Artificial Intelligence in Banking: The Evidence from Poland

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Abstract: The widespread use of new technologies has reduced the precise boundary between physical and digital realities. Dynamic development of artificial intelligence (AI) systems has contributed to the digital transformation of the global economy. Given its extensive range of potential applications, AI has the potential to impact a multitude of socio-economic domains, including politics, security, health care, medicine, economy, trade, finance, taxes, and production. As the banking sector plays a crucial role in the global economy, the question arises as to whether and to what extent banking market entities are willing to use artificial intelligence solutions in their business processes. This study aims to determine the scope of AI use by key banks operating in the Polish banking market. Achieving this goal requires determining what categories of AI are used by key banks operating in Poland, analysing AI methods used by those banks, and the fields of AI implementation. The research scope covers the analysis of AI applications in the largest banks operating in Poland, which together cover almost half of the market share (PKO Bank Polski S.A., Bank Pekao S.A., Santander Bank Polska S.A., mBank S.A. and ING Bank Śląski S.A). To obtain an up-to-date overview of AI usage, the research period is 2019-2024. The empirical part of the research is supported by an analysis of the widespread use of artificial intelligence and its dynamic international development based on academic papers and industry reports.

Keywords: Artificial intelligence, Bank AI, Banking market, Banking technology

1. Introduction

The 21st century can be called the era of novelty and digital progress, in which one innovation drives another innovation. The widespread use of new technologies has reduced the boundaries between physical and digital reality. The dynamic development of artificial intelligence (AI) systems has contributed to the digital transformation of the global economy. Given its extensive range of potential applications, AI has the potential to impact a multitude of socio-economic domains, including politics, security, health care, medicine, economy, trade, finance, taxes, and production.

AI changes companies' business models as it influences key fields of their operating activities – customer relationships, internal process optimisation, and data usage. The use of AI solutions is also a leading trend in the banking sector. Banks worldwide are beginning to appreciate the potential of AI use and are eager to implement its methods in their daily operations (Dobrescu & Dobrescu, 2018; ZBP & CPBiP, 2020, pp. 28-29; Ghandour, 2021; Paramesha et al., 2024). As the banking sector plays a significant role in the global economy, the question arises as to whether and to what extent banking market entities are willing to use artificial intelligence solutions in their business processes.

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The structure of the paper is as follows: It starts with a literature review on AI applications in the banking industry to define terms and specify the research perspective and hypotheses. The methodology and research results are then discussed. This section is followed by discussion and conclusions.

2. Artificial Intelligence - Literature Review and Hypotheses Development

According to many authors, the term 'artificial intelligence' was first mentioned in the context of the science of thinking (intelligent) machines in "A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence." It must be stressed that there is no agreement on the general theory, methodology, or choice of problems. The field of AI was launched based on the shared vision that computers can perform intelligent tasks related to any aspect of learning or any other feature of intelligence (McCarthy et al., 2006; Moor, 2006). During

its almost 70-year history, the term evolved owing to its complex character and continuous technological development. The interdisciplinary and multifaceted nature of the term leads to its definition from the perspective of different scientific fields, which may result in contradictory and mutually exclusive definitions. The definitions selected are presented in Table 1. Early definitions usually referred to learning, search, networks, robotics, vision, reasoning, language, cognition, and game-playing (Moor, 2006). Most stress the role of a machine (computer) or computer system and actions connected with intelligent behaviour (Kok et al., 2009). The researcher's approach was reflected in the institutional approach. For example, the updated OECD definition states that AI is "a machine-based system that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments. Different AI systems vary in their autonomy level and adaptiveness after deployment" (OECD, 2024, p. 1). On the other hand, the High-Level Expert Group (HLEG) of the European Commission defines AI systems as "software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best actions to take to achieve the given goal". AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behaviour by analysing how the environment is affected by their previous actions (Samoili et al., 2019, p. 9).

Table 1: The selected scientific definitions of AI

Authors	AI definition
Minsky, 1969	AI is the science of making machines do things that would require intelligence if done by men.
McCarthy, 1988	Artificial intelligence (AI) aims for machines to be more capable than humans at solving problems and achieving goals requiring intelligence. There has been some useful success, but the ultimate goal still requires major conceptual advances and is probably far off. There are three ways of attacking the goal. The first is to imitate the human nervous system. The second is to study the psychology of human intelligence. The third is understanding the common sense world in which people achieve their goals and develop intelligent computer programs. This last one is the computer science approach.
Fogel, 1995	Any system…that generates adaptive behaviour to meet goals in various environments can be considered intelligent.
Nilsson, 1998	Artificial Intelligence (AI), broadly (and somewhat circularly) defined, concerns intelligent behaviour in artefacts. Intelligent behaviour, in turn, involves perception, reasoning, learning, communicating, and acting in complex environments.
McCarthy, 2007	It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to biologically observable methods.
Statista, 2017	Artificial Intelligence (AI) essentially refers to computing technologies inspired by how people use their brains and nervous systems to reason and make decisions, but typically operate quite differently.
Kaplan & Haenlein, 2018	AI is a system's ability to correctly interpret external data, learn from such data, and use that learning to achieve specific goals and tasks through flexible adaptation.

