THE ROLE OF MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE IN OPTIMIZING COSTS AND INCREASING REVENUES OF TECHNOLOGICAL COMPANIES

Ivan Khalimonchuk[1], ID, Iryna Pozovna[2*] , ID

[1] *PhD Student, Department of Economic Cybernetics, Sumy State University, Sumy, Ukraine*
[2] *Senior lecture, Department of Economic Cybernetics, Sumy State University, Sumy, Ukraine*
[*]corresponding author: e-mail: i.didenko@biem.sumdu.edu.ua

Abstract: The following article delves into the profound impact of Artificial Intelligence (AI) and Machine Learning (ML) on enhancing business efficiencies and streamlining processes. With technological advancements continuing to accelerate, this subject has gained increasing significance. In an era where economies heavily rely on data, it has become imperative for companies to integrate AI and ML models into their business operations to maintain competitiveness, reduce expenses, and boost revenues. The research focuses on implementing various AI paradigms, including Natural Language Processing (NLP) and chatbots, across enterprises of diverse scales. It specifically explores their influence on enhancing sales, marketing, and customer service. These AI tools signify businesses' evolving strategies to navigate intricate markets. This research uses a quantitative analytical approach to evaluate the financial implications of integrating artificial intelligence (AI) within companies. To achieve this, we are utilizing both linear regression and random forest models for our analysis. This methodology enables a comprehensive analysis of the correlation between adopting advanced AI technologies and subsequent financial performance. The substantial body of research on AI and ML technologies underscores their escalating significance and the imperative for businesses to adapt to these changes. This study contributes to this extensive knowledge by furnishing empirical evidence of AI's impact on augmenting financial outcomes. The findings affirm that AI's strategic development and integration are crucial for enhancing company revenues and overall economic well-being. For this research, we selected the global Amazon investment report and the global AI/ML development growth from 2011 to 2023. This article underscores the practical implications and substantial benefits of leveraging AI and ML in real-world business scenarios. The conclusions suggest that businesses continuously refine and incorporate AI technologies into their models to achieve optimal operational efficiency. By outlines the advantages of specific AI models and provides a framework for companies aiming to utilize technology to gain a competitive edge in the market. Consequently, the practical significance of this research lies in its capacity to inform and enhance business strategies through the effective implementation of AI and ML.

Keywords: AI, ML, chatbot, natural language processing, NLP, linear regression, random forest.

1. Introduction. In the current phase of Industry 4.0, technology companies are progressively integrating advanced machine learning (ML) and artificial intelligence (AI) technologies into their operations to enhance productivity, drive innovation, and maintain a competitive edge in the market. The use of AI and ML in business operations is not limited to automation. These technologies are reshaping business strategies by reducing costs and improving revenue generation. While some believe that they can significantly enhance efficiency and profitability, others express concerns about potential risks, such as data privacy issues and job displacement.

The main goal of this study is to investigate how the growth of AI and ML affects the financial performance of technology companies, particularly in terms of reducing costs and increasing revenue. We have seen extremely fast growth in these technologies past few years which leads us to pay more attention to the current topic. For instance, the number of AI patents doubled in 2022 compared to 2021, and the same for the number of AI startups and AI publications (AI Index report, 2024). The number of companies rapidly incorporating AI features and opening their own research and development centers is increasing. This has generated significant interest in the subject among researchers and has opened up new areas for exploration.

By employing advanced linear regression and random forest models, our study delves deeply into historical data to uncover meaningful trends and connections between AI growth metrics and sales performance. This insightful analysis offers valuable insights into the dynamic relationship between AI progress and business achievements. The article examines different use cases for small/medium/big companies, such as using predictive modeling for financial forecasting, employing natural language processing (NLP) for customer interaction via chatbots, and implementing algorithmic solutions for delivering relevant search results.

2. Literature review.

According to research from the leading Stanford HAI Institute, we have observed a rapid increase in scientific publications related to artificial intelligence since 2019 compared to previous periods. For comparison based on Figure 1, in 2017, there were about 110,000 scientific publications, and after five years, there were 232,670 publications, indicating a more than twofold increase in interest in this topic. The number of AI patents doubled in 2022 compared to 2021 (Figure 2).
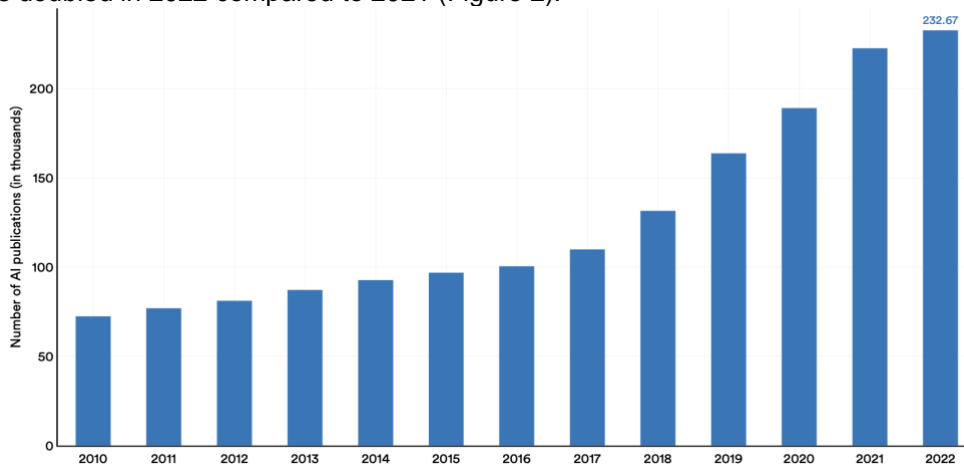

