.57%. With a gross pay of PLN 10,000, the tax wedge exceeds 40%. Then the size of the tax wedge reaches the highest value of 46.16% with gross pay of PLN 20,000 and PLN 20,100. Subsequent successive increases in salary no longer lead to an increase in the tax wedge, but its gradual decrease was noted. The tax wedge returns to its progressive character only when the gross pay is PLN 89,000. The highest recorded size of the tax wedge was 46.51% for gross pay of PLN 150,000 per month. The tax wedge for a salary of PLN 100,000 per month is lower than for a gross pay of PLN 17,000 per month. The presented tax wedge is not linear, it increases until the gross pay is reached in the amount of PLN 20,100, and then it decreases.

4. CONCLUSIONS

The article presents the subject of the tax wedge, which is basically characterized by progressivity. However, the increase in the size of the tax wedge in Poland, despite the two-stage, and in reality even three-stage tax scale, is inhibited by limiting the annual maximum basis for retirement and disability contributions. The tax wedge is clearly non-linear, which confirms the thesis formulated in this article. This translates into a higher burden of taxes and contributions among employees earning PLN 17,000 gross than employees earning PLN 100,000 gross. The non-linearity of the tax wedge has consequences, for example, in shaping the labor market, because with a high level of taxes and contributions, the reluctance to legal employment increases. Some employees may also choose to be self-employed. A high level of the tax wedge may also lead to migration of employees to countries where the level of tax and contribution burdens is lower. The increase in the tax wedge after exceeding PLN 89,000 in gross pay is due to the existence of the solidarity levy, which is a relatively new tax, in force since 2019 (Chmielecka, Szulc, 2020). The absence of this tax would result in a further gradual decrease in the tax wedge along with the increase in remuneration.

REFERENCES

- Chmielecka, A., Szulc, A. (2020). *Analiza wpływu zmian wprowadzonych przez ustawę „Polski Ład” na obciążenia podatkowo-składkowe” podmiotów sektora MMP*. „Przestrzeń, Ekonomia, Społeczeństwo”, 18/II. Sopotka Szkoła Wyższa. DOI: 10.23830/18/II/2020/7399.
- Deresz, A., Podstawka, M. (2017). *Zróźnicowanie obciążeń podatkowych podatników uzyskujących wynagrodzenia ze stosunku pracy oraz przedsiębiorców*. „Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu”, nr 488. DOI: 10.15611/pn.2017.488.02.
- Golinowska, S. (2014). *Funkcje państwa w zabezpieczeniu dochodów na okres starości. Zmiana warunków i paradygmatu na przykładzie polskiej reformy systemu emerytalnego* [w:] Frieske, K., Przychodaj, E., red., *Ubezpieczenia społeczne w procesie zmian*. Warszawa: Instytut Pracy i Spraw Socjalnych oraz Zakład Ubezpieczeń Społecznych.
- Kijanka, A., Kowalska-Musiał, M. (2020). *Analiza wielkości i struktury płacowego klina podatkowego w Polsce w latach 2005–2020*. „Zeszyt Naukowy.pl/Wyższa Szkoła Zarządzania i Bankowości w Krakowie”, nr 54.
- Polarczyk, K. (2007). *Klin podatkowy a bezrobocie*. „Infos, Biuro Analiz Sejmowych”, nr 17, 1–4. Warszawa: Wydawnictwo Sejmowe dla Biura Analiz Sejmowych [Access: 26.02.2023]. Access on the internet: [http://orka.sejm.gov.pl/wydbas.nsf/0/ef0b7b7611593a2fc12572f800391c99/\\$file/infos_017.pdf](http://orka.sejm.gov.pl/wydbas.nsf/0/ef0b7b7611593a2fc12572f800391c99/$file/infos_017.pdf).
- (2008). *Opodatkowanie wynagrodzeń za pracę (składki i PIT) w państwach Unii Europejskiej*. „Analizy Biura Analiz Sejmowych”, nr 6 [Access: 07.03.2023]. Access on the internet: <https://orka.sejm.gov.pl/WydBAS.nsf/0/CA3DD054B8A4AD20C12574960043A26A?OpenDocument>.
- Szaban, J. (2016). *Rynek pracy w Polsce i w Unii Europejskiej*. Warszawa: Difin.
- Szczepański, M. (2014). Zarządzanie ryzykiem długowieczności w polskim systemie emerytalnym. „Finanse, Rynki finansowe, Ubezpieczenia, 65”. Szczecin: Zeszyty Naukowe Uniwersytetu Szczecińskiego.
- Wojciuk, M., Dziemianowicz, R. (2017). *Assessment of progressiveness of tax wedge in Poland and selected European Union countries*. “Research papers of Wrocław University of economics”, No. 475. DOI: 10.15611/pn.2017.475.33.
- Związek Przedsiębiorców i Pracodawców (2020). *Portret przedsiębiorcy* [Access: 22.01.2023]. Access on the internet: <https://zpp.net.pl/projekty/portret-przedsiębiorcy/>.

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- Act of 13.07.2006 on the protection of employee claims in the event of the employer's insolvency (i.e. Journal of Laws of 2020, item 7 as amended).
- Act of 13.10.1998 on social insurance system (i.e. Journal of Laws of 2022, item 1009 as amended).
- Act of 20.04.2004 r. on employment promotion and labor market institutions (i.e. Journal of Laws of 2022, item 690 as amended).
- Act of 26.07.1991 on personal income tax (i.e. Journal of Laws of 2022, item 2647, as amended).
- Act of 27.08.2004 on health care services financed from public funds (i.e. Journal of Laws of 2022, item 64 as amended).
- Announcement of the Ministry of Family and Social Policy of 13.10.2022 on the amount of the limitation of the annual basis for calculating contributions to the pension and

disability insurance in 2023 and the amount of the forecast average salary adopted to determine it (M.P. of 2022, item 1014).

Regulation of the Ministry of Family and Social Policy of 16.03.2021 amending the regulation on differentiation of the rate percentage social security contribution for accidents at work and occupational diseases, depending on occupational hazards and their effects (Journal of Laws of 2021, item 489).

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THE MICROECONOMIC DETERMINANTS OF THE PERFORMANCE OF LARGE COMPANIES: CASE OF ALGERIAN COMPANIES

This research aims to identify and study the internal factors that can influence the financial performance of large Algerian companies and make them sustainable. This study is based on a sample of 78 large Algerian companies operating in four sectors: construction, trade, industry and services, over a period of four years from 2018 to 2021. For this purpose, we used the panel data regression method that takes into account both individual and temporal dimensions. The results of the statistical and econometric analysis showed that the debt ratios play negatively and very significantly on the economic profitability of large Algerian firms, it is also the case for the tangibility of assets, the sectors of activity, the public sector and the size of the firm. However, the capital turnover ratio and the age of the companies act favorably and significantly on their profitability. Self-financing, liquidity and the sector of activity present insignificant coefficients.

Keywords: financial performance, microeconomic determinants, large Algerian firms, panel data.

1. INTRODUCTION

Large and small businesses are an economic unit that occupies a predominant place in the national economic market; because of their impact on the nature and quality of the industrial network and their importance in terms of job creation and improvement of the quality of life. Faced with such tough and lively competition with increasingly modern and complex market expectations, each company must be resilient, that is to say, be able to face hard and unusual blows. Achieving performance then becomes an important issue that it must master. According to OTLEY (1999) performance is itself a multifaceted concept that does not have a single definition, everything depends on the stakeholders and the vision of the company: its strategy and its objectives. It is in this sense that the performance of a firm

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can be measured from different angles and is not limited to the financial dimension. However, it is often apprehended by financial indicators designed on the basis of information contained in the annual financial statements, the latter are intended to measure the financial performance of the company given that it presents a subjective measure of the ability to a business to use the assets of its primary mode of operation and generate revenue. The strength and performance of businesses contribute to the overall success of the country, including their contribution to the country's Gross Domestic Product (GDP) or through tax revenues that assist the government in operating smoothly and maintaining and enhancing the country's infrastructure.

In Algeria, during the recent COVID-19 health crisis, and despite recording significant revenue losses, it was observed that a significant number of large companies have risen to the collective challenges: this included producing essential products that were sorely needed, as exemplified by the agri-food giant "CEVITAL", as well as maintaining the operation of critical infrastructure networks (water, electricity, communication channels). While other major corporations, such as "Air Algérie", were on the brink of bankruptcy, estimating losses reaching 35 billion dinars by the end of 2020, without taking into account possible customer refunds (EL WATAN: 19/07/2020). Looking at the companies' results during this period, one is tempted to question the explanatory factors behind their performance. Indeed, while some companies manage to achieve good results, others struggle to attain positive outcomes. Thus, our work strives to address the following issue:

2. WHAT ARE THE MICROECONOMIC FACTORS THAT INFLUENCE THE PERFORMANCE OF LARGE COMPANIES IN ALGERIA?

This research question is divided into the following sub-questions:

- How firm's financial performance can be measured?
- Are firm's size, its legal status, and its available capital the only performance determinants of Algerian firms?
- Is there a consensus between present and past research?

The following hypothesis is formulated based on results that were obtained from precedent research.

The microeconomics factors that influence the performance of large Algerian firms are: firm's size, its legal status, and other factors related to financial structure (liquidity)

In order to answer the above-mentioned sub-questions, the following sub-hypotheses are proposed:

- H1: financial performance indicators are: economic added value EAV, Return on Equity (ROE), and Return On Assets (ROA)
- H2: there are other indicators that determine the performance of Algerian firms, namely, debt ratio
- H3: the present research will arrive at the same conclusions as past research.

Considerable amount of prior research on performance has focused mainly on banks not firms and the small amount that took firms, studied just small and mid-sized firms. In this research, however, the focus will be on large companies. Moreover, past research tended to take financial diagnostic variables unlike the present paper in which other variables that might influence performance will be examined.

To address this issue, we employed a descriptive approach and an analytical approach. The descriptive approach was utilized in the theoretical section, while the analytical approach, employed in the practical section, aims to yield concrete results through multiple

regression analysis on panel data from a sample of 78 Algerian companies over the period 2018–2021. The integration of both descriptive and analytical approaches will provide more comprehensive answers to the hypothesis outlined above.

3. COMPANIES PERFORMANCE, THEORETICAL FRAMEWORK

Currently, business performance has become a relevant concept in strategic management research. Although it is a widely used concept in academic literature, there is rarely harmony regarding its definition and measurement.

3.1. What is performance?

The word “Performance” entered the French dictionary in 1839 (Domin, Nièdu, 2012) and initially referred to the success achieved by a racehorse and the success of the race itself, then extended to the results and athletic achievement of a sportsman. It is derived from the English word “performance” (late 15th century), which means carrying out a task with regularity, method, and application. However, this English term has its origins in Old French from the Latin verb “parformer”, which dates back to the 13th century and meant to accomplish and execute (Renaud, Berland, 2007). According to (Bourguignon, 2009), this term was initially used in two fields: sports to describe the outcome of a competition, and mechanics to characterize the technical possibilities and capabilities of a machine before being adapted for businesses (Renaud, Berland, 2007). However, the 20th century is marked by the development of the concept of “performance”, which quantified the potential for exponential yield. This captured the attention of numerous researchers. Although it is a common concept in both academic literature and organizational contexts to denote a certain level of excellence (Issor, 2017), there is little consensus on its definition and measurement. According to (Issor, 2017): “It is a concept that does not achieve unanimity around a precise definition and measurement, as the latter depends on the intended objective, chosen analytical perspective, and the field of interest of the user” (El Amraoui, Hinti, 2022).

Nevertheless, numerous attempts have been made by various researchers to define this concept. Le Moigne (1996) demonstrates that the notion of competitiveness is crucial in understanding firm performance: “For both organizations and racehorses, performance is relative: it's not about doing 'well.' It's about not doing worse than others” (Hamadmad, 2017). According to Issor “performance is nothing other than the evolution or enlargement of the company (Issor, 2017). However, (Bourguignon, 2009) highlights the new managerial approach and defines performance as the achievement of organizational objectives, regardless of their nature. (Bouquin, 2004), on the other hand, demonstrates that a successful company is one that manages to meet the expectations of stakeholders and ensures the desired reward surplus for them. To this day, there is no universal and precise definition of the concept of performance. (Jean-Paul Bailly, 2005) observes that despite a certain vagueness surrounding the definition of performance, there are certain points of convergence among different definitions (Bailly, 2005), namely:

- Performance is often used in the context of valuation and is closely linked to value. The latter involves enhancing results and revenue (entailing a constant search for optimal costs).
- Achieving objectives on time.
- Strong positioning in relation to competitors.
- Sustaining current and future profitability.

Through this literature review, it becomes clear that performance is not a concept that is defined in an absolute or objective manner. It is a subjective concept that holds as many meanings as there are individuals or groups using it. Each firm can have its own interpretation depending on the stakeholders and the company's vision, strategy, and objectives. (Galambaud, 2003) emphasizes that “a company doesn't have one but multiple performances” (Amaazoul, 2018).

3.2. Approaches to performance

The literature highlights the existence of a multitude of tools and methods, both traditional and modern, for assessing the financial performance of companies.

3.2.1. Traditional approaches to performance measurement

This approach falls within the scope of neoclassical finance, where performance is translated into shareholder value. In other words, it refers to the surplus provided to shareholders in relation to their opportunity cost. (Gérard, and all, 1998) distinguishes between two types of measures within this approach: Measures derived from financial research (Tobin's Q ratio and Marris's ratio) and recent measures of created value (Economic Value Added – EVA and Market Value Added – MVA). It's important to note that the credibility of measuring shareholder value is conditioned by two assumptions: the efficiency of financial markets and the measurability of the cost of capital using the Capital Asset Pricing Model (CAPM).

3.2.2. Ratio Approach

This approach relies on the calculation of certain ratios such as Return on Equity (ROE), which measures how shareholders have fared over the year. It provides a genuine measure of performance from an accounting perspective as it expresses the percentage of corresponding results for each monetary unit invested (Mahi, 2021). And the ROE measures the company's ability to adequately and consistently compensate its shareholders from its operations (Alami et al., 2023). (Helfert, 1991) prefers to call this ratio the “return on net worth” and asserts that it is the most commonly used ratio by financial analysts to measure the return on owners' investment. Return on Investment (ROI) is a financial indicator that helps determine the profitability of invested capital. In other words, it measures the loss or gain generated by each monetary unit invested in projects. Not only does it assess the rate of return of any given project over a specific period, but when used frequently, it also predicts the future profitability trend of the company.

3.3. Literature review

Documentary analysis in scientific research allows for the interpretation of existing literature in light of recent developments and calculates the impact of this new information in the field by mapping the evolution of knowledge. So, we have chosen to present some studies carried out on the same subject. The study by (Hunjra et al., 2014) aimed to assess empirically the determinants of the performance of Tunisian insurance companies during the period of study from 2002 to 2018 using the panel data methodology. The empirical results show that only the microeconomic factors are determinants of the performance of insurance companies. The macroeconomic factors do not have significant effects on performance. Capital structure, solvency, risk capital management, premium growth, volume of capital, age and financial investments are the determinants of the performance of Tunisian insurance companies.

The study by (Nikolaus, 2015) examines the determinants of firm performance in Indonesian and Dutch companies during the period of 2009–2013. The sample consists of 276 Indonesian non-financial firms and 62 Dutch non-financial firms. Firm performance (dependent variable) is measured using Tobin's Q, while the independent variables include: leverage, ownership concentration, inflation, growth, and size. The study by (Assienin, Ouattara, 2016) aimed to explain the financial performance of Ivorian banks. To achieve this, they assembled a sample of 27 banks observed over a six-year period (2011–2016). The researcher selected the following explanatory variables: Liquidity (Total Loans/Total Assets), Operational Efficiency (Operating Costs/Operating Income), Ownership (1 = Public; 2 = National Private; 3 = Foreign Private), Amount of Bank Deposits, Cost of Funding (Interest Expenses to Customers/Total Customer Deposits), GDP. The explained variables include ROA (Net Income/Total Assets), ROE (Net Income/Equity), and NIM (Net Interest Margin or Net Interest Income/Total Assets). The ROE and NIM models are fixed-effects models, while the ROA model is a random-effects model. The study made by (Laha, and Sur, 2020) aimed to shed some light on the efficiency of the select 47 construction and engineering firms and the different microeconomic and macroeconomic factors affecting such efficiency during the period 1999–2000 to 2018–2019. For the purpose of this study, Stochastic Frontier Analysis was used primarily to determine the firm-level efficiency scores. Subsequently, the determinants of such firm-level efficiency were looked into using Panel Censored Tobit Regression Model. The results of the study showed that leverage, size, age, openness, exchange rate and price factor were the important determinants of the efficiency of the construction and engineering firms during the period of study. The study by (Ngoc and Nguyen, 2020) aimed to investigate the determinants of financial performance of 1343 Vietnamese companies classified into six different sectors and listed on the Vietnam Stock Exchange over a four-year period, from 2014 to 2017. These determinants include the company's size, liquidity, solvency, financial leverage, and financial adequacy. Meanwhile, financial performance is assessed using three different ratios: Return on Assets (ROA), Return on Equity (ROE), and Return on Sales (ROS). The study of (Derbali, Lamouchi, 2021) aimed to assess empirically the determinants of the performance of Tunisian insurance companies during the period of study from 2002 to 2018 using the panel data methodology. The sample used in our study is made up of 13 resident insurance companies listed on the Tunisian Stock Exchange during the period of study. We employ microeconomic and macroeconomic variables. The empirical results show that only the microeconomic factors are determinants of the performance of insurance companies. The macroeconomic factors do not have significant effects on performance. Capital structure, solvency, risk capital management, premium growth, volume of capital, age and financial investments are the determinants of the performance of Tunisian insurance companies with a different sign positive and negative. By This study (Odipo et al., 2020) aim to look at micro-economic determinants of long run performance of shares issued in Nairobi Securities Exchange from 1st Jan. 2007 to 31st Dec. 2013. Do these selected microeconomic determinants have statistically significant effects on long run return on equity issued in the Nairobi security exchange in Kenya? The study has a total 12 firms that issued shares in the security exchange during this period. In order to achieve the objectives of the study “a calendar study” approach on the issued shares was adopted. Monthly average returns were calculated for a period of 5 years. The study made bay (Quoc Trung, 2021) aimed to estimate the factors affecting Vietnamese small and medium-sized enterprises (SMEs) listed on the Hanoi Stock Exchange and the

Chi Minh City Stock Exchange between 2009 and 2019. The author adopts a quantitative method (the “Generalized Method of Moments” – GMM) to investigate six statistically significant variables positively affecting SMEs’ performance at 5%. These variables include the profitability lag, firm size, leverage ratio, revenue growth, gross domestic product growth, and the quality of national governance. One of the significant contributions of this study to the literature is to consider the leverage ratio as a tool to improve SMEs’ performance, and national governance quality is a mechanism to enhance SMEs’ efficiency.