Source: Author's elaboration based on Samoili et al. (2019, pp. 18-28); Situmorang (2024).

The relationship between software or hardware systems and human intelligence is reflected in AI categories, which include Artificial Narrow Intelligence (ANI), also called "Weak AI", Artificial General Intelligence (AGI), referred to as "Strong AI", and Artificial Super Intelligence (ASI), where a technological singularity occurs. ANI is a category of artificial intelligence that is designed to perform a specific task. The data collection processes, mechanisms, algorithms and tools used to create such systems are selected and filtered according to the type of service that it was created in the first place (Jiang et al., 2022). In contrast, AGI is designed to mimic humans and has human-like intelligence and reasoning. It can be used to perform a wide range of tasks. The final step in the evolution of AI is the creation of Artificial Super Intelligence. ASI is an AI system that can improve and develop itself, ultimately dominating human intelligence. Such development means a hypothetical point in the future when the pace of technological progress in AI becomes infinite (Becher, 2023). This type of AI can assist in creating new, better AI systems or even create one itself. The first hypothesis was formulated by considering the characteristics of those categories.

H1: Contemporary banks operating in the Polish banking market use the "weak" artificial intelligence.

The diverse and multidimensional nature of AI methods makes it challenging to provide a clear and consistent taxonomy. In addition, the dynamic global development and interdisciplinary nature of their applications make it difficult to establish a universal classification. For this reason, Table 2 lists selected methods of applying artificial intelligence that might be important from a banking perspective (Impact et al., 2019, pp. 10-27; ARTiBA, 2024; FinTech Poland, 2019, pp. 10-27).

Table 2: The AI techniques

AI technique	Characteristics
Natural Language Processing (NLP)	NLG converts structured data into the native language, employing algorithms to automate content creation. This streamlines content development, allowing creators to deliver information in various formats, such as charts and graphs. This automation reduces human intervention, enabling efficient dissemination of information across social and media platforms.
Text Analytics	Text Analytics involves the analysis of text structure by AI systems, aiding in interpreting meaning and intentions. An intelligent child can be likened to an AI system capable of independently distinguishing between different types of text samples, like family members' handwriting.
Speech Recognition	Speech Recognition, a vital subset of artificial intelligence, facilitates the conversion of human speech into an understandable format for computers. Serving as a bridge in human-computer interactions, this technology recognises and interprets human speech in multiple languages. Notable examples include Siri on iPhones, which showcases the practical application of speech recognition in everyday devices.
Virtual Agents	Virtual Agents, valuable tools for instructional designers, are computer applications that interact with humans. Widely integrated into web and mobile applications as chatbots, they act as customer service agents, handling queries and tasks. Notable examples include Google Assistant and Amazon's Alexa, showcasing the versatility of virtual agents as language assistants and software-as-a-service.
Machine Learning	Machine Learning involves training computers to learn and make decisions independently. Through algorithms and categorised or uncategorised training data, machines analyse information, draw inferences, and store knowledge for future use. For example, a child interacting with and learning about toys represents a form of machine learning through sensory experiences.
Deep Learning	Deep learning is a subset of machine learning that uses multilayered neural networks, called deep neural networks, to simulate the complex decision-making power of the human brain.
Data mining	The process of searching, extracting and analysing a large batch of raw data to identify patterns involving methods at the intersection of machine learning, statistics, and database systems.
Big Data	A mechanism for using artificial intelligence to research, verify and clarify extensive (in volume, velocity, and variety) and diverse collections of structured, unstructured, and semi-structured data that continue to grow exponentially over time.
Biometrics	The measurement and statistical analysis of people's unique physical and behavioural characteristics.

Source: Author's elaboration based on ARTiBA (2024), FinTech Poland (2019, pp. 10-27).