Figure 1. Number of AI journal publications, 2010–2022
Sources: Center for Security and Emerging Technology, 2023 | Chart: 2024 AI Index report
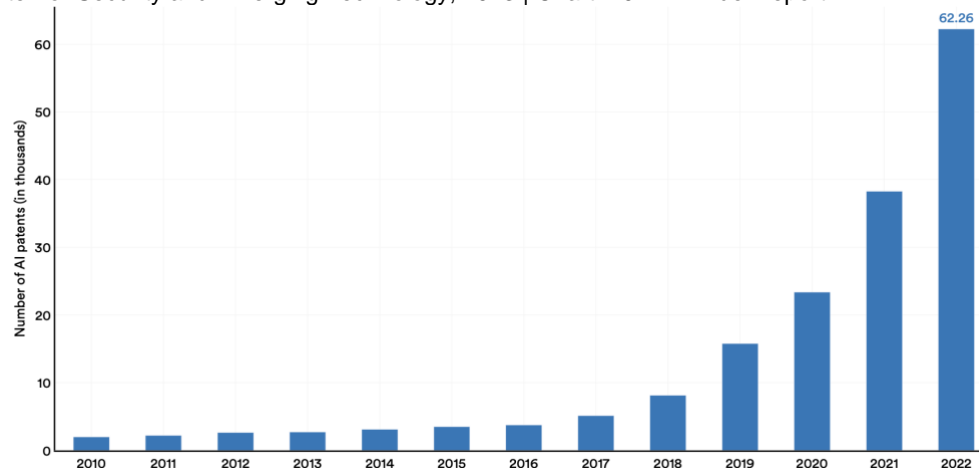

Figure 2. Number of AI patents granted, 2010–2022
Sources: Center for Security and Emerging Technology, 2023 | Chart: 2024 AI Index report

The Stanford Institute (Stanford HAI) conducts research, education, policy development, and practice to improve human lives. Under the leadership of faculty members from various Stanford departments, it develops AI technologies inspired by human intelligence, studies and predicts AI's impact on society, and creates applications that enhance human capabilities. The institute also facilitates discussions on policies at regional and national levels that influence legislation (Stanford HAI, 2024). It also publishes the annual AI Index report, which contains the statistical data used in this study.

The AI Index is an annual report that tracks and analyzes data related to artificial intelligence. The 2024 edition is the most comprehensive and includes new data on AI training costs, analysis of responsible practices in the field of AI, and the impact of technology on science and medicine. The report covers technical achievements, public perception of AI, and geopolitical aspects of its development, providing reliable and detailed information for decision-making by policymakers, researchers, and other stakeholders.

Christian Hildebrand & Anouk Bergner, in their article titled "AI-Driven Sales Automation: Leveraging Chatbots for Sales Growth" (Hildebrand & Bergner, 2019), explore the influence of chatbot interface design on user experience and brand perception. They assert that customizing chatbot interactions based on essential user traits like gender can cultivate trust and strengthen the connection between customers and the brand, potentially leading to increased sales. Likewise, Eleonora Pantano & Gabriele Pizzi, in "Forecasting Artificial Intelligence on Online Customer Assistance: Evidence from Chatbot Patents Analysis" (Pantano & Pizzi, 2020), investigate the evolution of AI in online retail, focusing on chatbots. Their analysis of chatbot patents over two decades highlights advancements in AI's ability to personalize customer interactions and improve the analytical skills of digital assistants for enhanced customer support. In his article "The Impact of Technology on Sales Performance in B2B Companies" (Smith, 2024), John Deep Smith analyzes how digital transformation and technologies such as AI, machine learning, and big data analytics have transformed traditional B2B sales processes. The article discusses critical areas, including the role of CRM systems, digital marketing, and automation tools like chatbots in improving sales efficiency and customer engagement. It also delves into IoT-enabled selling for personalized experiences and addresses challenges to technology adoption, such as resistance to change. The article includes case studies demonstrating these technologies' benefits and provides a future outlook on ongoing innovation in B2B sales. Integrating AI, sales, B2B, and retail is widely popular. Numerous authors have extensively elucidated the implementation of AI within this domain. (Adam et al., 2023; Chatterjee et al., 2023; Guha et al., 2021; Paschen et al., 2021; Sharma et al., 2023; Venkataramanan et al., 2024; Wisesa et al., 2020). It is advantageous for companies to enhance the sales process and fortify the marketing framework using AI (Kedi et al., 2024; Van Esch & Stewart Black, 2021).