4. ECONOMETRIC STUDY OF DETERMINANTS OF PERFORMANCE IN LARGE ALGERIAN COMPANIES

4.1. Research methodology

In order to build our final database required for modeling the econometric model, we approached the Directorate of Large Enterprises (DGE), the organization responsible for tax monitoring of the heaviest taxpayers in Algeria, specifically the management sub-directorate. We were able to gather accounting data from financial statements (balance sheets and income statements) of 78 companies under study, covering a time span of four (04) years (2018–2021), resulting in a total of 312 observations.

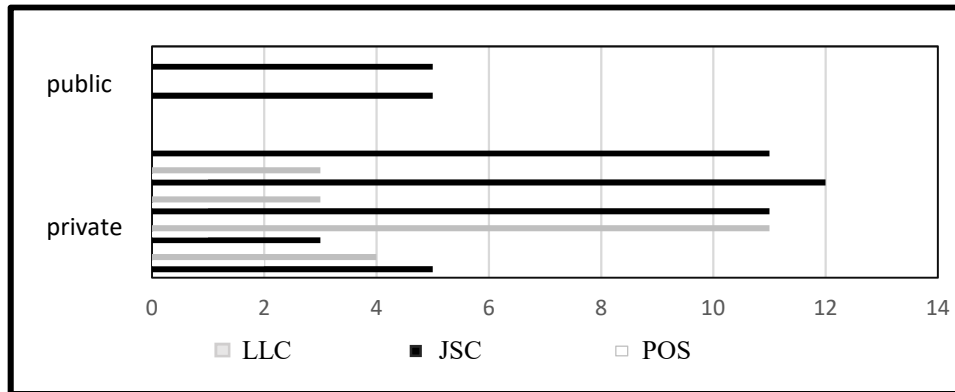


Figure 1. Sample presentation

Source: Own elaboration.

4.1.1. The dependent variable

We choose (ROA), a post-performance indicator that we will test in our model. His performance measure reflects the company's ability to generate profit from its asset base.

$$ROA = \frac{\text{Net profit}}{\text{Total assets}} \quad (1)$$

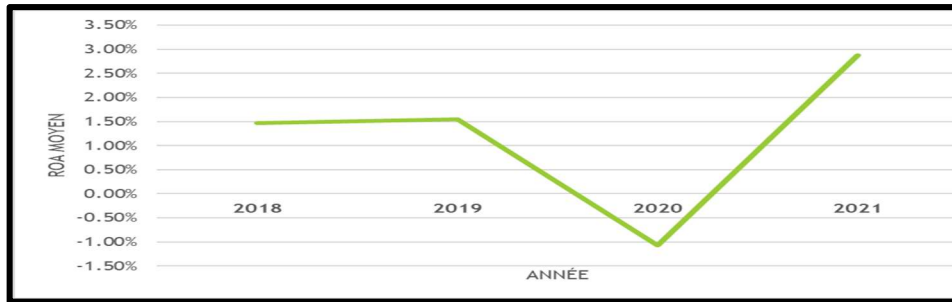


Figure 2. Evolution of ROA

Source: Own elaboration.

4.1.2. Independent variables

- Debt ratios: A distinction should be made between long-term debt and short-term debt, as the leader's behavior may be influenced by the maturity date of the held debt.
- Long and Medium-Term debt ratio: As previously mentioned, according to Jensen & Meckling (1976), long-term debt is very useful for mitigating agency costs and managing conflicts of interest between managers and shareholders. However, the theory of pecking order financing (Myers, 1975) states that companies with lower debt are more profitable. This is because they reinvest profits, while others borrow money, thereby increasing their leverage, which creates a negative relationship with financial performance. Medium and long-term debt financing is measured by the sum of long-term debt (Borrowings and Financial Debts + Other Non-Current Liabilities) divided by total liabilities.

$$\text{LMDR} = \frac{\text{long and medium terme debt ratio}}{\text{total liabilities}} \quad (2)$$

H1: Long-term debt has a negative influence on performance.

- Short-Term Debt ratio: (Scholes, Wolfson, 1988) state that companies prefer short-term debt when the tax rate is high. In this case, short-term debt will be less costly and the easiest way to achieve the desired optimal level of debt. (Emery, 2001) agrees, asserting that short-term debt helps increase the company's earnings and production, considering the risks related to refinancing and interest rates. The measurement of short-term debt financing is operationalized by the ratio of short-term debt (Suppliers and Related Accounts + Passive Treasury + Other Current Liabilities) to total liabilities.

$$\text{SDR} = \frac{\text{term debts}}{\text{Total liabilities}} \quad (3)$$

H2: There is a relationship (positive or negative) between short-term debt and company performance.

- The self-financing ratio: The trade-off theory (Myers, 1984) assumes that no funding model is preferred. However, according to agency theory, without taking on debt, managers can make decisions that benefit themselves at the expense of other shareholders. In this case, by incurring debt, they are compelled to optimize the investment decisions they make in order to fulfill their punctual commitment. On the other hand, according to hierarchical funding theory, internal funding is preferable to external funding, which is reflected in a negative relationship between them. This report allows us to measure the percentage of financial dependence of the company.

$$\text{SFR} = \frac{\text{stock holders equity}}{\text{Total equity}} \quad (4)$$

H3: Self-financing has a negative impact on the financial performance of companies.

- Liquidity (Working Capital Ratio): Measures the amount of easily convertible asset items that the company possesses to meet its short-term obligations. (Pattitoni, Spisni, 2014) demonstrate a strong positive relationship between the independent variables measured by the three liquidity ratios and the dependent variable measured by ROE (Return on Equity). This can be explained by the fact that a high level of liquidity can mitigate the impacts of adverse changes in the economic environment, the risk of being unable to repay short-term debts, and the risk of missing out on profitable investment opportunities due to financial issues. According to the study by (Matar, Eneizan, 2017), liquidity has a positive and significant impact on firm performance. The ratio below measures liquidity as done by (Gurbuz et al., 2010).

$$\text{LIQ} = \frac{\text{current assets}}{\text{current liabilities}} \quad (5)$$

H4: The liquidity ratio positively impacts the financial performance of companies.

- Tangibility: Tangible assets are physical assets that have a relatively well-defined market value based on their condition and useful life. They can include equipment, buildings, tools, and other physical properties... While the findings of the study by (Pouraghajan, Malekian, 2012) demonstrated that an increase in asset tangibility had a positive effect on financial performance (Zeitun, Tian, 2007) and (Onaolapo, Kajola, 2010) found that a high proportion of fixed assets reduces financial performance. Investing in fixed assets helps reduce labor costs, production expenses, and overall production costs. Furthermore, a company holding a significant proportion of fixed assets can access loans at a lower cost, as these assets serve as collateral for creditors.

$$\text{TANG} = \frac{\text{fixed assets}}{\text{Total assets}} \quad (6)$$

As a result, costs decrease and profits increase. Therefore, we formulate the following hypothesis:

H5: There is a positive and statistically significant relationship between tangibility and financial performance.

- Asset turnover: The mentioned ratio is an effective indicator of a company's ability to efficiently use its assets to generate sales, i.e., its revenue. It is calculated by dividing the company's revenue by its total assets, helping determine how much revenue the company has generated for every 1 unit of currency invested in its assets.

$$\text{ASSETTURN} = \frac{\text{gross sales}}{\text{Total assets}} \quad (7)$$

H6: The speed of capital turnover positively influences performance.

- Company size: Theoretically, the relationship between size and financial performance is equivocal. Company size is considered a determinant of financial performance by many researchers: Erasmus (2013), Nanda and Panda (2018), have found a positive influence between company size and financial performance. These and many others assert that a large company can have a greater impact on its current and potential investors, creditors, stakeholders, and even consumers – as evidenced by the high business performance of conglomerates and multinational corporations in the global economy. Size will positively influence their tax performance in the market. In other words, larger companies can exploit economies of scale. They are more innovative and competent than firms with limited capabilities and resources. On the other hand, Dhawan (2011), Ramasamy (2005), and Salman and Yazdanfar (2012) have found that company size has a negative effect on financial performance. According to them, improving performance can be challenging for larger companies, which might sometimes lead to a decrease in market performance. However, some researchers such as Durand and Coeurderoy (2001), Tzelepis and Skuras (2004) have found that company size does not have a significant influence on financial performance. The variable used in our study to measure company size is the natural logarithm of revenue:

$$\text{size} = \log(\text{gross sales}) \quad (8)$$

H7: Size has a positive impact on the financial performance of companies.

- Age: The relationship between a company's age and its performance is well-documented but yields contrasting results. Some economists like Coad (2018) use age as an indicator of the experience acquired by the company in its operations. However, certain shortcomings outweigh the advantages of age. Strong arguments support the view that older firms are more likely than younger firms to underperform on average. According to (Boeker, 1997), older companies suffer from the ossification of their routines, non-learning processes, blindness and conservatism, which lead to poor performance and decline. Evans (1987) agrees with this by concluding in his study that a company's performance, on average, decreases with age. Therefore, our hypothesis is as follows:

H8: The older a company is, the less it is performing.

This study proposes a model to test the research hypotheses. This model aims to investigate the effect of economic profitability through various selected variables such as: debt ratios, self-financing ratio, liquidity ratio, tangibility ratio, asset turnover, company size, company age. The model to be estimated is presented as follows:

$$ROA(t) = c + \beta_1 * LMDR(t) + \beta_2 * SDR(t) + \beta_3 * SFR(t) + \beta_4 * LIQ(t) + \beta_5 * TANG(t) + \beta_6 * AGE(t) + \beta_7 * ASSETTURN(t) + \beta_8 * size(t) \quad (9)$$

5. DISCUSSION OF RESULTS

For our sample of 78 companies spanning the years 2018–2021, totaling 312 observations, we obtained satisfactory results after regression with the PCSE model and we obtained this model:

$$ROA = -0.10175389 \text{ SDR} + -0.11712591 \text{ LMDR} + 0.00123383 \text{ SFR} - 0.00284949 \text{ LIQ} - 0.05640939 \text{ TANG} + 0.001216 \text{ AGE} + 0.00808189 \text{ ASSETTURN} - 0.0011691 \text{ size} + 0.12324003$$

Table 1. Regression result

Explanatory variable	Expected sign	Coefficient	P-value
SDR	-	-0.1017	0.000
LMDR	-	-0.117	0.000
SFR	-/+	0.0012	0.391
LIQ	+	-0.0028	0.196
TANG	+	-0.056	0.000
AGE	-	0.0012	0.000
ASSETTURN	+	0.008	0.002
SIZE	+	-0.0011	0.017

Source: Field survey.

The test for overall significance is significant with a probability (p-value) approaching 0. We will present the interpretation of the results obtained regarding the explanatory variables.

- **Short-term debts:** The results of the regression model indicate that short-term debts have a negative relationship with economic profitability, and they are statistically significant with a p-value approaching 0 and a coefficient of (-0.10175389). This implies that a 1% change in the short-term debt ratio, holding all other factors constant, leads to a decrease of 10.17% in the financial performance of companies. Our result presents a disagreement with “equilibrium theory”, which assumes a positive relationship between financial structure ratios and performance. However, the pecking order theory suggests an inverse relationship between debt and performance, as companies achieving high profitability prefer to finance their needs through internal funding first, only resorting to debt when internal financing is

insufficient. This is in contrast to the “equilibrium theory”. Our observation supports the results of (Czech Republic, 2013) and (Vätavu, 2015).

- Long and medium-term debts: Long-term debts have a negative coefficient of (-0.11712591) with a tolerance of error approaching 0. An increase in long-term debts by one unit leads to a decrease in ROA by 11.71%. Our result is not in line with the expectations of the Trade-Off Theory (TOT), which suggests a positive relationship between debt and a company's economic profitability. This could be attributed to a high level of bank borrowing. However, the result supports the Pecking Order Theory (POT) hypothesis and the findings of the study by (Abri and Balehouane, 2019).
- Self-financing: According to the obtained results, self-financing does not significantly impact the level of performance in large Algerian private enterprises (p-value of 39.1%). Our result aligns well with the Pecking Order Theory (POT) and the study by (Vätavu, 2013), but not with the agency theory.
- Liquidity: Table 2.14 displays a non-significant negative coefficient of (-0.00284949) (p-value of 19.6%). Our study thus suggests that liquidity negatively impacts the performance of large Algerian enterprises. This could be because these companies hold excessive amounts of liquidity, potentially indicating insufficient investment in productive assets that generate income. On the other hand, a company lacking adequate liquidity might struggle to meet short-term obligations and face insolvency risks. At this stage, we observe that large Algerian enterprises are mishandling their excess liquidity. This contradicts the findings of the study by (Matar, Eneizan, 2017) and the study by (Abri, Balehouane, 2019), both of which found a significant positive impact of liquidity on ROA. It also differs from the study by (Melwania, Manish, 2016), which found a non-significant positive impact.
- Tangibility: Presumably, asset tangibility should have a positive impact on the financial performance of the company. However, in our sample, a significant negative coefficient of (-0.05640939) emerges at the 0.1% significance level. This suggests that large Algerian enterprises acquire too many assets without improving their financial performance. In other words, the companies in the sample are not using their assets efficiently. The consequence could also result from the fact that during the period of the 2020–2021 health crisis, the higher the proportion of fixed assets, the higher the depreciation and inventory costs, which negatively affected the financial performance of the company. This observation aligns well with the findings of the study by (Vätavu, 2013).
- Age: The age of the company is positively correlated with its financial performance. This study reveals a coefficient of (0.001216) with a tolerance error approaching 0. This means that a 1% change in the age of the company, holding all other factors constant, results in a 0.12% change in the financial performance of large enterprises. Older firms often have a rich history and expertise that give them a better understanding of consumer expectations and a greater ability to adapt to market changes. They also benefit from an established reputation and a strong brand identity that allows them to stand out from competitors. In other words, the older the company, the higher its economic profitability. This result contradicts the findings of (Boeker, 1997) who found that older companies are less performing.
- Size: The results indicate a significant negative relationship with a 5% tolerance error between the size and the economic profitability ratio. A coefficient of

(-0.0011691) means that a 1% change in this explanatory variable, holding all other factors constant, results in a 0.11% change in performance. This can be justified by the fact that smaller companies are often more agile and adapt more quickly to market changes. They may also be more innovative and creative than larger ones, as they typically have less bureaucracy and hierarchy to manage, resulting in fewer agency problems. Furthermore, supervising various tasks can become more complex, leading to inefficient resource distribution, higher expenses, and reduced asset profitability. Our study thus supports the findings of (Dhawan, 2001; Ramasamy, 2005; Salman, Yazdanfar, 2012), but contradicts those of (Nguyen, T., Nguyen, V., 2018).

- Asset turnover: The asset turnover ratio is closely related to economic performance, as the results indicate. Companies with a high asset turnover rate are those with substantial liquidity and significant financing capabilities. This suggests that the company efficiently utilizes its assets to generate sales.

6. CONCLUSION

The objective of our empirical study was to identify the microeconomic factors explaining the financial performance of large Algerian enterprises, measured by the Return on Assets (ROA) ratio. To achieve this, we conducted a panel regression analysis using a sample of seventy-eight (78) large companies for the period from 2018 to 2021. Before performing the regression, we initially divided the sample into public and private enterprises to highlight characteristic differences. We found that public enterprises had lower economic profitability (ROA) but possessed larger sizes, higher long-term debts, and greater liquidity. We also observed that public enterprises tend to be older than private enterprises. The results from the corrected panel regression show that: on one hand, debt ratios, tangibility, size, have a negative and highly significant impact on the financial performance of large Algerian enterprises. On the other hand, company age and asset turnover have a positive and significant impact on the ROA ratio.