Another term we are also interested in is chatbots. Chatbots have undeniably emerged as a significant trend in recent years, completely revolutionizing customer-business interactions. With remarkable advancements in AI and natural language processing, they confidently handle complex queries, offer personalized support, and seamlessly automate sales processes (Bharadiya, 2023; Soni, 2020; Krishnan et al., 2022; Leung & Yan Chan, 2020).

3. Methodology and research methods.

Artificial Intelligence (AI) is a field of computer science that deals with creating systems capable of performing tasks that typically require human intelligence. These include speech recognition, decision-making, visual perception, and language translation. AI is achieved by studying the patterns of the human brain and analyzing cognitive processes, which enables the development of intelligent software and systems (Julius AI, 2024).

Machine Learning (ML) is a subfield of artificial intelligence that focuses on developing algorithms and statistical models that enable computers to learn from data, make predictions, or make decisions. This process occurs without explicit programming, automatically allowing systems to improve with experience. Machine learning uses various methods, such as supervised, unsupervised, semi-supervised, and reinforcement learning, to analyze and interpret large volumes of data (Julius AI, 2024).

Table 1 below presents algorithms and technologies that are currently relevant based on company sizes. We will divide companies into small, medium, and large and provide the top 3 technologies that might be used to improve financial performance.

Table 1. Companies compare based on the sizes and methodologies in AI that they are implementing

Cluster	Small companies	Medium companies	Big companies
Employees	from 1 to 5020	from 51 to 250	from 251
Income	from 2 million UAH	from 2 to 50 million UAH	from 50 million UAH
Market Local/Regional/Global	Local or Regional	National or Global	Global with offices in different countries and

			continents
Methodology 1	Linear regression	Random Forest	Deep Learning
Methodology 2	K-means clustering	Support vector machine (SVM)	Reinforcement Learning
Methodology 3	Decision tree model	Neural Networks	Chatbots and NLP (Natural Language Processing)

Sources: compiled by the authors according to data from 2024

In the study, we consider investigating technologies actively implemented within large companies, as they are the major investors in artificial intelligence research. These companies perform the following tasks: price optimization, personalization of recommendations, analysis of reviews, automation of marketing campaigns, and demand forecasting.

The most widespread adoption in sales and marketing has been achieved by chatbots based on machine learning, particularly Natural Language Processing (NLP). This is evidenced by the investment in their development over the last few years and the targeted use of AI. For example, the share of personalized marketing, the use of chatbots for sales and support, and the forecasting of trends account for 32% as of 2023 (Figure 3). Such models require a lot of data and resources for their construction, training, and testing, which is why usually only large companies can invest funds in such research with the prospect of generating revenue in the future.

Implementing these AI-driven technologies allows large companies to enhance their operational efficiency and set a precedent in the industry, often leading to a competitive advantage. The ability to harness vast amounts of data for insights and predictions significantly contributes to better decision-making processes and more effective strategies, improving their market position and profitability.
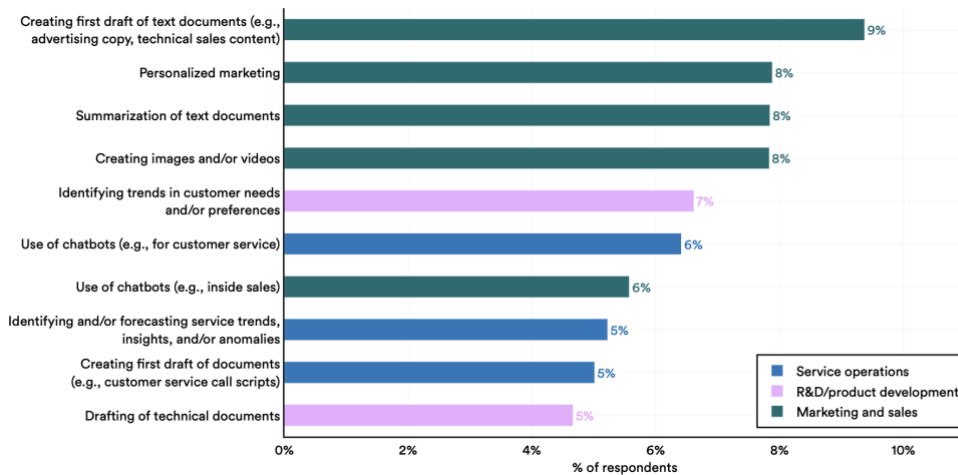

Figure 3. Most commonly adopted generative AI use cases by function, 2023
Sources: McKinsey & Company Survey, 2023 | Chart: 2024 AI Index report

Chatbots are software applications that use artificial intelligence (AI) to communicate with people through text or voice interfaces. Chatbots can perform various tasks, such as answering questions, providing information, assisting with reservations, and facilitating purchases. They are widely used in customer service, e-commerce, and other areas (IBM, 2023).