In conclusion, our study contributes to understanding the key determinants of financial performance for large Algerian companies. It reveals the complex interplay of various microeconomic factors that influence ROA, shedding light on the importance of debt management, asset efficiency, company size, sectoral differences, and other variables in driving financial success. However, self-financing has a positive but non-significant impact on financial performance. Liquidity plays a negative and non-significant role in the economic profitability of large Algerian enterprises.

REFERENCES

- Abri, A., Balehouane, H.N.E.H. (2019). *Les déterminants de la performance financière des entreprises privées algériennes* (Doctoral dissertation).
- Aditiya, P. (2006). *Executive compensation: Firm performance and governance. An empirical analysis*. "Economic and political weekly", No. 36.
- Alami, M., Makhtari, M. (2023). *Les défis d'évaluation de la performance organisationnelle dans les entreprises*. „International Journal of Accounting, Finance, Auditing, Management and Economics”, 4(2-1). DOI: 10.5281/zenodo.7811073.
- Alexander, C. (2018). *Firm Age and performance*. "Journal de Evolutionary Economics", 28(1). DOI: 10.1007/s00191-017-0532-6.

- Amaazoul, M. (2018). *Synthèse des principales approches définitives du concept de performance en sciences de gestion*. "RCMP", No. 2, Décembre.
- Assienin, K.A., Ouattara, A. (2016). *Les facteurs explicatifs de la performance des banques ivoiriennes: une analyse des données de panel*. "Education".
- Bailly, J.P. (2005). *Comment accroître la performance par un meilleur management*. Paris.
- Boeker, W. (1997). *Executive migration and strategic change*. "Administrative Science Quarterly", 42.
- Boughaba, Y. El Idrissi, S. (2021). *Banking financial performance: an analytical essay in the Moroccan banking context*. "REMFO", No. 13, Juin.
- Bouquin, H. (2004). *Le contrôle de gestion*, Presses Universitaires de France, Collection *Gestion*, 6ème édition. Paris.
- Bourguignon, A. (2009). *Performance et contrôle de gestion*. Encyclopédie de Comptabilité, *Contrôle de gestion et Audit*, Ed. Economica.
- Charreaux, G. (1998). *Le point sur la mesure de performance des entreprises*. Université de Burgundy, May, "RePEc".
- Coad, A., Daunfeldt, S.O., Halvarsson, D. (2018). *Bursting into life: firm growth and growth persistence by age*. "Small Business Economics", 50(1).
- Derbali, A.M.S., Lamouchi, A. (2021). *Determinants of the performance of insurance companies*. "International Journal of Productivity and Quality Management", 34(2). DOI: 10.1504/IJPQM.2021.118383.
- Dhawan, R. (2011). *Firm size and productivity differential: theory and evidence from a panel of US firms*. "Journal of Economic Behaviour and Organization", Vol. 44.
- Domin, J.P., Nieddu, M. (2012). *La pluralité des approches en termes de performance*. *Économie et institutions* (En ligne). Access on the internet: <http://journals.openedition.org/ei/483>.
- Durand, R. Coeurderoy, R. (2001). *Age, order of entry, strategic orientation, and organizational performance*. Université Catholique de Louvain, Belgique.
- El Amraoui, H., Hinti, S. (2022). *La performance d'entreprise: Histoire d'un concept (1950–2020)*. "Revue Française d'Économie et de Gestion", Vol. 3, No. 5.
- Galambaud, B. (2003). *GRH et performances*. AGEF, colloque de Marrakech, 23 et 24 janvier.
- Gerrard, M., Blanton, H., Gibbons, F.X., Russell, D.W. (1998). *Reasoned action and social reaction: willingness and intention as independent predictors of health risk*. "Journal of personality and social psychology", 74(5).
- Gurbuz, A.O., Aybars, A. (2010). *The impact of foreign ownership on firm performance, evidence from an emerging market: Turkey*. "American Journal of Economics and Business Administration", 2(4).
- Hamadmad, H. (2017). *Définition d'une expression temporelle de la performance des entreprises manufacturières*. Thèse doctorat, Université Savoie Mont Blanc, France, 2017.
- Helfert, E.A. (1991). *Techniques of Financial Analysis Illinois*. Richard D. Irwin, Inc.
- Hunjra, A.I., Chani, D.M.I., Javed, S., Naeem, S., Ijaz, M.S. (2014). *Impact of micro economic variables on firms performance*. "International Journal of Economics and Empirical Research", 2(2). DOI: 10.1504/IJPQM.2021.118383
- Issor, Z. (2017). *La performance de l'entreprise: un concept complexe aux multiples dimensions*.
- Laha, K., Sur, A.D. (2020). *Macroeconomic and microeconomic determinants of efficiency of Indian construction & engineering firms: an investigation*. "Ramanujan International Journal of Business and Research", 5. DOI: 10.51245/rijbr.v5i1.2020.219.

- Matar, A., Eneizan, B.M. (2018). *Determinants of Financial Performance in the Industrial Firms: Evidence from Jordan*. "AJAEES", 22(1), Article No. 37476, Janvier.
- Myers, S.C. (1975). *A Note on the Determinants of Corporate Debt Capacity, working paper*. London: Graduate School of Business Studies.
- Myers, S.C. (1984). *The capital structure puzzle*. "Journal of Finance", 39.
- Nguyen, T., Nguye, V. (2020). *The determinants of profitability in listed enterprises: A study from vietnamese stock exchange*. "Journal de Asian Finance, Economics and Business" Vol. 7, No. 1. DOI: 10.13106/jafeb.2020.vol7, no1.
- Nikolaus, V. (2015). *Determinants of firm financial performance in Indonesia and the Netherlands: A comparison*. Bachelor's thesis, University of Twente.
- Odipo, M., Olweny, T., Oluoch, O. (2020). *Microeconomic firm characteristics and long run returns: The case of firms that issued equity at nairobi securities exchange*. "Journal of Advances in Economics and Finance", 5(4). DOI: 10.22606/jaef.2020.54002.
- Onaolapo, A.A., Kajola, S.O. (2010). *Capital structure and firm performance: Evidence from Nigeria*. *European Journal of Economics, Finance and Administrative Sciences*, 25.
- Pattitoni, P., Petracchi, B., Spisni, M. (2014). *Determinants of profitability in the EU-15 area*. "Journal Applied Finance and Economy", 24(11). DOI: 10.1080/09603107.2014.904488.
- Pervan, M., Pervan, I., Ćurak, M. (2017). *The Influence of Age on Firm Performance: Evidence from the Croatian Food Industry*. Université de Split of Economics, Split, Croatie.
- Pouraghajan, A., Malekian, E. (2012). *The Relationship between Capital Structure and Firm Performance Evaluation Measures: Evidence from the Tehran Stock Exchange*. "International Journal of Business and Commerce", 1(9).
- Quoc Trung, N.K. (2021). *Determinants of small and medium-sized enterprises performance: The evidence from Vietnam*. "Cogent Business & Management", 8(1). DOI: 10.1080/23311975.2021.1984626.
- Ramasamy, B. (2005). *Firm size, ownership and performance in the Malaysian palm oil industry*. "Asian Academy of Management Journal of Accounting and Finance", Vol. 1.
- Renaud, A., Berland, N. (2007). *Mesure de la performance globale des entreprises. Comptabilité et environnement*. France.
- Salman, A.K., Yazdanfar, D. (2012). *Profitability in Swedish SME firms: a quantile regression approach*. "International Business Research", Vol. 5, No. 80.
- Tari, M.L. (2018). *La décision financière et son impact sur la performance financière mesurée par la rentabilité*. "Recherches économiques et managériale", No. 23, Ecole Supérieure de Commerce.
- Tzelepis, D., Skuras, D. (2004). *The effects of regional capital subsidies on firm performance: an empirical study*. "Journal of Small Business and Enterprise Development", 11(1).
- Vătavu, S. (2015). *The impact of capital structure on financial performance in Romanian listed companies*. "Procedia economics and finance", 32.
- Zeitun, R., Tian, G.G. (2007). *Capital structure and corporate performance: evidence from Jordan*. "Australasian Accounting Business and Finance Journal", 1(4).

ANNEXES

Descriptive analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
ROA	312	.0120201	.1207958	-.4986771	1.416037
DCT	312	.5164232	.3441001	.0095279	2.406773
DLMT	312	.1760492	.2381003	-.0132679	1.052196
AF	312	.6086253	2.820536	-44.81017	19.31384
LIQ	312	1.604758	1.802373	.060501	14.96586
TANG	312	.2644283	.2316487	-2.117901	.6935951
AGE	312	17.30178	10.48055	.1722222	54.00556
ASSETTURN	312	.6790624	1.132254	0	9.45019
size	312	21.04146	4.310961	0	26.01444

Correlation matrix

	ROA	DCT	DLMT	AF	LIQ	TANG	AGE
ROA	1.0000						
DCT	-0.3148	1.0000					
DLMT	-0.2365	-0.2929	1.0000				
AF	0.0311	-0.0178	-0.0885	1.0000			
LIQ	0.1423	-0.4294	-0.0126	0.0365	1.0000		
TANG	-0.0602	-0.1922	0.2264	-0.0513	-0.3996	1.0000	
AGE	-0.0070	-0.1973	0.3361	-0.0235	-0.0421	0.1384	1.0000
ASSETTURN	0.1117	-0.0095	-0.1386	0.0282	0.1451	-0.1271	-0.1970
size	-0.0030	0.0160	-0.1220	-0.0083	-0.0122	-0.0573	0.1396

Estimation result

Coefficients: **generalized least squares**
Panels: **heteroskedastic**
Correlation: **no autocorrelation**

Estimated covariances = 78 Number of obs = 312
Estimated autocorrelations = 0 Number of groups = 78
Estimated coefficients = 14 Time periods = 4
Wald chi2(13) = 263.12
Prob > chi2 = 0.0000

ROA	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
DCT	-.101754	.0109739	-9.27	0.000	-.1232624 -0.0802456
DLMT	-.1171259	.0103638	-11.30	0.000	-.1374386 -0.0968132
AF	.0012334	.0014378	0.86	0.391	-.0015846 .0040514
LIQ	-.0028495	.0022053	-1.29	0.196	-.0071717 .0014728
TANG	-.0564094	.0106176	-5.31	0.000	-.0772196 -.0355992
AGE	.001216	.0001997	6.09	0.000	.0008245 .0016075
ASSETTURN	.0080819	.0026484	3.05	0.002	.0028912 .0132726
size	-.0011691	.000492	-2.38	0.017	-.0021334 -.0002048

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THE IMPACT OF TECHNOLOGICAL INNOVATION ON FIRM PERFORMANCE IN NIGERIA CONSOLIDATED BREWERIES PLC

This research investigated the impact of technological innovation on firm performance. The study was conducted among employees of Nigeria Consolidated Breweries in Ijebu-Ode area of Ogun state. A sample size of one hundred and two (102) employees was purposively selected from Nigeria Consolidated Breweries in the study area. Primary data was employed for this study. Descriptive statistics analysis was employed to analyze the demographic factors of respondents. Results of this study revealed that there was significant positive effect of technological innovation on firm performance ($R = 0.881$, $p < 0.005$). Also, the findings of this study further revealed that technological learning had significant positive effect on firm performance ($\beta = 0.654$, $p < 0.005$). Based on the results, it was recommended that the management of the firm should adopt technological innovation as an essential ingredient of competitive advantage for new product development.

Keywords: technological innovation, technological learning, innovation, firm competitiveness, organizational performance.

1. INTRODUCTION

The technological innovation has become increasingly widespread since Schumpeter proposed this concept in his book "The theory of economic development" in 1912. It is well recognized that in today's hypercompetitive environment seeking to respond the changes constantly arising in the environment does not rely on the static process of sole

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knowledge accumulation or growth of technology assets through resource based view rather it is dependent on the mutual relationship between firm's capabilities (e.g. effective coordination and adaptation of internal and external competencies), technology (e.g. timely responsiveness), and innovation (e.g. flexible innovations) (Karabulut, 2020).

Under this new paradigm, sources of knowledge and transfer of technology can be external to firms. Skilled and educated workers lie in the centre of the identification, acquisition, assimilation, and absorption of external knowledge. Rapid technology change and increased technological complexity makes 'openness' essential for firms. Venture capital translates R&D outcomes to the market because it directly contributes to the execution of an innovative idea (including those coming from external technology sources) and shares the risks in new product development (Karabulut, 2015). These processes facilitate internal and external knowledge exchanges and push innovation across the boundaries of the firm.

In most industries, even industry leaders cannot research and develop a new technology completely on their own. Technological challenges and financial constraints push independent organisations, or even competitors, to collaborate. With progression in technology, more interdisciplinary subjects have emerged. Therefore, a different innovation environment started to form, which Chesbrough later called "open innovation". A strategic perspective of trade-off between the benefits and the cost of open innovation is required to ensure firms with open strategy can balance between taking advantage of open innovation and maintaining core firm-specific competitive advantages (Kocoglu, Imamoglu, Huseyin, Keskin, 2012).

Obembe and Ojo (2014) suggested that organizational performance is multiple hierarchical constructs which indicating financial performance and operational performance such as market share and quality. There are many research studies analyzed the impact of innovation and firm performance. The relationship between the innovation and organizational performance is predominant. Previous research has indicated that there are often mixed results. They fluctuate between the positive and negative results. Innovative performance act as a mediator role between types and performance aspects. Innovation has a strong and direct impact on the organization performance (Karabulut, 2015). Financial, market and production performance positively linked with innovation and innovative performance act as a mediator for their direct positive impact. Innovation strategy is the core indicator of the organizational performance.

Although there are numerous conceptual studies that have been tested in extant literature studies. However, they are limited with numbers and depth of the analysis. Most of the studies have investigated the relationship between innovations typologies, innovation performance mainly linked with the manufacturing sector. The studies related to the service sector have made the investigation linked with the company business strategies with the perspective of innovation (Dotun, 2015). Especially, innovation capability is far-less concerned and under-examined within the service sector.

On the other hand, most of the research dealt with innovation capability and firm performance typologies (Abdu, Adamu, 2018). There are no studies intimately studies the relationship between technological innovation, innovation capability and firm performances in the literature. Research in the specific features of technological innovation and issues in the Nigerian service industry is quite limited and untested until recently especially compared to the banking sector. This study is therefore taken upon as an attempt at determining the impact of technological innovation on firm performance.

The broad objective of the study is to examine the impact of technological innovation on firm performance. Specific objectives of this study are to: first and foremost, determine the impact of technological innovation on firm performance. Secondly, examine the effect of technological learning on firm performance.

The following questions are raised in the course of this study: Firstly, what is the impact of technological innovation on firm performance? Secondly, is there any effect of technological learning on firm performance?

This study will enable firms take into account the competition level in their sector prior to strategic decisions. This is because an increasing competition is affected by developing structure of the global markets and division of labour today. This study will therefore help companies to achieve a key point in the competitiveness of manufacturing and service firms which is innovation performance. Furthermore, this study will enable them to view the impact of technological innovation capability on company's performance in another dimension. This is because innovation is an interactive process characterized by technological interrelated uses between sub-systems. This study will therefore enlighten firms on how to use technological innovation in enhancing customer competence and technological competence in the industry which they operate in. Also, the findings of this study will act as a starting point for future researchers to embark on similar areas of study thereby contributing to the existing body of knowledge and expanding the frontier of knowledge. It is in the opinion of the researcher that gaps may still exist that this study may not have covered, therefore future researchers can help to fill this gap.

2. LITERATURE REVIEW

2.1. Concept of Innovation

After Schumpeter's first introduction of innovation concept, it was long taken for granted that innovation refers only to activities that occurred within a firm or within an R&D department, which therefore made creativity and innovation important strategic resources guarded by careful management and legislative protections. This is now classified as "closed innovation," in which each step in the innovation process is dependent on a firm's own capabilities (Adeyeye, 2014). Toward the end of the twentieth century, this closed innovation model was gradually disrupted as a result of the increased mobility of skilled workers, more rapid technological change and increased technological complexity, and the prevalence of venture capital.

Innovation often happened by using open technologies and high-quality open resource and relies on a different kind of knowledge and information system. Knowledge management is the most important part of the innovation, especially knowledge-intensive industry like insurance. Knowledge is a competitive advantage for underwriting and servicing in insurance companies. In the insurance industry trade secrets, confidential information and valuable ideas are part of the workforce knowledge. Therefore, using knowledge management system to capture the internal expert will be crucial to the insurance companies (Hamidi, Benaddjelil, 2015). The firm's capability to innovate is the most crucial factor for competitive advantage in highly turbulent market condition. Innovation capability leads organization to develop innovations continuously to respond the changing market environment and it's embedded with all the strategies, system and structure that support innovation in an organization (Stefan, Bengsston, 2017).

Innovation can only happen if the company has the capacity to innovate (Adeyeye, Jegede, Adekemi, Aremu, 2016). Innovation capability is considered as the valuable assets for the firms to provide and sustaining competitive advantage and in the implementation of the entire strategy. It is composed through the main process within the firm and cannot separate from the other practices. It is tacit and non-modifiable and closely correlated with the experimental acquirement and interior experiences (Abdu, Adamu, 2018). The capability of innovation facilitates firms to introduce new product quickly and adopt new systems rather it is important to factor for feeding the ongoing competition. Innovation performance can be explained as combination of assets and resources. Therefore, it requires wide variety of resources, assets, and capabilities to drive through success in rapidly changing environment (Abdu, Adamu, 2018).

2.2. Concept of Technological Innovation

Adeyeye (2014) stated that technological innovation is a unique technique or manufacturing process owned by a company, which allows it to react quickly to an environmental shift. Karabulut (2015) posits that technological innovation designates the capability of an organization to choose, diffuse and then improve its technology. As such, it is a progressive process of experience accumulation including the use of technology, the improvement and application of existing technology. Kocoglu et al., (2012) emphasizes that technological innovation is the skill involved in realizing and supporting a company's technological innovation strategy. Obembe and Ojo (2014) point out that technological innovation is the ability to access and digest external knowledge into some unique skill or knowledge, then using it in a dynamic way to improve or develop a new product and launch it successfully.

Namusonge, Muturi and Olawoye (2016) also remark that technological innovation is the combination of knowledge techniques and management skills from different areas, that by strengthening these areas, the company can build its organizational competitiveness. According to Dotun (2015) technological innovation involves acquisition of more and flexible process equipment, in combination with more flexible organization and administrative processes that facilitates or enables frequent changes in the production line. Jayani and Hui (2018) define technological innovation as the successful implementation of creative ideas within an organization. While Hamidi and Benadjelil (2015) says that technological innovation is the process of turning opportunities into new ideas and of putting them into widely used practice. Hamidi and Benadjelil sees this as a process that includes the technical, design, manufacturing, management and commercial activities involved in the marketing of a new or improved product.

According to Adeyeye (2014) technological innovation involves acquisition of more and flexible process equipment, in combination with more flexible organization and administrative processes that facilitates or enables frequent changes in the production line. Technological innovation as the successful implementation of creative ideas within an organization while Dotun (2015) says that technological innovation is the process of turning opportunities into new ideas and of putting them into widely used practice. Janayi and Hui (2018) sees technological innovation as a process that includes the technical, design, manufacturing, management and commercial activities involved in the marketing of a new or improved product. Azubuike (2013) suggests that innovations do not have to be breakthrough or paradigm shifting. Stefan and Bengston (2017) suggests that the overall management of technological innovation includes the organization and direction of human

and capital resources towards effectively creating new knowledge, generating ideas aimed at new and enhanced products, manufacturing processes and services, developing those ideas into working proto types and finally transferring them into manufacturing, distribution and use.

2.3. Technological Innovation and Firm Competitiveness

Technological innovation is broadly seen as an essential component of competitiveness, embedded in the organizational structures, processes, products and services within a firm. Innovativeness is one of the fundamental instruments of growth strategies to enter new markets, to increase the existing market share and to provide the company with a competitive edge. Schumpeter (1934) described different types of innovation as new product, new methods of production, new sources of supply, the exploitation of new markets and new ways to organize business.

Drucker (1985) defined innovation as the process of equipping in new improved capabilities or increased utility. Metcalfe (1998) stated that when the flow of newness and innovation desiccate firms' economic structure settles down in an inactive state with little growth. Therefore, innovation plays a significant role in creating the differences of performance and competition among firms. Further buttressing the relationship between innovation and corporate performance, McAdam and Keogh (2004) investigated the relationship between Firms' performance and its familiarity with innovation and research. They found that the firms' inclination to innovations was of vital importance in the competitive environments in order to obtain higher competitive advantage. Zehir, Esin and Karaboga (2015) stated that most firms seek technological innovation to gain competitive advantage in their market.

As described by Zhang, Delin, Shumin, Xiang and Jizhen (2018), technology is one of the main sources of competitive advantage for a company. Within the same industry, companies with a technological edge tend to have better profitability as well as being faster in developing new product lines or other technological innovation. According to numerous studies related to resource-based theory, such as Zhnage et al., (2018), technological innovation is at the core of the company's competitive capability. Dotun (2015) suggests it is the most important core asset. Azubuike (2013) attest that a company should develop its competitive edge in order to acquire long lasting competitive advantages. Companies need to be constantly aware of the changing environment while keeping and developing new technological capabilities in order to survive.

2.4. The Relationship between Technological Learning and Innovation

Innovation allows organizations to progress parallel with the changes flourishing in the environment. It's a strategic key in responding to the new challenges of an environment full of uncertainties (Azubuike, 2013). For an organization, innovation would denote the generation or adoption of novel ideas or behaviour. In the literature the idea that innovation is essential for firms' long-term success and survival constituting a competitive instrument is widely recognized (Jayani, Hui, 2018). Stefan and Bengston (2017) suggestions as; organizations fit to the changing conditions of the technology and the market by diversifying and adapting, and even rejuvenating or "reinventing" through innovation.

Namusonge, Muturi and Olawoye (2016) claimed that technological learning provides a base of knowledge upon which innovations can be developed. The degree of novelty is dependent on the situation and the individuals through which the technological learning

emerges, thereby the breadth, depth and speed of technological learning leverages the ability to integrate organization specific technologies and technological skills that equip the actors in the technological learning process to adapt quickly to changing environment. Furthermore, technological learning is considered as having impact on firm, innovation at three levels namely; instrumental, innovative and creative (Durowoju, 2017). Instrumental impact drives incremental change in firm processes, outputs operations and performance, innovative impact results in radical change in firm processes, outputs, operations and performance and finally creative impact leads to architectural change in firm processes, outputs, operations and performance (Durowoju, 2017).

2.5. Innovation and Organizational Performance

Azubuikwe (2013) stated that innovation is the specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or a different service. It is capable of being presented as a discipline, capable of being learned, capable of being practiced. Entrepreneurs need to search purposefully for the sources of innovation, the changes and their symptoms that indicate opportunities for successful innovation and they need to know and to apply the principles of successful innovation.

Since the beginning of the recent decade when the competitive environment went through a major transformation due to globalization, business organizations have intensified their search for strategies that will give them a sustainable competitive advantage. Such strategies generally require that the firm continuously differentiates its products and process, that is, firms must constantly be innovative (Hamidi, Benabdeljlil, 2015). In such condition, where innovation in products and process regarded as an essential prerequisite for the organizational survival and success, attention to entrepreneurship orientation and change to an entrepreneur organization attracted the much attention of academic researchers and organizational members. McAdam and Keogh (2004) confirmed that entrepreneurial orientation is manifest in product and process innovations.

Karabulut (2015) described entrepreneurial orientation as the process, practice, and decision-making activity that leads to new entry. Karabulut (2015) delineated five dimensions of EO including innovativeness, risk taking, proactiveness, competitive aggressiveness and autonomy, which underlie nearly all entrepreneurial processes. Innovativeness is an organization's tendency to engage in and support new ideas, novelty, experimentation, and creative processes that may result in new products. The organization researchers are of the view that adoption of innovation is a main vehicle for organization adaptation and change to improve firm performance especially under the conditions like scarce resources, dynamic business environment, intense competition and changing customers demand for better quality (Dotun, 2015).

Schumpeter (1942) emphasized the role of innovation in the entrepreneurial process. He stated that this was a process of "creative destruction" where wealth was created when existing market structures were disrupted by the introduction of new goods or service that shifted resources away from existing firms and caused new firms to grow. Innovativeness has become an important factor used to identify entrepreneurship. Drucker (1985) and Durowoju, (2017) believe that innovation is the specific tool for entrepreneurs, the means by which they exploit change as an opportunity for a different business or a different service. The scholars further believe that innovation is better practiced in phases. Innovation involves the exploitation of new ideas.

Namusonge, Muturi and Olawoye, (2016) claimed that innovation is the ability to take quick advantage of scientific or technological discoveries, commercializing them in ways

that translate the new discoveries into added-value goods and services and processes for their customers/clientele. In its original sense, innovativeness can be defined as the degree to which an individual or other entity is relatively earlier in adopting new ideas than the other members of a system (Abdu & Adamu, 2018). Similarly, it is the tendency to support new ideas, experimentation and creative processes. Durowoju (2017) also associate innovation closely with creativity; however, they suggest that it must be linked to entrepreneurship if the innovation is to become a commercial opportunity to be exploited.

Adeyeye, Jegede, Adekemi and Aremu (2016) classified innovations into three: product, process and technological. According to them, product innovation involves shortening the product life cycle, expand commercial production process, generate sales and revenue and recoup development investments. This also connotes the number of implemented innovations in the product line. Firms' ability to launch new and sophisticated products in increasingly fast cycle is essential to success in the currently dynamic business environment. Process innovation entails the number of innovations implemented in the manufacturing or service process. Product and Process innovations are inter-connected and interwoven in an effort to meet certain production targets. Zhang, Delin, Shunmi, Xiang and Jizhen (2018) technological innovation involves acquisition of more and flexible process equipment, in combination with more flexible organization and administrative processes that facilitates or enables frequent changes in the production line.

2.6. Theoretical Review

2.6.1. Lazonick's Theory of the Innovative Enterprise

Lazonick's (2005) theory of the innovative enterprise is rooted in the Chandlerian Framework as it focuses on how strategy and structure determine the competitive advantage of the business enterprise. It also builds on Lawrence and Lorsch (1967) conceptualization of organizational design problems as differentiation and integration. The theory distinguishes the optimizing firm from the innovative firm. Lazonick identifies three social conditions that support the development of the innovative firm. The first condition is strategic control, which refers to the set of relations that give key decision-makers the power, knowledge and incentives to allocate the firm's resources to confront market threats and opportunities. The second condition is organizational integration. That is, the horizontal and vertical integration of skills and knowledge to support cumulative learning over-time. The third condition is financial commitment to ensure that sufficient funds are allocated for competence development to sustain the cumulative innovative process.

The essence of the innovative enterprise, according to Lazonick (2005), deals with the organizational integration of skill base that can engage in collective and cumulative learning. The theory of the innovative firm propounded by Lazonick, alongside other researchers in the field of strategy stresses the importance of organizational and management processes as core elements that underpin firms, innovative performance. Innovative performance is seen in the literature as one of the most important drivers of other aspects of firm performance. Hence, innovative performance exerts positive effects on firm's production, market and financial performances. Innovative performance, especially in the form of new product success, is linked in the literature to an increase in sales and market shares, since it contributes considerably to the satisfaction of existing customers and gaining of new customers.

3. METHODOLOGY

The descriptive survey research was employed in this study. Descriptive survey research is effective in describing the existing conditions or variables being investigated. The reason for adoption of descriptive design methodology is that it helps the researcher to come into close contact with the population of study as well as obtaining accurate information from the respondents. The area for this study is Nigeria Consolidated Breweries located in Ijebu-Ode area of Ogun state. The study area is chosen because it will enable the researcher to have a proper coverage and gathering of information needed from the respondents of study. Also, the study area which is the Nigeria Consolidated Breweries is recognized for its groundbreaking technological innovation which made it recognized amongst other producers of brewed products in the Nigerian manufacturing industry.

The population of this study includes all employees of Nigeria Consolidated Breweries who are fully employed and who may be junior, senior or managerial level workers in the company. Hence, the population of this study included a total of one hundred and thirty-seven (137) employees of Consolidated Breweries Plc. The sample will be drawn from the population of the study using simple random sampling technique. The justification for using simple random sampling technique is because it will enable all respondents of this study to have equal chances of been selected for this study. However, the total number of respondents for the purpose of this study will be drawn from one hundred and thirty-seven (137) employees of Nigeria Consolidated Breweries located in Ijebu-Ode area of Ogun state. The size is considered sufficiently large enough to carry adequate estimation of the study. One hundred and thirty-seven (137) copies of questionnaires were administered out to the respondents but only one hundred and two (102) questionnaires were returned. Therefore, a total number of one hundred and two (102) returned questionnaires were valid instruments for this study. The sample for this study included a total of one hundred and two (102) employees of Consolidated Breweries Plc, Ijebu-Ode Ogun state.

The research instrument used for this study is a questionnaire designed by the researcher. The questionnaire is divided into two sections. The first section seeks to obtain the personal information of the respondents while the second section contains items relating to the objectives set out from the chapter one of this study. The split-half statistic method will be used to determine the reliability status of the research instrument. The administered questionnaires after retrieval will be parted into two groups of odd numbers and even numbers. The scores of the two groups will be correlated using Pearson's Product Moment Correlation method. The Cronbachs' Alpha Coefficient method will be used to test the reliability and validity of the research instrument. The responses of the respondents will be coded using frequency percentage counts and simple percentage in analyzing the data on the research instrument. The statistical method of linear regression would be used to test the hypothesis which will be done with the aid of Statistical Package for Social Sciences version 20.0.

4. RESULT AND DISCUSSION

For this study, the analytical techniques employed in analyzing the data collected from the respondent were the Simple Percentage Analysis. The descriptive statistics of the data is shown below:

Table 1. Descriptive Statistics of the Data

Gender	<i>Male</i>	<i>Female</i>			
	38.2%	61.7%			
Age	<i>20–30 years</i>	<i>31–40 years</i>	<i>41–50 years</i>	<i>51–60 years</i>	
	34.3%	28.4%	15.6%	21.5%	
Marital Status	<i>Single</i>	<i>Married</i>	<i>Divorced</i>	<i>Widowed</i>	<i>Widower</i>
	28.4%	20.5%	15.6%	16.6%	18.6%
Academic Qualification	<i>SSCE</i>	<i>OND/HND</i>	<i>B.Sc.</i>	<i>M.Sc.</i>	<i>Others</i>
	21.5%	30.3%	23.5%	13.7%	10.7%
Organization Level	<i>Junior Staff</i>	<i>Middle Level Supervisor</i>	<i>Senior Staff</i>		
	48%	31.3%	20.5%		
Year of Experience	<i>Below 5 years</i>	<i>6–10 years</i>	<i>10 years & above</i>		
	46%	33.3%	20.5%		

Sources: (Field Survey, 2022).

4.1. Hypotheses Testing

H₀₁: Technological innovation has no significant effect on firm performance.

Table 2. Summary of Regression Results of the effect of Technological Innovation on Firm Performance

R = 0.881						
R² = 0.776						
Adjusted R² = 0.772						
Standard Error = 0.49021						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	567.531	1	516.612	235.245	.000 ^a
	Residual	161.340	101	.631		
	Total	213.871	102			
a. Dependent Variable: Firm Performance						
b. Predictors: (Constant), Technological Innovation						

Degree of freedom at 0.05% level of significance

Source: (Field Survey, 2023).

From the analysis of results in table I above, it shows the summary of the regression results, it therefore revealed that technological innovation has a significant impact on firm performance. The values of the regression results as follows ($R = .881$; $P < 0.005$) shows that technological innovation has a significant impact on firm performance. This means that firm performance improves as a result of the improvement in the technological and innovative capabilities of a firm. The null hypothesis is therefore rejected, while the alternative hypothesis is accepted that technological innovation has a significant impact on firm performance.

H₀₂: There is no significant effect of technological learning on firm performance.

Table 3. Summary of Regression Results on the effect of Technological Learning on Firm Performance

R = .654^a						
R² = .428						
Adjusted R² = .423						
Standard Error = 3.06103						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	792.994	1	792.994	84.632	.000 ^b
	Residual	1058.797	101	9.370		
	Total	1851.791	102			
a. Dependent Variable: Firm Performance						
b. Predictors: (Constant), Technological Learning						

Degree of freedom at 0.05% level of significance

Source: (Field Survey, 2023).

From the analysis of results in table II above, it shows the summary of the regression results, it therefore revealed that technological learning has a significant effect on firm performance. The values of the regression results as follows ($R = .654$; $P < 0.005$) shows that technological learning has a significant relationship with firm performance. This means that technological learning is a strong predictor of firm performance. Hence, the more technological knowledgeable the employees in an organization, the less time they are able to complete tasks and achieve more within the time given in the organization.

4.2. Discussion of Findings

From the result of the analysis of hypothesis one, it was revealed that technological innovation has a significant impact on firm performance. This means that firm performance improves as a result of the improvement in the technological and innovative capabilities of a firm. The result corroborated the study of Obembe and Ojo (2014) on the effects of technological capabilities, Innovations and clustering on the performance of firms. The result shows positive impact of technological capabilities, innovations, and clustering on the performance of firms.

In addition, the analysis of hypothesis two established that technological learning is a strong predictor of firm performance. Hence, the more technological knowledgeable the employees in an organization, the less time they are able to complete tasks and achieve more within the time given in the organization. This result corroborated the findings of Azubuike (2013) on understanding the way in which technological innovation capabilities affect the efficiency and potential of firm performance. The study posits the importance of technological innovation as an essential ingredient of competitive advantage for new product development. The survey findings verify the existence of correlation between technological innovation and firm performance on new product development.