Among the main risks associated with using artificial intelligence and chatbots are the potential inaccuracies in search results, which can mislead users, requests based on confidential information, health information, etc. Companies typically employ content moderators and involve human oversight in controlling output to minimize negative user experiences with the model.

In the study, Amazon was selected as the subject company. According to the AI Index (Figure 4), companies like Amazon are developing the most machine learning models. In the fourth quarter of 2023, the company introduced a new chatbot-based solution (improved compared to previous versions) that helps better understand customer inquiries and their primary needs, increasing sales and customer satisfaction through better search result delivery. Additionally, the company is implementing solutions for optimizing logistics (by forecasting demand), dynamic pricing, and customer service. However, this technology requires constant refinements to ensure maximum accuracy.
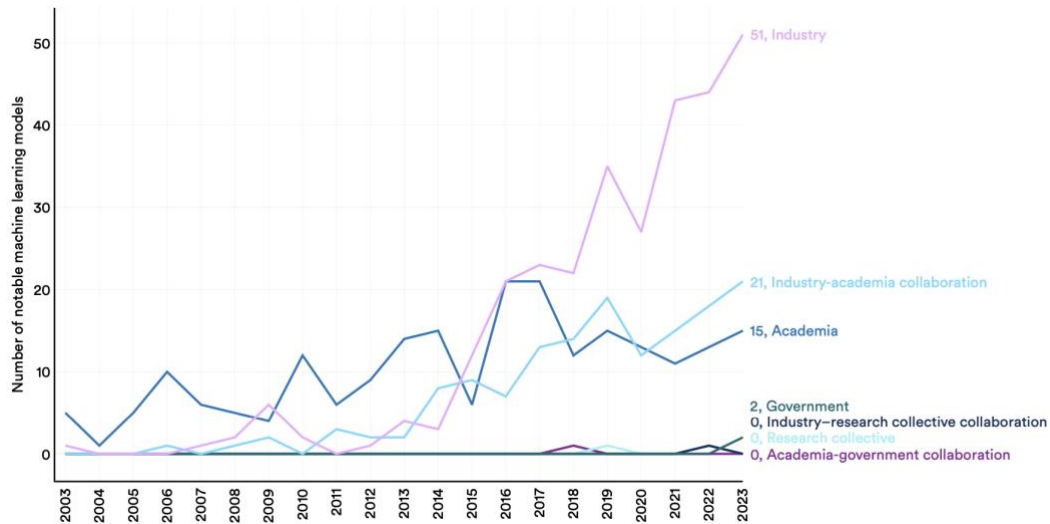
Figure 4. Number of notable machine learning models by sector, 2003–2023
Sources: Epoch, 2023 | Chart: 2024 AI Index report

For the analysis, the leading financial indicators from Amazon's annual global financial reports from 2011 to 2023, which the company publishes annually on its official website (Amazon.com, Inc., 2024), were selected: total net sales, total operating expenses, operating income, interest income, interest expenses, and net income. We are particularly interested in total net sales, as the primary efforts are to increase them, enhance customer satisfaction, and reduce the time from product search to final purchase.

Data from the AI Index Report 2024 for the same period (2011-2023), global level) were selected as variables that might impact the company's financial performance, specifically total AI investments, the number of AI projects (Git, 2024), likes on AI projects on Git, the number of registered AI patents, the number of machine learning models in the business sector, and the number of AI startups.

The main objective is to explore the impact of AI development in the field on the sales of a company actively implementing these technologies.

Linear regression and random forest models were used for this research. The main calculations were performed using Python libraries commonly used for statistical modeling - pandas, numpy, and sklearn. Linear regression analysis predicts a variable's value based on another variable's value. The variable you want to predict is called the dependent variable. The variable you are using to predict the other variable's value is called the independent variable (IBM, 2023). Random forest is a flexible, easy-to-use machine learning algorithm that produces, even without hyper-parameter tuning, a great result most of the time. It is also one of the most-used algorithms due to its simplicity and diversity (it can be used for classification and regression tasks) (IBM, 2023).

The primary metrics that were selected to assess the quality of the model included Mean Squared Error (MSE) and the coefficient of determination (R^2) from the sklearn package. These metrics were chosen to provide a comprehensive evaluation of the model's performance, with MSE indicating the average of the squares of the errors between predicted and actual values, and R^2 representing the proportion of the variance in the dependent variable that is predictable from the independent variables. Mean Squared Error represents the average of the squared difference between the original and predicted values in the data set. It measures the variance of the residuals. The coefficient of determination or R-squared represents the proportion of the variance in the dependent variable which the linear regression model explains. It is a scale-free score i.e. irrespective of the values being small or large, the value of R square will be less than one (Chugh, 2024).