5. DISCUSSION AND IMPLICATIONS FOR MANAGEMENT

The objective of the study was to examine impact of technological innovation on corporate performance. This is imperative because in today's hypercompetitive

environment seeking to respond the changes constantly arising in the environment does not rely on the static process of sole knowledge accumulation or growth of technology assets through resource based view rather it is dependent on the mutual relationship between firm's capabilities (e.g. effective coordination and adaptation of internal and external competencies), technology (e.g. timely responsiveness), and innovation (e.g. flexible innovations).

The study concluded that technological innovation is an indispensable aspect of corporate performance. This is because without advancement in the production method, processing of products will continually experience a downward slope which will therefore indicate that the business organization is not meeting up with customers demand, however meeting up with customers demand through the adoption of technological innovation increases the profitability of the firm. Findings of this study revealed that technological innovation predicts corporate performance because without advancement in the tools and techniques of production, such an organization will gradually lose its customers to competitors.

The study therefore concluded that companies who want to experience increment in their level of profitability should seek new ways and means of product deliver, meeting up with customers demand, increase the level at which technological learning is been dispersed in the organization. This study has therefore achieved the objective which it set out to achieve in determining the impact of technological innovation on corporate performance.

The following recommendations are made in the light of the findings of this study: firstly, the management of the firm should adopt technological innovation as an essential ingredient of competitive advantage for new product development. Secondly, technological innovation should be adopted so as to develop innovative products in very short time frames, with market acceptance and creating business value. Lastly, firms should make significant improvement in technological learning because it will help them to achieve high returns on the investment and increase their profitability.

REFERENCES

- Abdu, M., Adamu, J. (2018). *Determinants of firms' innovation in Nigeria*. "Kasetsart Journal of Social Sciences", 3(9).
- Adeyeye, A., Jegede, O.O., Adekemi, J., Aremu, F.S. (2016). *Micro level determinants of small firms' innovation*. "Innovation and Development", 6(1).
- Adeyeye, C. (2014). *The Impact of Technological Innovation on Organizational Performance*. "Industrial Engineering Letters", 4(3).
- Azubuike, V.M. (2013). *Technological Innovation Capability and Firm's Performance in New Product Development*. "Journal of Innovativeness," 13(1).
- Dotun, F.O. (2015). *The key determinants of innovation in SMEs in south-western Nigeria*. "European Scientific Journal", 11(13).
- Drucker, P.F. (1985). *The discipline of innovation*. "Harvard Business Review", 63(3).
- Durowoju, S.T. (2017). *Impact of Technological Change on Small and Medium Enterprises Performance in Lagos State*. "Economic and Environmental Studies", 17(4).
- Globocnik, D., Elke, P., Baumgartner, R.J. (2018). *Open innovation and its effects on economic and sustainability Innovation Performance*. "International Journal of Innovation and Knowledge", 4(7).

- Hamidi, S., Benabdeljlil, N. (2015). *Managerial and Technological Innovations: Any Relationship?* "Procedia – Social and Behavioral Sciences", 18(1).
- Jayani, R.P., Hui, Y. (2018). *Relationship between innovation capability, innovation type, and firm performance.* "Journal of Innovation & Knowledge", 3(9).
- Karabulut, A.T. (2015). *Effects of Innovation Types on Performance of Manufacturing Firms in Turkey.* "Procedia – Social and Behavioral Sciences", 19(5).
- Karabulut, A.T. (2020). *Digital innovation: An antecedent for digital transformation.* International "Journal of Commerce and Finance", 6(2).
- Kocoglu, I., Imamoglu, S.Z., Huseyin, I., Keskin, H. (2012). *Learning, R&D and Manufacturing Capabilities as Determinants of Technological Learning: Enhancing Innovation and Firm Performance.* "Procedia – Social and Behavioral Sciences", 5(8).
- Lawrence, P.R., Lorsch, J.W. (1967). *Organization and Environment.* Boston M.A.: Harvard University Press.
- Lazonick, W. (2005). *The institutional triad and Japanese development.* Translated into Japanese in Glenn Hook and Akira Kudo, eds., *The Contemporary Japanese Enterprise*, Yukikaku Publishing, 1.
- McAdam, R., Keogh, K. (2004). *Transitioning towards creativity and innovation measurement in SME's.* "Creativity and Innovation Management", 13(2).
- Metcalf, J.S. (1998). *Evolutionary economics and creative destruction* (Vol. 1). Psychology Press.
- Namusonge, G.S., Muturi, W., Olawoye, O. (2016). *The Role of Innovation on Performance of Firms on Nigerian Stock Exchange.* "Journal of Management Research", 4(12).
- Obembe, J.J., Ojo, O.J. (2014). *Effects of Technological Capabilities, Innovations and Clustering on the Performance of Firms in the Nigerian Furniture Industry.* "International Journal of Management Technology", 2(2).
- Oliveira, S.R.M., Alves, J.L., Boer, H. (2017). *Innovation in the product development process and performance of firm: An experience of value co-creation based on incorporation of technological innovations by the 3D modelling and additive manufacturing.* "European Journal of Knowledge Research", 6(2).
- Schumpeter, J.A. (1934). *The theory of Economic Development.* Massachusetts: Harvard University Press, Cambridge.
- (1942). *Capitalism, socialism & democracy.* New York: Harper and Row.
- Stefan, I., Bengtsson, L. (2017). *Unravelling Appropriability Mechanisms and Openness Depth Effects on Firm Performance across stages in the Innovation Process.* "Technological Forecasting & Social Change", 12(1).
- Yavarzadeh, M.R., Salamzadeh, Y., Dashtbozorg, M. (2015). *Measurement of organizational maturity in knowledge management implementation.* "International Journal of Economic, Commerce and Management", 3(10).
- Zehir, C., Esin, C., Karaboga, T. (2015). *Linking entrepreneurial orientation to firm performance: The role of differentiation strategy and innovation performance.* "Procedia Social and Behavioral Sciences", 2(10).
- Zhang, S., Delin, Y., Shumin, Q., Xiang, B., Jizhen, L. (2018). *Open innovation and firm performance: Evidence from the Chinese mechanical manufacturing industry.* "Journal of Engineering and Technology Management", 4(8).

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MAPPING THE LANDSCAPE OF ARTIFICIAL INTELLIGENCE IN SUPPLY CHAIN MANAGEMENT: A BIBLIOMETRIC ANALYSIS

Industry 4.0 concepts and technologies, which focus on interconnectivity, digitalization, and automation, are critical to the long-term success of both micro and macroeconomic entities. Artificial Intelligence (AI) has emerged as a critical enabler for effective Supply Chain Management (SCM) within this framework. This research study conducts a thorough examination of the current literature to investigate the role of AI in SCM. The study attempts to identify research trends, appraise the present state of knowledge, and provide insights on management implications through a systematic review and the use of bibliometric analytic methodologies. The management implications of this study provide light on the potential benefits and possibilities that AI may provide to SCM operations. The research findings provide firms with the means to improve their supply chain operations, elevate decision-making processes, and achieve a competitive advantage in the changing business landscape by properly using the potential of AI.

Keywords: industry 4.0, artificial intelligence, supply chain management, bibliometric analysis.

1. INTRODUCTION

The advent of Industry 4.0, commonly referred to as the fourth industrial revolution, encompasses a range of concepts and technologies aimed at enhancing the competitiveness of industrial organizations. The focus lies in the realms of interconnection, digitization, and automation (Bag et al., 2021; Chauhan et al., 2022; Ghadge et al., 2020). Within this context, AI can be defined as the field of study and engineering dedicated to intelligent machines, with a specific emphasis on the development of intelligent computer programs (McCarthy et al., 2006). In the realm of AI, a plethora of methodologies and techniques exists. However, for the purpose of this research, we adopt a classification that encompasses five broad categories: (1) techniques involving mathematical optimization, (2) network-based approaches that represent problems as sets of states and transitions, (3) methodologies employing agent-based modeling and interactions within multi-agent

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systems, (4) approaches incorporating automated reasoning based on preexisting knowledge, and (5) machine learning and big data analytics techniques. Leveraging these techniques can yield a multitude of intriguing applications within the field of SCM (Baryannis et al., 2019).

While interest from practitioners and researchers remains high, there is still a need to investigate AI's contribution to the subject of SCM. Several research have emphasized the importance of this requirement (Riahi et al., 2021; Toorajipour et al., 2021). The current study intends to fill this knowledge gap by conducting a literature review and answering the following key research question (RQ): What role does AI play in SCM research? Using bibliometric research, the goal of this study is to identify, present, and analyze essential features connected to the implementation of AI in SCM. The document seeks to accomplish four major goals:

1. To illustrate the evolution of AI scientific production in SCM over time, including the quantity of published documents, research categories, and associated source dynamics.
2. To identify prominent nations and their joint research initiatives in AI in SCM.
3. To identify the most commonly used terms and their relationships with other ideas.
4. To identify the most often utilized AI approach in SCM research.

The study's methodology centered around a comprehensive bibliometric analysis, systematically examining a vast array of literature from the Scopus database to deeply explore and understand the multifaceted role of AI in SCM. A bibliometric analysis was conducted in June 2023. The research sample was established using the Scopus database. From the search topic "supply chain management" a total of 1 076 documents in various languages were identified. Filtered data exported from Scopus were processed using different software solutions, including VOSviewer and Microsoft Excel. Among these, VOSviewer played a crucial role in mapping bibliographic data and identifying prominent concepts and emerging research themes based on average publication year. By accomplishing these goals, this study aims to bridge the research gap by providing a comprehensive understanding of the role of AI in SCM research. The findings will contribute to a deeper understanding of the potential applications, benefits, and challenges associated with the integration of AI in SCM. This knowledge will not only advance academic understanding but also provide practical insights for organizations seeking to harness the power of AI to optimize their supply chain operations.

The structure of this research paper is organized as follows. Section 2 describes the study's chosen research methodology and methodologies, as well as a full explanation of the systematic literature review procedure. Section 3 provides a descriptive and content analysis of the listed studies. Section 4 discusses the research findings. Section 5 outlines the limitations and practical applications. Finally, Section 6 concludes with a quick reflection on the primary contributions of this study.

2. RESEARCH METHODOLOGY AND METHODS

The purpose of this research is to conduct a comprehensive review of AI in the context of SCM. Within the field of SCM, the phrases "artificial intelligence", "machine learning", and "deep learning" were explored to characterize the study subject and set conceptual limits. A complete and representative study sample was constructed using the Scopus database in June 2023, precisely on the topic of "AI in SCM". A further study of similar databases, such as Web of Science, Science Direct, and Emerald, revealed no significant

variations in the resultant research studies. As a result, it was decided that Scopus would be the primary database for analyzing secondary data throughout this research investigation. A query based on title, abstract, and keywords was used to discover and collect relevant papers pertinent to the study subject. To achieve a thorough comprehension of the subject of research, author keywords (AK) and keywords plus (KP) were used. For this study, the search strings included “artificial intelligence” AND “keywords”. The keywords used were “supply chain”, “production”, “marketing” and “logistics”, which were extracted from the comprehensive definition of SCM by (Stock and Boyer, 2009). They supplement the amount of knowledge about a subject by giving an independent expansion of author keywords. Both AK and KP are required for bibliometric analysis since they disclose commonly recurring phrases and concepts, enabling researchers in gaining a more holistic view of existing research efforts across multiple subfields (Zhang et al., 2016; Pech et al., 2022).

Upon conducting the aforementioned search using the designated methodology, a comprehensive collection of scholarly documents emerged, amounting to a total of 1 098 publications written in various languages. Among these publications, the predominant language of dissemination was English, with a substantial count of 1076 documents. The remaining documents were distributed across other languages, including Chinese (12), German (5), Turkish (3), and Spanish (2). To ensure consistency and coherence within the study, a language-based exclusion criterion was meticulously established. Consequently, all non-English written documents were systematically excluded from further analysis and investigation. By applying this criterion, a refined and homogeneous dataset consisting solely of English-written papers was obtained, resulting in a final count of 1076 articles. To ensure a comprehensive overview of the information encompassed within the Scopus database, the exclusive criterion utilized in this study was the language of the documents, specifically English. By adopting this approach, it aimed to gather relevant insights from a diverse range of sources, including researchers, academics, and practitioners. Consequently, all document types were included, encompassing articles, proceedings papers, book chapters, books, and editorial materials. By incorporating these varied document types, the research sought to establish a meaningful starting point and provide a holistic perspective on the subject matter. Additionally, to capture emerging trends and developments, early access publications were also considered in the research sample.

In order to obtain a comprehensive understanding of the concept of AI in SCM, the analysis encompassed all Scopus categories. This wide-ranging approach facilitated the identification of research trends across multiple domains, such as computer science, engineering, business, management, mathematics, social science, and more. In future research, specific elements within these domains with a high frequency of occurrence will be further identified for a more targeted and focused analysis. Following the collection of 1076 English documents, the acquired records were exported in both Excel (.csv format) and Plain Text File (.txt format) for subsequent processing and analysis. This step was taken to facilitate the examination of the data using specialized software tools such as VOSviewer. By leveraging these software tools, the collected data from the Scopus database underwent a comprehensive analysis. This analysis encompassed the identification of various key aspects within the dataset, including the top categories, publication titles, publishers, significant authors, institutions, and countries. Moreover, collaboration networks were examined to assess the extent of collaborative efforts within the researched field. This analysis aimed to shed light on the interconnectedness and collaborative dynamics among researchers and institutions. Additionally, the data analysis

involved the identification of main conceptual clusters and concept maps, allowing for a visual representation of the interrelationships between different concepts and themes present in the dataset. This visualization aided in understanding the prevailing themes and the connections between them, taking into consideration the occurrences, links, and total link strengths. Furthermore, a co-occurrence analysis of all keywords was conducted to explore the thematic evolution within the researched field. This analysis sought to identify the latest developments, emerging trends, and the interconnectedness of different research themes based on the co-occurrence patterns of keywords.

3. RESULTS

This section undertakes a comprehensive examination of the outcomes obtained from querying the Scopus database on the topic of "AI in SCM". The acquired results, spanning the years from 2000 to 2023, were subjected to rigorous analysis utilizing various analytical tools such as VOSviewer and Excel. The subsequent paragraphs present an in-depth and comprehensive exposition of the key findings derived from these analytical processes. Through this analysis, valuable insights and trends within the field of AI in SCM are unveiled, providing a significant contribution to the existing body of knowledge in this domain. Among the 1076 articles that were identified, 407 of them are categorized as conference papers, while 170 are attributed to other forms of publication such as book chapters or books (see Table 1).

Table 1. Categorization of document type

Paper type	Number
Conference paper	499
Article	407
Book chapter	66
Review	60
Conference review	40
Book	13
Others	13

Source: Authors' own processing with data from Scopus.

The cumulated evolution of published documents in the period between 2001 and 2023 is presented in Figure 2. Between the years 2002 and 2007, the publication volume pertaining to the subject of AI in SCM exhibited a relatively modest level, with a gradual upward trend observed, ranging from 5 publications in 2002 to 17 publications in 2007. Subsequently, a noteworthy rise in publication volume occurred from 2008 onwards, indicating an escalating interest in the intersection of AI and SCM. This upward trajectory persisted steadily, punctuated by sporadic spikes in specific years. Notably, between 2008 and 2010, a substantial surge in publication volume was witnessed, culminating in the highest point of 72 publications in 2010. This suggests an increasing recognition and concentrated research focus on the subject during this particular period. Following the peak in 2010, a slight decline in publication volume transpired until 2012, suggesting a potential stabilization or realignment of research endeavors within the field. From 2012 to 2016, the publication volume remained relatively consistent, displaying minor fluctuations but no

significant overall growth or decline. Starting in 2017, another remarkable increase in publication volume emerged, indicative of renewed interest and heightened research activity within the domain. This upward trend persisted through 2022, reaching its zenith with 189 publications in that year, signifying a substantial surge in research output. Examining the most recent data point in 2023, the publication volume slightly decreased compared to 2022; however, it remains substantial, with 103 publications. Collectively, the evaluation of publication volume over the analyzed period reveals a growing research interest and escalating activity in the realm of AI in SCM. Notably, significant growth has been observed in recent years. The expanding volume of publications signifies the presence of a thriving research community dedicated to exploring and advancing the application of AI within the context of SCM.

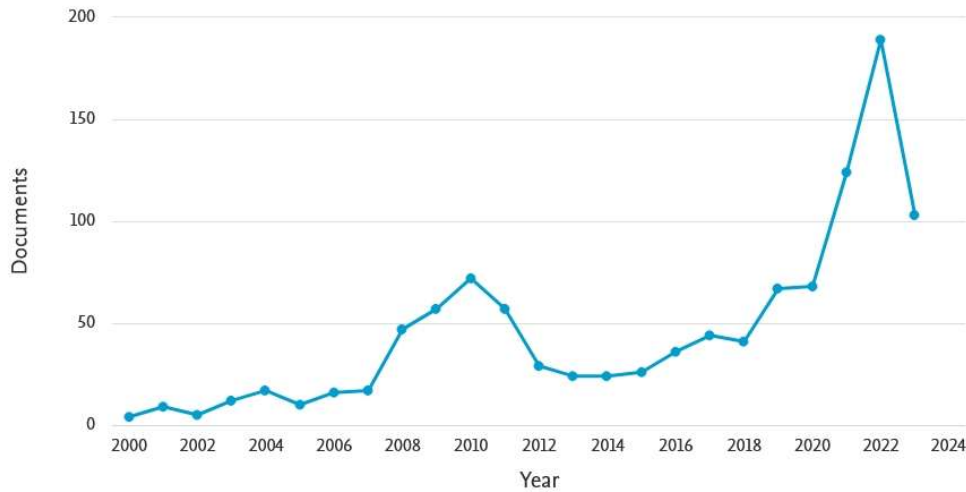


Figure 1. Evolution of publication volume and citation metrics over time

Source: Authors' own processing with data from Scopus.

Figure 2 presents the studies' outcome, which have been categorized by the authors' country. China demonstrates a remarkable leadership position in terms of publication volume throughout the analyzed period, boasting 190 publications. This substantial output signifies a significant research effort and a keen interest in the field of AI in SCM within the academic community in China. Following closely, the United States exhibits a strong research activity with 154 publications, establishing itself as a prominent contributor in this domain. India also emerges as a noteworthy participant in AI in SCM research, with 140 publications, solidifying its position as a valuable contributor to the existing literature. Germany and the United Kingdom exhibit a relatively high publication volume with 82 and 77 publications, respectively, indicating active research engagement and a commitment to advancing knowledge in these countries. Additionally, France, Italy, Australia, Hong Kong, and Canada contribute to the publication volume in AI in SCM, albeit with comparatively smaller numbers than the leading countries.

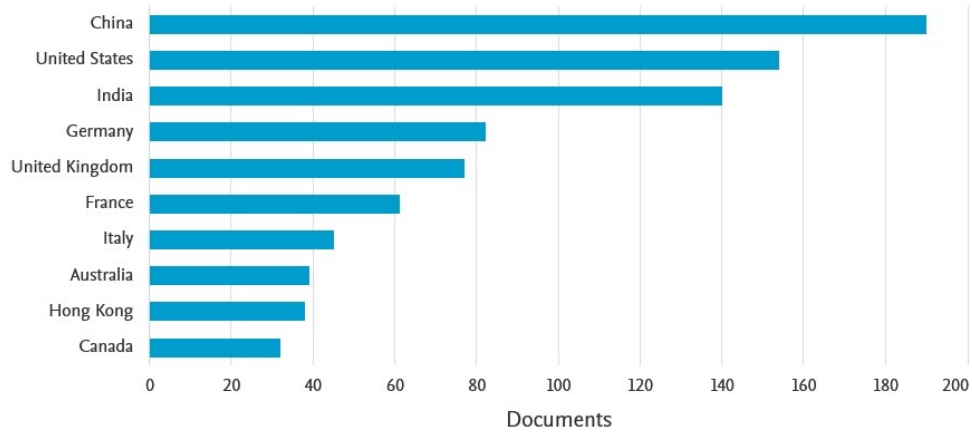


Figure 2. Documents by 10 top country

Source: Authors' own processing with data from Scopus.

For the purpose of co-authorship analysis at the country level, a specific criterion was applied to ensure robustness and meaningful results (Figure 3). Only countries that had a minimum of five documents available in the Scopus database on the researched topic were included in the analysis, irrespective of the number of citations associated with those documents. Following this criterion, a total of 53 countries met the eligibility criteria for inclusion in the study. The collected data, consisting of the co-authorship relationships

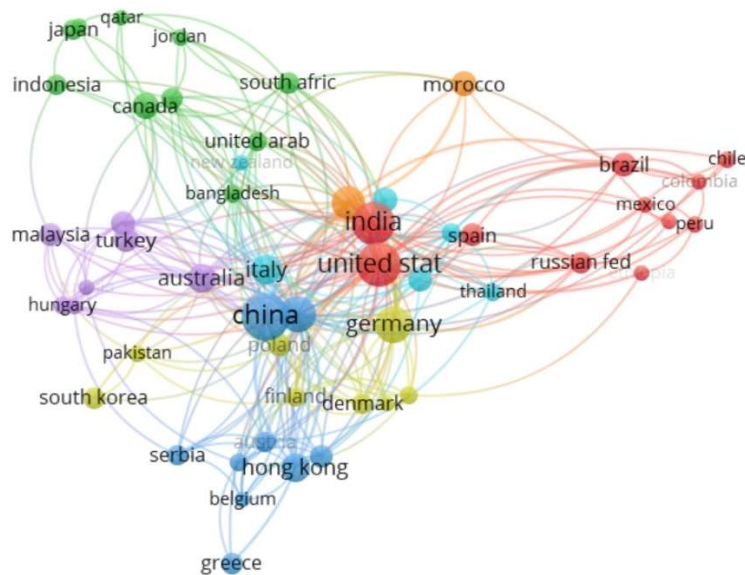


Figure 3. Country as a unit of analysis – Network Visualization

Source: Authors' own processing with VOSviewer.

among these 53 countries, was subjected to further processing using advanced automated clustering algorithms provided by VOSviewer. This enabled the generation of a comprehensive map (Figure 3) that visually represented the interconnections among the countries based on their co-authorship relationships. The generated map provided valuable insights into the research collaboration landscape, revealing key metrics such as the number of organizations involved (53), the number of distinct clusters formed (7), the total number of links (279), and the overall strength of the co-authorship connections (481) between the countries.

In terms of the word cloud based on KP (Figure 4), the most prominent concepts are: chain (433); management (366); supply (330); intelligence (265); systems (238); artificial (219); analysis (135); system (115); optimization (101); data (91); decision (86); models (84); programming (69); planning (65); control (60) etc. These results demonstrate the significance and frequency of these concepts within the analyzed dataset.



Figure 4. Word Cloud based on Keywords Plus (KP)

Source: Authors' own processing with classic.wordclouds.com

Table 2 shows a classification of AI approaches used in SCM. The number of instances of each approach is presented, showing the frequency with which these techniques were used in the study literature under consideration. Machine learning is the most common approach, with 171 instances in the literature. This demonstrates the broad use of machine learning methods and models in SCM research. Machine learning allows for the examination of big datasets in order to extract useful insights and make data-driven

decisions (Lee & Mangalarah, 2022). Another common AI approach in SCM is genetic algorithms, which occur 55 times in the literature. The Genetic technique is a sophisticated optimization technique that is inspired by natural selection and genetics. Fuzzy Logic and Data Mining techniques also demonstrate significant utilization, with 32 and 39 occurrences, respectively. Fuzzy logic is used to deal with imprecise or unclear data (Shore & Venkatachalam, 2003), whereas data mining is the process of discovering meaningful patterns and insights from vast databases (Kusiak & Smith, 2007). Artificial Neural Networks (ANN), a computer model inspired by the neural structure of the human brain, occur in 25 instances. These networks are particularly well-suited to pattern recognition and prediction applications (Silva et al., 2017). With 12 instances, Support Vector Machine (SVM), a supervised learning technique used for classification and regression problems, is significantly less common.

Table 2. Categorization of AI technique

AI technique	Number
Machine learning	171
Genetic algorithm	55
Agent-based systems	45
Data mining	39
Fuzzy logic	32
Artificial neural networks	25
Support vector machine	12

Source: Authors' own processing with data from Scopus

Table 3 summarizes the distribution of publications in several domains linked to the application of AI in SCM. The table provides useful insights into the areas of AI research in SCM that are concentrated, as well as the diverse levels of participation across different disciplines. With a total of 696 publications discovered in the literature study, the discipline of computer science stands out as the most productive. Researchers in this subject are critical to the advancement of AI algorithms, models, and frameworks that may be used to optimize supply chain processes. Their experience substantially helps to the development and implementation of AI-driven SCM systems, enabling improvements in automation, predictive analytics, and optimization. Engineering, with 486 articles, comes in second. Engineers offer their experience to the use of AI techniques in SCM, concentrating on the development and integration of AI-based solutions to optimize supply chain operations. Their contributions vary from boosting logistics and transportation efficiency to inventory management and production planning procedures. The subject of Business, Management, and Accounting also has a significant amount of publications, with a total of 294 articles. This demonstrates the rising acknowledgment of the influence of AI on SCM from a commercial and management perspective. Their research offers light on the managerial consequences and strategic concerns related with the adoption and deployment of AI in SCM. With 179, 99, and 88 articles, the domains of Mathematics, Social Science, Economics, Econometrics, and Finance likewise contribute significant contributions to AI in SCM research. Researchers in these fields contribute to the theoretical underpinnings and quantitative analysis of AI approaches in SCM, allowing for a better understanding of their influence on supply chain dynamics. The relatively modest number of publications in

the domains of Energy and Environmental Science, with 63 papers each, reflects an increasing interest in using AI approaches to optimize energy use, decrease environmental impact, and promote sustainability within supply chain activities. Finally, 31 articles in the Materials Science area highlight possible uses of AI approaches in the management and optimization of materials procurement throughout the supply chain.

Table 3. Categorization of subject area

AI technique	Number
Computer science	696
Engineering	486
Business, Management and Accounting	294
Decision Science	257
Mathematics	179
Social Science	99
Economics, Econometrics and Finance	88
Energy	63
Environmental Science	63
Materials Source	31

Source: Authors' own processing with data from Scopus

4. DISCUSSION

In addressing the main RQ concerning the role of AI in SCM, we now present a clear and comprehensive answer. The application of AI techniques in SCM has yielded valuable insights and advancements in optimizing various aspects of the supply chain. One specific AI technique that has emerged as a valuable optimization tool in SCM is GA have emerged as valuable optimization tools in SCM. They are frequently employed in supply chain network design (Altiparmark, 2009), where they aid in determining the optimal configuration of facilities, distribution centers, and transportation routes (Yeh, Chuang, 2011; Zhou et al., 2002). Additionally, GA is utilized in optimizing inventory management (Hiassat et al., 2017), production scheduling (Naso et al., 2007), and vehicle routing problems (Lau et al., 2009). Leveraging the principles of natural evolution and selection, GA provides an efficient approach for solving complex optimization problems encountered in SCM (Lau et al., 2009). Furthermore, Data Mining techniques play a pivotal role in extracting valuable insights and patterns from extensive datasets, thereby contributing significantly to SCM. Within SCM, Data Mining finds application in various areas, including demand forecasting (Aburto, Weber, 2007), customer segmentation (Tsiptsis, 2011), market basket analysis (Kaur, 2016), and identification of patterns related to product quality and supply chain disruptions. By analyzing historical data, Data Mining enables businesses to identify trends, anomalies, and areas for improvement, facilitating data-driven decision-making and the optimization of supply chain operations (Vercellis, 2011).

Fuzzy Logic techniques are another essential tool applied in SCM to address uncertainties and imprecise data. Fuzzy Logic finds utility in various SCM decision-making processes, such as supplier selection (Ordoobadi, 2009), production planning (Sharma et al., 2022; Min, 2010), and inventory control (Tirkolae, 2021; Jain et al., 2022) quality control (Pournader et al., 2021). By considering the varying degrees of relevance

and importance associated with different factors, Fuzzy Logic enables decision-makers to incorporate imprecise and subjective information, thereby fostering flexible and adaptive decision-making in uncertain environments.

One of the key applications of AI in SCM is through the use of ANN. These networks consist of interconnected nodes, or „neurons”, which process and transmit information. These networks are capable of learning from data, making predictions, and identifying patterns in complex datasets. They are frequently used in demand forecasting models to assess past sales data, market trends, and other relevant aspects, allowing for reliable estimates of future demand. ANN models are also used in inventory management to optimize stock levels and improve order fulfillment operations (Li & Kuo, 2008; Baryannis et al., 2019). Furthermore, ANN is important in predictive maintenance because it can detect trends and abnormalities in equipment performance, allowing for preemptive maintenance activities (Foo et al., 2018; Lim et al., 2022). SVM a powerful machine learning technique, finds extensive application in SCM for classification and regression tasks. SVM finds applications in SCM for demand forecasting (Yue, 2007), quality control (Pallathadka et al., 2023), and supply chain risk analysis (Toorajipour et al., 2021), enabling accurate prediction of future demand, effective detection of defects, and proactive management of supply chain risks.

This study efficiently answered the major RQ about the function of AI in SCM. Significant insights into the contributions and consequences of various AI approaches and their applications in SCM have been achieved via a thorough investigation of their applications. The study's findings show the critical significance that AI techniques such as GA, Data Mining, Fuzzy Logic, ANN, and SVM play in optimizing various areas of the supply chain. These methodologies have found use in fields such as supply chain network design, inventory management, demand forecasting, quality control, and supply chain risk analysis. The study's findings emphasize the need of utilizing AI in SCM to increase operational efficiency and decision-making processes, implying the potential for enhanced supply chain performance.

5. LIMITATIONS AND IMPLICATIONS

As with any research endeavor, this study has inherent limitations. The literature review conducted in this research focused exclusively on the Scopus database. While Scopus is widely recognized and comprehensive, limiting the search to a single database may have influenced the scope and comprehensiveness of the findings. To ensure a more comprehensive understanding of the contribution of AI to SCM studies, it is recommended to compare the results obtained from Scopus with other relevant databases. The primary goal of this study was to encompass a broad body of knowledge on the topic. Consequently, it was not feasible to delve into the specifics of each individual study identified in the literature review. Therefore, a more focused and in-depth evaluation of specific AI techniques or aspects is highly recommended to gain a more nuanced understanding of their contributions to SCM studies.

It is important to acknowledge that the breadth of the subject matter may have resulted in a trade-off between breadth and depth in this study. Consequently, certain nuances and intricacies of individual studies may not have been fully explored. Future research efforts could benefit from narrowing the focus to specific AI techniques or subfields within the broader field of interest. This approach would allow for a more comprehensive examination and analysis of the selected areas. Moreover, the limitations of this study extend to the

availability and accessibility of published literature. Despite employing comprehensive search strategies within the Scopus database, it is possible that relevant studies from other databases or sources may have been inadvertently excluded. To address this limitation, researchers are encouraged to expand their search to additional databases and sources to ensure a more comprehensive coverage of the existing literature.

To overcome these limitations, it is recommended that researchers undertake more targeted and specialized investigations concentrating on specific AI techniques or subdomains within the broader field of interest. This approach would enable a more detailed and comprehensive evaluation of the literature, leading to a deeper understanding of the contributions of AI to SCM studies. Furthermore, it would facilitate comparisons across different databases, enhancing the overall understanding of the topic.

The literature review on the contribution of AI to SCM reveals a managerial implication that centers around recognizing the potential advantages and opportunities associated with incorporating AI into SCM practices. The review underscores the diverse applications of AI techniques, including ANN, Fuzzy Logic, GA, Data Mining, and SVM, in enhancing decision-making, optimizing operations, and overall improving supply chain performance. Understanding the contributions of AI to SCM empowers managers to identify specific areas within their supply chain where AI techniques can be effectively utilized. This knowledge facilitates informed decision-making regarding the adoption and implementation of AI technologies. For instance, AI can be leveraged in demand forecasting models, inventory management systems, predictive maintenance strategies, and supply chain risk analysis, among other areas. Managers can evaluate their unique supply chain needs and identify the AI techniques that align with their organizational objectives and challenges.

Furthermore, the literature review provides valuable insights into the potential challenges and limitations associated with the adoption and implementation of AI in SCM. Managers can capitalize on this understanding to proactively address these challenges and develop strategies to mitigate potential risks. For example, investments can be made in data quality and availability to ensure accurate AI predictions and analyses. Additionally, managerial focus can be directed toward building the necessary technological infrastructure and cultivating the required capabilities within the workforce to effectively harness AI tools. Additionally, the review emphasizes the significance of a focused and targeted approach when integrating AI into SCM practices. Managers can employ insights from the literature review to identify specific AI techniques or subfields that align with their organization's distinct supply chain requirements. This approach enables a more efficient and effective implementation of AI technologies, ensuring appropriate allocation of resources and yielding tangible benefits.

6. CONCLUSIONS

This research presents a comprehensive examination of the role of AI in SCM through a bibliometric analysis. By conducting a literature review and analyzing research trends, this study has revealed valuable insights and implications. The analysis of publication volume over time has revealed a substantial increase in research interest and activity at the intersection of AI and SCM, particularly in recent years. This growth signifies the growing recognition of the potential benefits and applications of AI in SCM practices. Furthermore, the evaluation of publication volume by country has underscored the global interest in this field, with China, the United States, and India emerging as significant contributors to the

scholarly literature. The categorization of AI techniques used in SCM has shed light on the diverse array of approaches employed in research. ANN, Fuzzy Logic, GA, Data Mining, and SVM have been identified as key techniques that contribute to enhancing decision-making, optimizing operations, and improving overall supply chain performance. Each technique offers specific benefits and finds applications within SCM, spanning from demand forecasting to inventory management and supply chain risk analysis.

For future study, a more in-depth look into certain AI approaches inside SCM is recommended, with an emphasis on their unique contributions in various supply chain scenarios. To increase the research's comprehensiveness, future studies could utilize a larger range of academic databases in addition to Scopus. The inclusion of case studies or primary research with firms actively applying AI in SCM might provide useful insights. Furthermore, researching new AI approaches and their scalability in the changing environment of SCM will be beneficial. This methodology would allow for a more comprehensive view of AI's role and potential in current supply chain procedures.