Sklearn is a free and open-source machine learning library for the Python programming language. It offers a variety of algorithms for classification, regression, and clustering, including support vector machines, random forests, gradient boosting, and many others. This library is a popular tool among developers and researchers because it simplifies the implementation of complex machine learning algorithms, allowing focus on model development rather than low-level implementation details (Scikit-learn, 2024).

NumPy (Numerical Python) is a Python library that adds support for large, multidimensional arrays and matrices and an extensive collection of high-level mathematical functions to operate on them (NumPy, 2024).

Pandas is a library for the Python programming language that provides powerful tools for data processing and analysis. It is built on data structures, particularly Series and DataFrame (Pandas, 2024). Pandas allows data to be imported from various formats such as CSV, JSON, Excel, and SQL and perform various operations such as aggregation, filtering, and data manipulation. The library also integrates with NumPy, allowing the use of all NumPy functions on Series and DataFrame. Both libraries are essential tools for data analysis and scientific computing in Python.

4. Results. The following were chosen as independent variables: total AI investments, number of AI projects (information from Git), number of likes for AI projects on Git, number of registered AI patents, number of machine learning models in the business sector, and number of AI startups. For modeling using linear regression and random forest, it was determined that 30% of the data would be used for testing and 70% for training.

The first model we tested using linear regression investigates the relationship between Total Sales and AI Total Investment. The model shows a strong correlation between the two variables. With a high coefficient of determination (R^2= 0.92118), the model is suitable for further use. The Mean Squared Error (MSE) for this model is 2254765929.04, which is also good for this model and the amount of data we have. The linear regression line is in Figure 4.
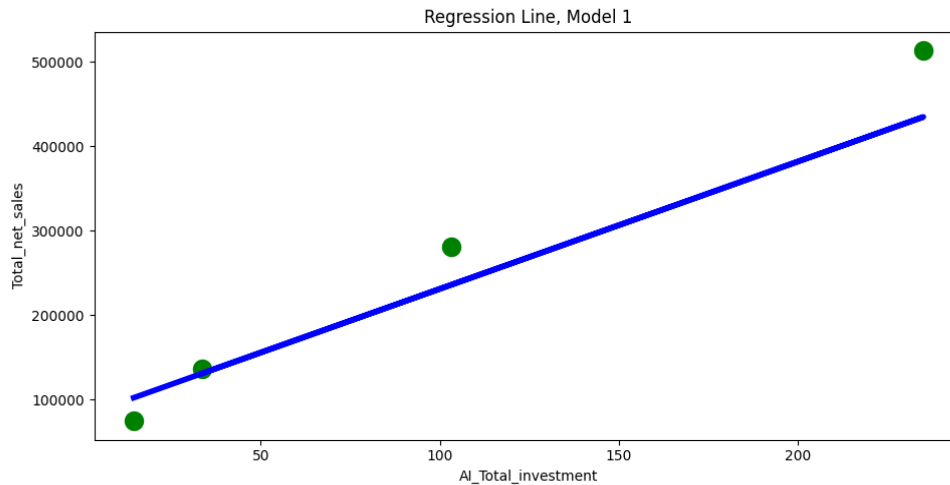

Figure 4. Regression Line for AI_Total_investment and Total_net_sales
Sources: created by the authors based on results of calculations in the scope of research

The second comparison is ML models (industry) and Total Sales. The high mean squared error (6307608966.87) indicates a significant number of variable errors. However, the coefficient of determination (0.77951) is still high. The linear regression line for this model can be found in Figure 5.
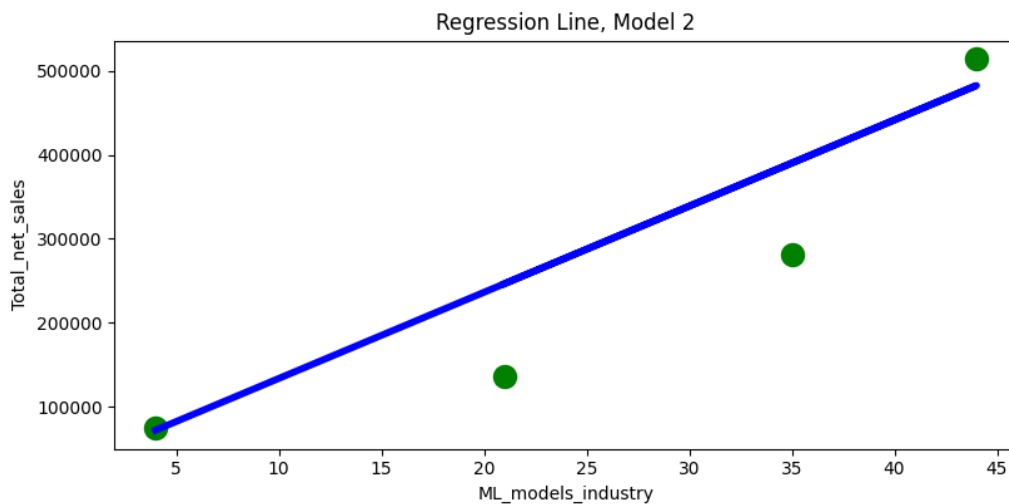

Figure 5. Regression Line for ML_models_industry and Total_net_sales
Sources: created by the authors based on results of calculations in the scope of research

In our analysis of AI company startups and their impact on total sales, we found a high mean squared error (7727801383.40), indicating significant error variability. This measure does not fully capture the strong influence of AI startups on the sales of a company that actively implements AI. The coefficient of determination for this model is 0.77952, and the model line is illustrated by the linear regression line in Figure 6.
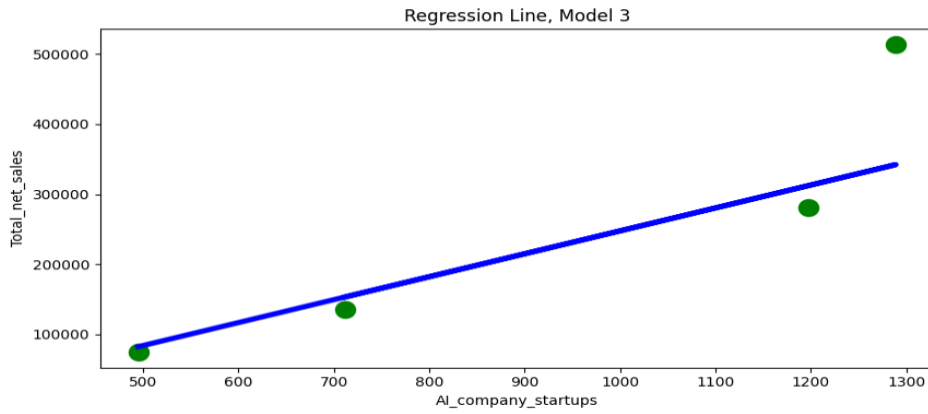
Figure 6. Regression Line for AI_company_startups and Total_net_sales
Sources: created by the authors based on results of calculations in the scope of research

The next model examines the relationship between the number of AI patents granted and total sales. Similar to general AI investments, this model demonstrates a high coefficient of determination (0.93381) and a relatively low mean squared error (1893380138.40), indicating its suitability for further analysis and application. The linear regression line for this model is in Figure 7.
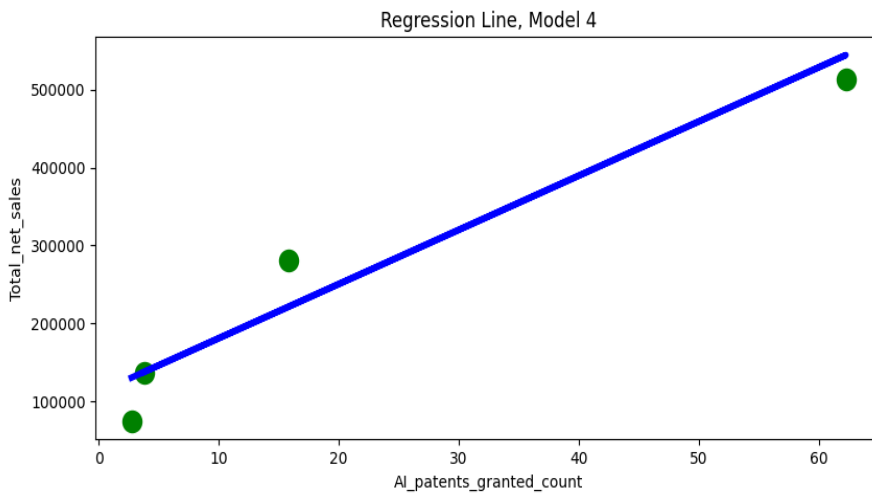

Figure 7. Regression Line for AI_patents_granted_count and Total_net_sales
Sources: created by the authors based on results of calculations in the scope of research