The research acknowledges its limitations. The literature review focused exclusively on the Scopus database, and it is recommended to expand the coverage to include other databases for a more comprehensive understanding of the topic. Additionally, the broad scope of the subject matter limited the depth of analysis for individual studies, highlighting the need for more focused and specialized investigations into specific techniques or subfields within AI and SCM. The research findings yield managerial implications, emphasizing the recognition of the potential benefits of AI and the importance of a targeted approach. Managers can leverage the insights gained from this research to identify suitable AI techniques for their supply chain, address challenges, and make informed decisions regarding the adoption and implementation of AI technologies. Proactive measures, such as investing in data quality and building the necessary technological infrastructure, can enable organizations to maximize the benefits of AI in SCM.

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REFERENCES

- Aamer, A., Eka Yani, L., Alan Priyatna, I. (2020). *Data analytics in the supply chain management: Review of machine learning applications in demand forecasting*. *Operations and Supply Chain Management: An "International Journal"*, 14(1). DOI: 10.31387/oscm0440281.
- Aburto, L., Weber, R. (2007). *Improved supply chain management based on hybrid demand forecasts*. *Applied Soft Computing*, 7(1). DOI: 10.1016/j.asoc.2005.06.001.
- Altıparmak, F., Gen, M., Lin, L., Karaoglan, I. (2009). *A steady-state genetic algorithm for multi-product supply chain network design*. *Computers & industrial engineering*, 56(2). DOI: 10.1016/j.cie.2007.05.012.
- Aria, M., Cuccurullo, C. (2017). *Bibliometrix: An R-tool for comprehensive science mapping analysis*. *Journal of Informetrics*, 11(4). DOI: 10.1016/j.joi.2017.08.007.
- Bag, S., Pretorius, J.H.C., Gupta, S., Dwivedi, Y.K. (2021). *Role of institutional pressures and resources in the adoption of big data analytics powered artificial intelligence, sustainable manufacturing practices and circular economy capabilities*. *Technological Forecasting and Social Change*, 163. DOI: 10.1016/j.techfore.2020.120420.

- Baryannis, G., Papadopoulos, T., Manthou, V. (2019). *Artificial neural networks in supply chain management: A comprehensive review*. "Applied Sciences", 9(10). DOI: 10.3390/app9102149.
- Baryannis, G., Validi, S., Dani, S., Antoniou, G. (2019). *Supply chain risk management and artificial intelligence: state of the art and future research directions*. "International Journal of Production Research", 57(7). DOI: 10.1080/00207543.2018.1530476.
- Belhadi, A., Mani, V., Kamble, S.S., Khan, S.A.R., Verma, S. (2021). *Artificial intelligence-driven innovation for enhancing supply chain resilience and performance under the effect of supply chain dynamism: an empirical investigation*. "Annals of Operations Research". DOI: 10.1007/s10479-021-03956-x.
- Benzidia, S., Makaoui, N., Bentahar, O. (2021). *The impact of big data analytics and artificial intelligence on green supply chain process integration and hospital environmental performance*. "Technological forecasting and social change", 165. DOI: 10.1016/j.techfore.2020.120557.
- Chauhan, S., Singh, R., Gehlot, A., Akram, S.V., Twala, B., Priyadarshi, N. (2022). *Digitalization of Supply Chain Management with Industry 4.0 Enabling Technologies: A Sustainable Perspective*. "Processes", 11(1). DOI: 10.3390/pr11010096.
- Di Vaio, A., Boccia, F., Landriani, L., Palladino, R. (2020). *Artificial intelligence in the agri-food system: Rethinking sustainable business models in the COVID-19 scenario*. "Sustainability", 12(12). DOI: 10.3390/su12124851.
- Dubey, R., Bryde, D.J., Blome, C., Roubaud, D., Giannakis, M. (2021). *Facilitating artificial intelligence powered supply chain analytics through alliance management during the pandemic crises in the B2B context*. "Industrial Marketing Management", 96. DOI: 10.1016/j.indmarman.2021.05.003.
- Foo, P.Y., Lee, V.H., Tan, G.W.H., Ooi, K.B. (2018). *A gateway to realising sustainability performance via green supply chain management practices: A PLS-ANN approach*. "Expert Systems with Applications", 107. DOI: 10.1016/j.eswa.2018.04.013.
- Ghadge, A., Er Kara, M., Moradlou, H., Goswami, M. (2020). *The impact of Industry 4.0 implementation on supply chains*. "Journal of Manufacturing Technology Management", 31(4). DOI: 10.1108/jmtm-10-2019-0368.
- Grover, P., Kar, A.K., Dwivedi, Y.K. (2022). *Understanding artificial intelligence adoption in operations management: insights from the review of academic literature and social media discussions*. "Annals of Operations Research", 308(1–2). DOI: 10.1007/s10479-020-03683-9.
- Hiassat, A., Diabat, A., Rahwan, I. (2017). *A genetic algorithm approach for location-inventory-routing problem with perishable products*. "Journal of manufacturing systems", 42. DOI: 10.1016/j.jmsy.2016.10.004.
- Jain, M., Sharma, D.K., Sharma, N. (2022). *Artificial Intelligence Computing and Nature-Inspired Optimization Techniques for Effective Supply Chain Management* [In:] Data Analytics and Artificial Intelligence for Inventory and Supply Chain Management (pp. 63–80). Singapore: Springer Nature Singapore. DOI: 10.1007/978-981-19-6337-7_4.
- Kaur, M., Kang, S. (2016). *Market Basket Analysis: Identify the changing trends of market data using association rule mining*. "Procedia computer science", 85. DOI: 10.1016/j.procs.2016.05.180.
- Kusiak, A., Smith, M. (2007). *Data mining in design of products and production systems*. "Annual Reviews in Control", 31(1). DOI: 10.1016/j.arcontrol.2007.03.003.

- Lau, H.C., Chan, T.M., Tsui, W.T., Pang, W.K. (2009). *Application of genetic algorithms to solve the multidepot vehicle routing problem*. "IEEE transactions on automation science and engineering", 7(2). DOI: 10.1109/tase.2009.2019265.
- Lee, I., Mangalaraj, G. (2022). *Big data analytics in supply chain management: A systematic literature review and research directions*. "Big data and cognitive computing", 6(1). DOI: 10.3390/bdcc6010017.
- Li, S.G., Kuo, X. (2008). *The inventory management system for automobile spare parts in a central warehouse*. "Expert Systems with Applications", 34(2). DOI: 10.1016/j.eswa.2006.12.003.
- Lim, A.F., Lee, V.H., Foo, P.Y., Ooi, K.B., Wei-Han Tan, G. (2022). *Unfolding the impact of supply chain quality management practices on sustainability performance: an artificial neural network approach*. "Supply Chain Management: An International Journal", 27(5). DOI: 10.1108/scm-03-2021-0129.
- McCarthy, J., Minsky, M.L., Rochester, N., Shannon, C.E. (2006). *A proposal for the dartmouth summer research project on artificial intelligence*, august 31, 1955. "AI magazine", 27(4). DOI: 10.1609/aimag.v33i2.2417.
- Min, H. (2010). *Artificial intelligence in supply chain management: theory and applications*. "International Journal of Logistics: Research and Applications", 13(1). DOI: 10.1080/13675560902736537.
- Naso, D., Surico, M., Turchiano, B., Kaymak, U. (2007). *Genetic algorithms for supply-chain scheduling: A case study in the distribution of ready-mixed concrete*. "European Journal of Operational Research", 177(3). DOI: 10.1016/j.ejor.2005.12.019.
- Ordoobadi, S.M. (2009). *Development of a supplier selection model using fuzzy logic*. "Supply chain management: An international journal", 14(4).
- Pech, G., Delgado, C., Sorella, S.P. (2022). *Classifying papers into subfields using Abstracts, Titles, Keywords and KeyWords Plus through pattern detection and optimization procedures: An application in Physics*. "Journal of the Association for Information Science and Technology", 73(11). DOI: 10.1002/asi.24655.
- Pournader, M., Ghaderi, H., Hassanzadegan, A., Fahimnia, B. (2021). *Artificial intelligence applications in supply chain management*. "International Journal of Production Economics", 241. DOI: 10.1016/j.ijpe.2021.108250.
- Rajput, S., Singh, S.P. (2019). *Connecting circular economy and industry 4.0*. "International Journal of Information Management", 49. DOI: 10.1108/13598540910970144.
- Riahi, Y., Saikouk, T., Gunasekaran, A., Badraoui, I. (2021). *Artificial intelligence applications in supply chain: A descriptive bibliometric analysis and future research directions*. "Expert Systems with Applications", 173. DOI: 10.1016/j.eswa.2021.114702.
- Rodríguez-Espíndola, O., Chowdhury, S., Beltagui, A., Albores, P. (2020). *The potential of emergent disruptive technologies for humanitarian supply chains: The integration of blockchain, artificial intelligence and 3D printing*. "International Journal of Production Research", 58(15). DOI: 10.1080/00207543.2020.1761565.
- Rosendorff, A., Hodes, A., Fabian, B. (2021). *Artificial intelligence for last-mile logistics-Procedures and architecture*. "The Online Journal of Applied Knowledge Management (OJAKM)", 9(1). DOI: 10.36965/ojakm.2021.9(1)46-61.
- Sharma, R., Shishodia, A., Gunasekaran, A., Min, H., Munim, Z. H. (2022). *The role of artificial intelligence in supply chain management: mapping the territory*. "International Journal of Production Research", 60(24). DOI: 10.1080/00207543.2022.2029611.

- Shore, B., Venkatachalam, A.R. (2003). *Evaluating the information sharing capabilities of supply chain partners: A fuzzy logic model*. "International Journal of Physical Distribution & Logistics Management", 33(9). DOI: 10.1108/09600030310503343.
- Silva, N., Ferreira, L.M.D., Silva, C., Magalhães, V., Neto, P. (2017). *Improving supply chain visibility with artificial neural networks*. "Procedia Manufacturing", 11. DOI: 10.1016/j.promfg.2017.07.329.
- Stock, J.R., Boyer, S.L. (2009). *Developing a consensus definition of supply chain management: a qualitative study*. „International Journal of Physical Distribution & Logistics Management”, 39(8). DOI: 10.1108/09600030910996323.
- Tirkolaee, E.B., Sadeghi, S., Mooseloo, F.M., Vandchali, H.R., Aeini, S. (2021). *Application of machine learning in supply chain management: a comprehensive overview of the main areas*. "Mathematical problems in engineering". DOI: 10.1155/2021/1476043.
- Toorajipour, R., Sohrabpour, V., Nazarpour, A., Oghazi, P., Fischl, M. (2021). *Artificial intelligence in supply chain management: A systematic literature review*. "Journal of Business Research", 122. DOI: 10.1016/j.jbusres.2020.09.009.
- Tsiptsis, K.K., Chorianopoulos, A. (2011). *Data mining techniques in CRM: inside customer segmentation*. John Wiley & Sons. DOI: 10.1002/9780470685815.
- Vercellis, C. (2011). *Business intelligence: data mining and optimization for decision making*. John Wiley & Sons. DOI: 10.1002/9780470753866.
- Yeh, W.C., Chuang, M.C. (2011). *Using multi-objective genetic algorithm for partner selection in green supply chain problems*. "Expert Systems with applications", 38(4). DOI: 10.1016/j.eswa.2010.09.091
- Yue, L., Yafeng, Y., Junjun, G., Chongli, T. (2007, August). *Demand forecasting by using support vector machine*. In Third International Conference on Natural Computation (ICNC 2007) (Vol. 3). IEEE. DOI: 10.1109/icnc.2007.324.
- Zhang, J., Yu, Q., Zheng, F., Long, C., Lu, Z., Duan, Z., 2016. *Comparing keywords plus of WOS and author keywords: A case study of patient adherence research: Comparing Keywords Plus of WOS and Author Keywords*. "Journal of the Association for Information Science and Technology", 67(4). DOI: 10.1002/asi.23437.
- Zhou, G., Min, H., Gen, M. (2002). *The balanced allocation of customers to multiple distribution centers in the supply chain network: a genetic algorithm approach*. "Computers & Industrial Engineering", 43(1–2). DOI: 10.1016/s0360-8352(02)00067-0.

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ANALYSIS OF THE FUNCTIONS OF PROJECT MANAGEMENT INFORMATION SYSTEMS – TRADITIONAL APPROACH

Project management information systems in enterprises help managers to manage, improve and track the progress in the implementation of projects from their conception to the achievement of results. The article reviews the literature and presents the most commonly used applications for storing, organizing and controlling project information in accordance with the traditional approach to project management. The authors analyzed the possibility of implementing the processes and achieving the results defined for them, presented in the Project Management Body of Knowledge, by means of five selected project management information systems. On the basis of the obtained results of research conducted on a group of Project Managers, conclusions were formulated, also indicating directions for further research.

Keywords: Project Management Information Systems, Project Management, traditional approach, analysis of the functions.

1. INTRODUCTION

Project management is a complex process involving activities in the field of planning, implementation, monitoring and control of implemented projects, characterized by a unique, one-off and complex set of activities with a clearly defined goal and time frame (PMI, 2017). To be successful, enterprises must deliver products, services or solutions on time, within budget, meeting established specifications while managing project risks (Raymond, Bergeron, 2008). Project management, which has long been considered an important feature of successful companies (Peters, Waterman, 1984), thanks to the use of Project Management Information Systems (PMIS), can increase the success of the project by up to 75% (Light, Rosser, Hayward, 2005). The use of PMIS, although not sufficient to ensure success, has therefore become a necessity. Project Management Information

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Systems is more than ever necessary for the efficient and effective management of projects and supporting Project Managers in making decisions (Raymond, Bergeron, 2008).

Research so far of Project Management Information Systems in a traditional approach assessed and compared tools that, according to the Project Management Software ranking, are not among the most popular solutions (Capterra). The authors analyzed, for example: Microsoft Project Server, SAP Project System, Planisware, GanttProject, ProjectLibre, Basecamp and P2ware Project Manager (Berzisa, 2009; Handzel, Terlikowska, 2016; Przewoźnik, Strojny, 2018; Kosieradzki, 2014; Bitkowska, Waszkiewicz, Cimoch, 2022; Micale, La Fata, Lombardo, La Scalia, 2021). While on choice of IT software to support project management is most influenced by mobility, i.e. the possibility of smooth use of the tool on various devices (Przewoźnik, Strojny, 2018), i.e. a feature that characterizes the most popular solutions available on the market.

The aim of the article is to analyze the possibility of implementing processes and achieving the results defined for them presented in the Project Management Body of Knowledge (PMBoK) by five selected Project Management Information Systems.

2. TRADITIONAL PROJECT MANAGEMENT IN LITERATURE

Rapidly changing market conditions, new technologies, short product life cycles and many other social and business factors affect the way projects are managed in organizations. Different types of projects require different procedural models for successful implementation. Models organize and normalize the methods and tools used in the various phases of project implementation (Thesing, Feldmann, Burchardt, 2021). For example, R.K. Wysocki distinguishes methods that follow the traditional project management model (Traditional Project Management – TPM) and the agile model (Agile), based on an iterative process (Wysocki, Witkowska, 2013).

TPM is a universal practice that includes a set of techniques and tools used to initiate, plan, monitor and control ongoing projects in order to achieve the desired result relatively clearly defined by the client at the beginning of the project (Trocki, Wyrozębski, 2015). Traditional project management is mainly used for projects where activities are performed sequentially and there are rarely any changes. In order for the project to be implemented in a goal-oriented and time-bound manner, it is planned comprehensively from start to finish by defining a hierarchical structure of tasks over time. Execution of the plan as precisely as possible increases the likelihood of success (Thesing, Feldmann, Burchardt, 2021).

The concept of traditional project management is based on a predictable project implementation scheme. Each project has the same life cycle, regardless of the specification and type of work carried out, which is a set of five stages overlapping with varying intensity: starting, planning, implementation, monitoring, closing (Figure 1) (Kapustka, 2013).

In the professional project management environment, among the methodological standards, for many years the study *A Guide to the Project Management Body of Knowledge (PMBoK Guide)* by the international association Project Management Institute (PMI) has been in the foreground. The PMBoK Guide is a set of structured and comprehensive guidelines, widely recognized as an important compendium of knowledge in the field of Project Management (Fridgeirsson, Ingason, Jonasson, Jonsdottir, 2021). From the first edition from 1986 to the seventh from 2021, it is the most recognizable and widespread set of best practices grouped into 49 processes, accompanied by an appropriate set of information, initiation documents, helpful techniques and process results

(Brzozowski, 2020). The processes in the PMBoK Guide are grouped in a two-dimensional system. In the first dimension, ten areas of knowledge were indicated: Project Integration Management, Project Scope Management, Project Schedule Management, Project Cost Management, Project Quality Management, Project Resource Management, Project Communications Management, Project Risk Management, Project Procurement Management, Project Stakeholder Engagement in the Project (Table 1). In the second dimension of process grouping, the idea of a five-stage project life cycle was used (PMI, 2017).