The next to validate is AI GitHub stars to Total Sales. The regression model shows weak dependency (Figure 8). AI company startups do not influence sales volume. For this model, we have the lowest coefficient of determination (0.56985) and high MSE (12305171323.25).
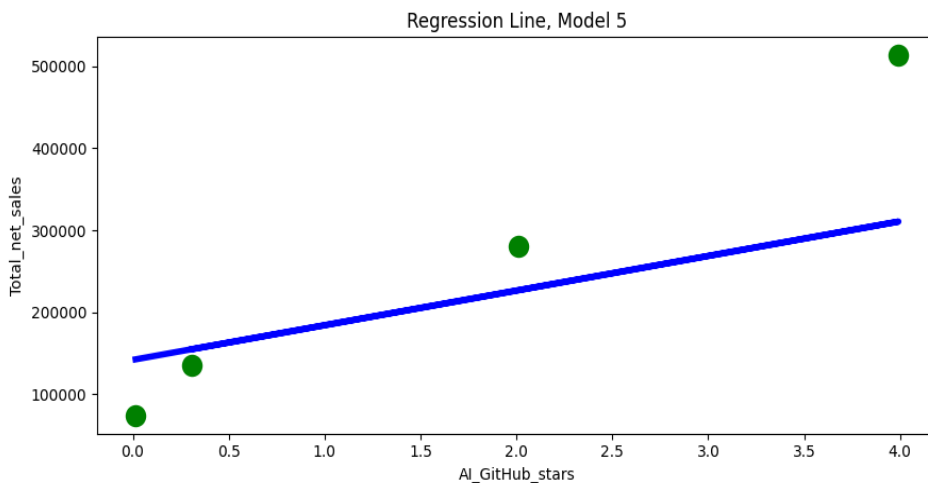

Figure 8. Regression Line for AI_GitHub_stars and Total_net_sales
Sources: created by the authors based on results of calculations in the scope of research

The last model we tried involved the number of AI projects (information from Git) and Total Sales. Among all the factors we considered, the count of AI projects appears to be the most significant indicator of sales influence. The high coefficient of determination (0.94167) and the low mean squared error (1668424523.06) suggest a strong correlation.
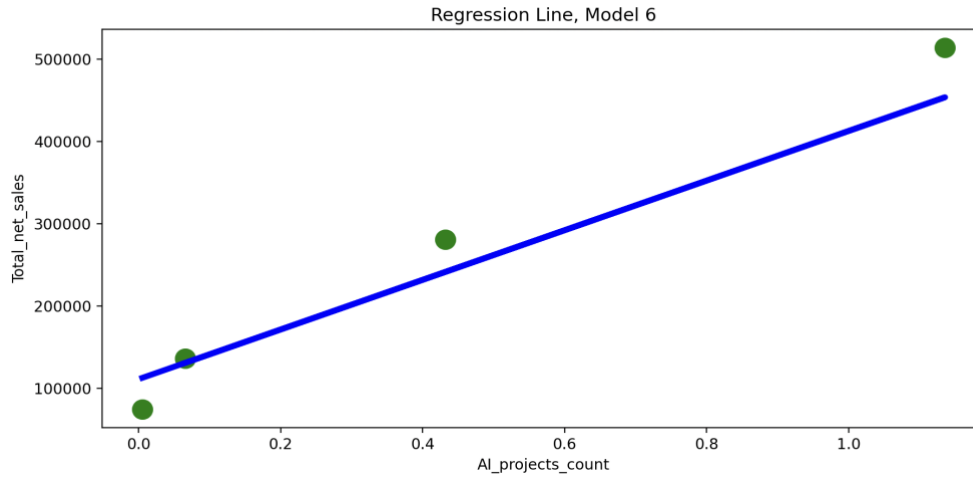

Figure 9. Regression Line for AI_projects_count and Total_net_sales
Sources: created by the authors based on results of calculations in the scope of research

The second part of the research is to check AI measures using random forest. We created two runs of this model: all 6 AI measures(RF6) and 3 AI measures (RF3) that we selected based on the linear regression model's result. The results of this model are in Table 2.

Table 2. Results of Linear Regression and Random Forest models

Measure	RF6	RF3	Random forest explanation
AI total investment	17.5%	35%	One of the most important variables with a high weight is the random forest model. General investments in AI are one of the critical factors that impact sales.
AI projects count	17%	35%	High significance for both models confirms the result of the linear regression.
AI GitHub stars	13%	-	Three indicators were excluded from the model because this indicator shows the lowest impact results based on the outcomes of both models.
AI patents granted count	18%	30%	The most crucial variable when modeling with six considered indicators. However, when modeling with three indicators, it was surpassed in importance by the number of projects on Git.
ML models (industry)	18.5%	-	It was excluded from the analysis of three indicators due to weak results in linear regression.
AI Company Startups	16%	-	It was excluded from the analysis of three indicators due to weak results in linear regression.

Sources: systematized by the authors based on results of calculations in the scope of this article

The outcome from the random forest model provides additional support for the results obtained from our linear regression analysis, indicating that the total investment in AI, the number of AI projects undertaken, and the count of AI patents granted exert a substantial influence on the total sales of a company that is committed to the continuous implementation of AI and ML technologies. This highlights the critical role that AI and ML initiatives play in driving the company's sales performance. Both models offer valuable insights for future research. They can be utilized to forecast sales by incorporating various AI-specific features, such as NLP chatbots, marketing campaign models, and prediction models.

5. Conclusions. The study examined the role of machine learning and artificial intelligence in predicting key performance indicators of technology companies. The results showed that the significant factors

influencing the sales of large companies are General AI Investments, the Number of AI Projects on Git, and the Number of Registered AI Patents. This indicates a strong correlation between the investigated factors, which allows for relatively accurate forecasts in the future with more data from various companies.