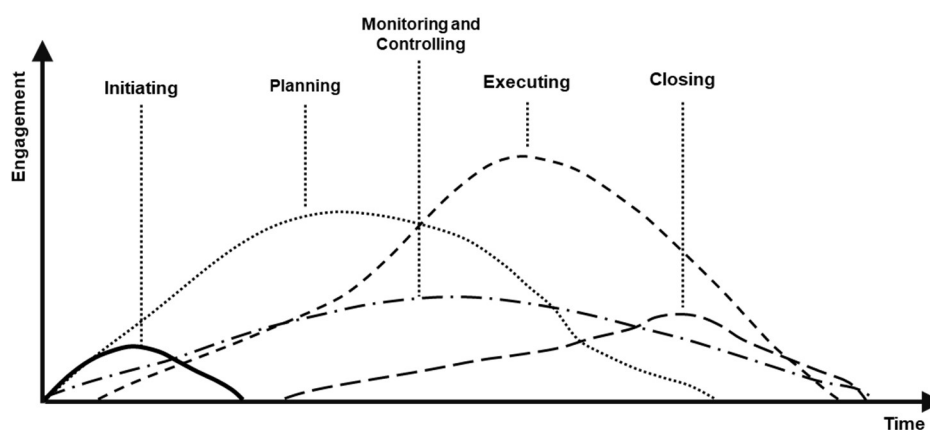


Figure 1. Project life cycle

Source: (Kapustka, 2013).

Table 1. Knowledge areas according to the PMBoK Guide

Knowledge areas	Description
1. Project Integration Management	Processes and activities related to identifying, defining, coordinating and connecting various processes and activities. In the context of a project request, integration exhibits the characteristics of unification, communication, consolidation and interdependence. These activities should be carried out from the start of the project to the end of the project. Project Integration Management includes 7 groups of processes: Develop Project Charter, Develop Project Management Plan, Direct and Manage Project Work, Manage Project Knowledge, Monitor and Control Project Work, Perform Integrated Change Control, Close Project or Phase.
2. Project Scope Management	The processes required to ensure that the project has all the necessary work to successfully complete it. Scope management focuses on defining, monitoring and controlling what is and is not included in the project. The processes of this knowledge area are Plan Scope Management, Collect Requirements, Define Scope, Create WBS, Validate Scope, Control Scope.
3. Project Schedule Management	Processes required to complete the project on time. Project Schedule Management includes Plan Schedule Management, Define Activities, Sequence Activities, Estimate Activity Durations, Develop Schedule, Control Schedule.

Table 1 (cont.). Knowledge areas according to the PMBoK Guide

Knowledge areas	Description
4. Project Cost Management	Processes involving estimating, planning, budgeting, financing, managing and controlling incurred costs. The area covers the process of Plan Cost Management, Estimate Costs, Determine Budget, Control Costs.
5. Project Quality Management	The processes of applying the organizational quality policy in planning, implementing, monitoring and controlling the quality requirements of the project and product in order to achieve the objectives of the stakeholders. Activities in the field of Plan Quality Management, Manage Quality and Control Quality are implemented in this area.
6. Project Resource Management	The processes of identifying, acquiring and managing the resources necessary for the successful implementation of the project. These processes ensure that the project manager and project team have the right resources available at the right place and time. Project Resource Management processes are Plan Resource Management, Estimate Activity Resources, Acquire Resources, Develop Team, Manage Team, Control Resources.
7. Project Communications Management	Processes to meet the information needs of the project and its stakeholders by creating artifacts and carrying out activities designed to achieve an efficient flow of information. Project Communication Management consists of the process of Plan Communications Management, Manage Communications and Monitor Communications.
8. Project Risk Management	Processes involving risk management planning, identification, analysis, response planning, project risk monitoring and implementation of responses to identified opportunities and threats. The goal of project risk management is to minimize the impact of factors having a negative impact on the project in order to increase the chances of project success. The area includes Plan Risk Management, Identify Risks, Perform Qualitative Risk Analysis, Perform Quantitative Risk Analysis, Plan Risk Responses, Implement Risk Responses, Monitor Risks.
9. Project Procurement Management	The processes necessary to properly execute the purchases or acquisition of products, services, or deliverables that need to be sourced from outside the organization. The area also includes the management and control processes required to develop and administer contracts, which can be implemented by authorized members of the project team, management or purchasing department. Project Order Management processes include Plan Procurement Management, Conduct Procurements, Control Procurements.
10. Project Stakeholder Engagement	The processes necessary to identify individuals, groups or organizations that may affect or be affected by the project, to analyze their impact and expectations, and to develop appropriate strategies for effective stakeholder engagement in project and implementation decisions. The processes of Stakeholder Engagement Management in the Project are Identifying Stakeholders, Plan Stakeholder Engagement, Manage Stakeholder Engagement, Monitor Stakeholder Engagement.

Source: (PMI, 2017; Fridgeirsson, Ingason, Jonasson, Jonsdottir, 2021; Imran, Soomro, 2022).

3. REVIEW OF PROJECT MANAGEMENT INFORMATION SYSTEMS

Project Management Information Systems consist of tools and techniques used by Project Managers and members of project teams to create, collect, merge and transfer the

results of project management processes. They are used to support all aspects of implemented projects from the beginning to their completion. PMIS is one of the environmental factors of the conducted activity and enables access to automated tools such as software supporting scheduling, communication, collection and distribution of information used as part of the project management and management process (PMI, 2017).

The PMIS industry is now dominated by leading software vendors such as Microsoft, Oracle and Metier Management Systems (formerly Lockheed) and a number of small independent companies. IT tools provided by these entities are evolving towards more integrated project lifecycle management, their wider use in organizations or cloud computing (Braglia, Frosolini, 2014).

The authors analyzed 5 tools that meet all 18 characteristics of PMIS: Traditional Methodologies; Time & Expense Tracking; Task Management; Resource Management; Reporting/Project Tracking; Project Planning/Scheduling; Prioritization; Milestone Tracking; Kanban Board; Issue Management; Idea Management; Gantt/Timeline View; Customizable Templates; Cost-To-Completion Tracking; Collaboration Tools; Client Portal; Billing & Invoicing and Agile Methodologies (Captterra).

3.1. Trello – an example of a tool based on a Kanban board

An online collaboration, project management and task organization tool available in four editions: Free, Standard, Premium and Enterprise. Premium and Enterprise editions offer users an extended set of features. Trello is an intuitive application that allows you to complete any type of project and task. Teams using Trello can easily organize their work and deliver projects from initiation to completion by creating and managing kanban boards, managing deadlines, attaching files, creating checklists, and more. With over 100 integrations with other key tools such as Google Drive, Slack, Jira, and more, Trello is an organization's design hub for cross-team collaboration (Trello).

3.2. ClickUp – an advanced system to project management

A comprehensive platform that allows users to use a wide range of features to help and support them in project management. ClickUp is the hub where teams come together to plan, organize and collaborate on tasks using features like Tasks, Docs, Chat, Goals and Whiteboards. The platform also enables integration with over 1,000 other applications, enabling teams of all types and sizes to perform their tasks more efficiently, replacing inflexible and overlapping tools. ClickUp is available in five editions Free, Unlimited, Business, Business Plus and Enterprise (ClickUp).

3.3. Monday.com – system for IT management, including project management

Customizable, web-based and mobile cloud-based work management platform. Designed to help teams and organizations increase operational efficiency by tracking projects, tasks and workflows, data visualization and team collaboration. It includes automation, centralization and real-time integration with other applications used in the implementation of projects. Monday.com adapts to the way you work, allowing for more efficient and effective management and tracking of work progress, helping you organize projects and follow the plan. The platform is available in one of five versions: Individual, Basic, Standard, Pro and Enterprise (Monday.com).

3.4. Smartsheet – modern work management solutions

An online platform that allows project teams to plan, track, automate and report on their work. Smartsheet is used for collaboration, project management, scheduling, assigning tasks and tracking progress in ongoing projects, sharing documents, managing calendars and work using a tabular layout. The tool is distinguished by an easy-to-use interface, functional dashboards and work automation functions. Smartsheet can import data from Microsoft Office or Google applications and integrate with other tools. The platform is available in three variants: Pro, Business or Enterprise on a subscription basis with no free tiers (Smartsheet).

3.5. Wrike – a comprehensive project management tool

Project management software that gives teams the ability to manage and track work progress. It enables users to collaborate with each other, streamlining the flow of information, allowing companies to focus on their core tasks. Wrike allows you to divide projects into management stages, assign tasks to individual team members, visualize the progress of their implementation using Gantt charts and Kanban boards, allocate resources and forecast their use. Automation and artificial intelligence features eliminate time-consuming administrative tasks, streamlining the work of project teams. Wrike comes in five editions: Free, Team, Business, Enterprise and Pinnacle (Wrike).

4. METHODOLOGICAL ASSUMPTIONS OF THE RESEARCH

The aim of the article is to analyze the possibility of implementing the processes defined by the Project Management Institute and achieving the results specified for them by five selected IT tools supporting project management. It is a response to the identified practical problem related to the methodical implementation of modern projects with the support of popular systems. At the same time, the article is an attempt to fill the theoretical and empirical gap in the field of management and quality sciences, which lacks positions developing the PMIS issue. This justifies undertaking empirical research and answering: To what extent do popular and commonly used tools supporting project management allow achieving the results defined for individual 49 processes specified in the PMBoK Guide?

The authors, based on the identification and analysis of 49 processes proposed by the Project Management Institute, listed 24 factors that are a direct effect of the implementation of processes grouped within 10 areas of knowledge indicated in the PMBoK Guide.

The study was conducted in February 2023 by a group of 10 certified project management practitioners working in the field of IT, marketing and economic consulting. Participants expressed their willingness and consent to take part in the study, during which they became acquainted with the functions offered by Trello, ClickUp, Monday.com, Smartsheet and Wrike and assessed the possibility of implementing processes and achieving the results defined for them on a five-point scale. Evaluation structure:

- Value 1 – The indicated result cannot be achieved.
- Value 2 – Achieving the result possible to a limited extent through integration with other systems and tools.
- Value 3 – No integration possible.
- Value 4 – Achieving the result possible to the full extent through integration with other systems and tools.
- Value 5 – Full ability to achieve the indicated result by using the offered functions.

5. RESEARCH RESULTS

On the basis of a study conducted on a group of certified project management experts, using an online Microsoft Forms form, a list was prepared presenting a list of factors assessed from the perspective of the possibility of their achievement and the results in the form of an arithmetic mean. The values obtained are shown in Table 2 as integers.

Table 2. Test results

No.	Factor	Trello	ClickUp	Monday.com	Smartsheet	Wrike
1	1.1. Project Charter	2	4	2	2	2
	1.2. Issue Log	2	4	2	2	2
	1.3. Final Report	2	4	2	4	2
2	2.1. Requirements Documentation	2	4	2	2	2
	2.2. Project Scope Statement	2	4	2	2	2
	2.3. Scope Baseline	4	2	5	5	2
3	3.1. Activity List	5	5	5	5	5
	3.2. Milestone Lis	3	3	3	2	1
	3.3. Project Schedule Network Diagram	1	1	4	1	1
	3.4. Schedule Baseline	2	2	5	4	4
	3.5. Project Schedule	4	5	5	5	5
4	4.1. Cost Baseline	1	1	1	5	1
5	5.1. Quality Metrics	2	4	2	2	2
	5.2. Quality Report	2	4	2	2	2
	5.3. Quality Control Measurements	2	4	2	2	2
6	6.1. Team Charter	2	2	2	3	1
	6.2. Resource Breakdown Structure	1	1	1	1	1
	6.3. Assignment of Physical Resources	1	1	1	1	1
	6.4. Design Team Assignment	5	5	5	5	5
	6.5. Resource Calendar	1	2	1	1	1
7	7.1. Communication in the Project	4	4	4	1	1
8	8.1. Risk Register	2	4	2	5	2
9	9.1. Bid Documents	1	1	5	1	1
10	10.1. Stakeholder Register	2	4	2	5	2
Summary		55	75	67	68	50

Source: own study.

The conducted research indicates the partial possibility of implementing the processes and the results defined for them presented in the Project Management Body of Knowledge by five selected IT tools supporting project management. Trello, ClickUp, Monday.com,

Smartsheet and Wrike allow the greatest extent to carry out activities in the area of project scope and schedule management, i.e. processes carried out at the stage of project initiation and planning. IT systems also allow for the assignment of a project team to individual tasks, without allowing them to manage material and financial resources.

According to experts, the IT tool supporting the implementation of projects, which to the greatest extent allows the achievement of results defined for individual project management processes, is ClickUp. The tool, thanks to numerous integrations, allows to a large extent to implement the project based on the traditional project management model. The remaining systems subject to the study, to a much lesser extent, allow their practical use in the implementation of projects assuming the fulfillment of assumptions regarding the full use of 10 areas of knowledge indicated in the standard developed and published by the Project Management Institute.

6. SUMMARY

The article is a verification of the possibility of using selected tools to implement the project in accordance with the traditional project management model. The study was a pilot study, which was carried out in a small group of experts. Further, extended analyzes of IT tools are necessary, taking into account systems dedicated to the classical approach and quantitative empirical research, which will illustrate the selection of tools used by project organizations to manage integration, scope, schedule, costs, quality, resources, communication, risk, procurement and involvement of stakeholders in the project. In addition, in further research, selected tools supporting project management should be compared to the ClickUp system, in terms of the functions offered.

REFERENCES

- Berzisa, S. (2009). *The Baseline Configuration of Project Management Information System*. "Rigas Tehniskas Universitates Zinatniskie Raksti", 40.
- Bitkowska, A., Waszkiewicz, M., Cimoch, I. (2022). *Contemporary IT tools supporting project and process management*.
- Braglia, M., & Frosolini, M. (2014). *An integrated approach to implement project management information systems within the extended enterprise*. "International Journal of Project Management", 32(1).
- Brzozowski, M. (2020). *Wykorzystanie metodyk zarządzania projektami w świetle badań empirycznych* [In:] *Wybrane aspekty zarządzania procesami, projektami i ryzykiem w przedsiębiorstwach*. Łódź: Wydawnictwo Uniwersytetu Łódzkiego.
- Capterra (2023). Access on the internet: https://www.capterra.com/project-management-software/?sortOrder=most_reviews.
- Clickup (2023). Access on the internet: <https://clickup.com/>.
- Fridgeirsson, T.V., Ingason, H.T., Jonasson, H.I., Jonsdottir, H. (2021). *An authoritative study on the near future effect of artificial intelligence on project management knowledge areas*. "Sustainability", 13(4).
- Handzel, Z., Terlikowska, M. (2016). *Informatyczne wspomaganie zarządzania projektami na przykładzie aplikacji P2ware Project Manager*. „Zeszyty Naukowe Wyższej Szkoły Ekonomii i Informatyki w Krakowie”, 12.
- Imran, R., Soomro, T.R. (2022, February). *Mapping of Agile Processes into Project Management Knowledge Areas and Processes*. In 2022 International Conference on Business Analytics for Technology and Security (ICBATS). IEEE.

- Kapusta, M. (2013). *Zarządzanie projektami krok po kroku*. Warszawa: Wdgard.
- Kosieradzki, W., *Skuteczne zarządzanie projektami zgodnie z metodyką PRINCE2® przy użyciu oprogramowania firmy P2ware*; Podręcznik użytkownika; P2ware 2014.
- Light, M., Rosser, B., Hayward, S. (2005). *Realizing the benefits of projects and portfolio management*. Gartner, Research ID G, 125673.
- Micale, R., La Fata, C.M., Lombardo, A., La Scalia, G. (2021). *Project Management Information Systems (PMISS): A Statistical-Based Analysis for the Evaluation of Software Packages Features*. "Applied Sciences", 11(23).
- Monday (2023). Access on the internet: <https://monday.com/>.
- Peters, T.J., Waterman, R.H. (1984). *In search of excellence*. "Nursing Administration Quarterly", 8(3).
- PMI. The Project Management Body of Knowledge (PMBOK Guide), 6th ed.; Project Management Institute, Inc.: Newtown Square, PA, USA, 2017.
- Przewoźnik, G., Strojny, J. (2018). *Wielowymiarowa analiza oprogramowania do wspomagania zarządzania projektami*. „Zeszyty Naukowe. Organizacja i Zarządzanie”, Politechnika Śląska.
- Raymond, L., Bergeron, F. (2008). *Project management information systems: An empirical study of their impact on project managers and project success*. "International Journal of project management", 26(2).
- Smartsheet (2023). Access on the internet: <https://www.smartsheet.com/>.
- Thesing, T., Feldmann, C., Burchardt, M. (2021). *Agile versus waterfall project management: decision model for selecting the appropriate approach to a project*. "Procedia Computer Science", 181.
- Trello (2023). Access on the internet: <https://trello.com/pl>.
- Trocki, M., Wyróżębski, P. (2015). *Planowanie przebiegu projektów*. Warszawa: Oficyna Wydawnicza SGH.
- Wrike (2023). Access on the internet: <https://www.wrike.com/>.
- Wyróżębski, P. (2017). *Badanie panelowe metodologicznych aspektów angażowania interesariuszy na przykładzie metodyki PMBoK Guide*. „Zeszyty Naukowe. Organizacja i Zarządzanie”, Politechnika Śląska.
- Wysocki, R.K., Witkowska, M. (2013). *Efektywne zarządzanie projektami: tradycyjne, zwinne, ekstremalne*. Gliwice: Helion.

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