The analysis of the results reveals a significant correlation between sales and all six AI-related measures. Particularly noteworthy are the exceptionally strong correlations between sales and AI projects (R^2=0.94), AI patents granted (R^2=0.93), and AI Total Investment (R^2=0.92). These findings provide compelling evidence that the increasing interest in AI and the substantial investment in new AI developments are exerting a positive influence on sales. The analysis of AI project startups (R^2=0.78) and ML model industries (R^2=0.78) provides limited insights due to the lack of reliable statistical information. This leads us to the conclusion that not all new models and startups are suitable for enhancing sales efficiency. The model with the poorest performance is AI GitHub stars (R^2=0.57). This leads to the conclusion that the preferences of developer communities have minimal impact on business outcomes.

The research demonstrated that both methods can help analyze data in artificial intelligence and company financial metrics. Still, the choice of method and the number of indicators considered are crucial for achieving the best results.

Machine learning and artificial intelligence play a decisive role in enhancing the efficiency of technology companies' business processes. They optimize costs through improved forecasting and data analysis and increase revenues by implementing developments that enhance user experience with the platform or website. Thanks to their predictability and flexibility, such tools facilitate better resource management, price optimization, demand forecasting, and rapid response to trends, providing companies with a competitive advantage in today's rapidly changing world. The research results could be valuable for researchers interested in AI and businesses, particularly the intersection of retail and technology. They could also benefit companies seeking insights into the potential impact of implementing new features into their business or investing in AI research for their company.

Conflicts of Interest: Authors declare no conflict of interest.

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РОЛЬ МАШИННОГО НАВЧАННЯ ТА ШТУЧНОГО ІНТЕЛЕКТУ В ПРОЦЕСІ ОПТИМІЗАЦІЇ ВИТРАТ ТА ЗБІЛЬШЕННІ ДОХОДІВ ТЕХНОЛОГІЧНИХ КОМПАНІЙ

Іван Халімончук, аспірант, кафедра економічної кібернетики, Сумський державний університет, м. Суми, Україна.
Ірина Позовна, старший викладач, кафедра економічної кібернетики, Сумський державний університет, м. Суми, Україна

У статті розглянуто вплив штучного інтелекту (ШІ) та машинного навчання (МН) на підвищення бізнес-ефективності та оптимізацію процесів у технологічних компаніях. В епоху, коли економіка серйозно залежить від даних, для компаній стало обов'язковим інтегрувати моделі ШІ та МН у свою бізнес-операційну діяльність, щоб зберегти конкурентоспроможність, зменшити витрати та збільшити доходи. Дослідження зосереджується на реалізації різних парадигм ШІ, включаючи обробку природної мови та чат-ботів на підприємствах різних масштабів. Вони зосереджені на вивченні їхнього впливу на підвищення продажів, оптимізації маркетингової діяльності та обслуговування клієнтів. Ці інструменти ШІ вказують на еволюцію стратегій бізнесу для того щоб зберігати конкурентоспроможність в сучасних реаліях. У цьому дослідженні ми використовуємо кількісний аналітичний підхід для оцінки фінансових наслідків інтеграції штучного інтелекту (ШІ) на показники компанії. Ми використовуємо як лінійну регресію, так і моделі випадкового лісу для нашого аналізу, щоб зрозуміти яка кореляція між досліджуваними змінними. Ця методологія забезпечує всеосяжний аналіз кореляції між впровадженням передових технологій ШІ та фінансовими показниками діяльності підприємства. Значна кількість досліджень щодо технологій ШІ та МН підкреслює їх зростаюче значення та необхідність для бізнесу адаптуватися до цих змін. Ця робота робить внесок у ці обширні знання, надаючи емпіричні докази впливу ШІ на покращення фінансових результатів. Результати підтверджують, що стратегічний розвиток та інтеграція ШІ є критично важливими для підвищення доходів компаній і загального фінансового добробуту. В якості даних для даного дослідження було обрано міжнародний звіт для інвесторів компанії Амазон та глобальний розвиток ШІ у період з 2021 по 2023 роки. Ця стаття підкреслює практичні наслідки та значні переваги використання ШІ та МН у реальних бізнес-сценаріях. Висновки натякають на те, що бізнесу слід постійно вдосконалювати та впроваджувати технології ШІ у свої діяльності, щоб досягти оптимальної операційної ефективності. Окреслюючи переваги специфічних моделей ШІ, наданий аналіз забезпечує рамки для компаній, які прагнуть використовувати технології для здобуття конкурентних переваг на ринку. Отже, практичне значення цього дослідження полягає в його здатності вдосконалювати та впливати на бізнес-стратегії через ефективну реалізацію ШІ та МН.
Ключові слова: ШІ, МН, чат-боти, обробка природної мови, лінійна регресія, модель випадкового лісу.