Implementing AI techniques aims to automate business processes in various areas, resulting in gains that drive a competitive advantage. According to Davidson (2003), there is a 50% probability that all manual and repetitive human tasks associated with goods and services will be automated by AI by 2044; however, the probability will rise to almost 90% if the time horizon is extended to 2100 (Davidson, 2023). By automating tasks such as data entry, document processing and customer support, companies can significantly reduce the time and effort required to complete them and improve operational efficiency (Agrawal, Gans & Goldfarb, 2019, pp. 197-236; Paramesha et al., 2024). Furthermore, implementing AI for automation minimises errors and mistakes, resulting in a significant cost reduction. This allows the company to allocate resources more effectively and maximise profitability (Acemoglu & Restrepo, 2016; Post, 2023). AI-driven systems can improve decision-making by providing insightful data from automation and data analytics. They can quickly and efficiently evaluate vast amounts of data and identify patterns, trends and correlations that human analysts may miss (Houbrechts, 2023). With AI, organisations can increase their competitiveness by, for example, improving their supply chains, predicting customer preferences and identifying market trends. The specific AI methods used by market entities, including banks, depend on internal and external factors and involve doubts, as artificial intelligence has both advantages and disadvantages (Ghandour, 2021). The application of AI in the banking sector is potentially extensive. In the front office, AI may be used for tasks such as voice assistant-based customer service and biometrics-based authentication. The literature on customer service uncovers the use of AI for a better

understanding of customers' adoption of digital banking services (Payne et al., 2019; Belanche et al., 2020), better segmenting and targeting banks' products and services (Smeureanu et al., 2013), and a better customer experience (Soltani et al., 2019; Trivedi, 2019). In the middle office, AI is employed for anti-fraud risk monitoring and automation of complex legal and compliance workflows. Finally, in the back office, AI is used for credit underwriting with a smart contract infrastructure (Fares, Butt & Lee, 2022). Research on AI applications in the banking sector refers to machine learning (Khandani et al., 2010; Marinakos & Daskalaki, 2017; Jagtiani & Lemieux, 2019) or a data mining approach (Ince & Aktan, 2009; Alborzi & Khanbabaei, 2016) used in credit and loan analyses. Data mining has also been analysed as a tool to predict bankruptcy (Olson et al., 2012) and to optimise risk models (Akkoç, 2012). AI techniques and their possible implementation in banks' operating activities are presented in Table 3.

Table 3: The areas of possible AI applications in banking operating activity

Banking operating activity		Text Analytics	Machine Learning	Robotics	Chatbots	Biometrics & Identity
Front Office	Customer service					
	Help desk		√	√	√	√
	Identity management, access control					
Back Office	Business processes automation					
	Payments and credit services	√	√	√	√	
	Complains management					
	Insurance and credit risk analysis (Underwriting)					
Banking services	Customer Relationship Management (CRM)			√	√	
	Financial Advisory					
Management, risk and compliance	Compliance					
	Risk Management	√	√			√
	Reporting					

The review of AI methods and their potential applications in banking operating activities was the foundation for establishing the following hypotheses:

H2: The most frequently used AI methods are machine learning, chatbots and robotics.

H3: Banks operating in the Polish banking market mostly use AI for customer service and risk management.

3. Research Design

The subject of the research presented in this article is artificial intelligence. Based on the literature review, in this research, AI will be defined following the HLEG as "software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best actions to take to achieve the given goal."

The principal objective of this study is to determine the scope of artificial intelligence use by key banks operating in the Polish banking market. Achieving this goal requires determining the categories of AI used by key banks operating in the Polish banking market (SO1), the AI techniques used by key banks operating in the Polish banking market (SO2), and the main areas of AI application (SO3). The following hypotheses were based on these questions:

H1: Contemporary banks operating in the Polish banking market use the "weak" artificial intelligence.

H2: The most frequently used AI methods are machine learning, big data and robotics.

H3: Banks operating in the Polish banking market mostly use AI for customer service and risk management.

The research sample includes the five largest banks operating in the Polish banking market in terms of asset value: PKO Bank Polski SA (PKO BP), Bank Pekao SA (PeKaO), Santander Bank Polska SA (Santander), mBank SA (mBank), and ING Bank Śląski SA (ING BSK). The first three entities are also leaders in terms of the number of customers and the financial result (Redzik, 2024) – see Table 4.

Table 4: The characteristics of sample banks

Bank	Assets (in mld PLN)	Number of customers (in mln)	Net profit (in mln PLN)
PKO BP	444.00	11.8	3 333.00
Pekao	288.00	6.6	1 719.00
Santander	263.77	5.8	3 009.00ł
ING BSK	232.84	5.0	1 714.00
mBank	225.39	5.7	- 703.00

To obtain an up-to-date overview of how AI is used by key banks operating in the Polish banking market, the time range of this article is 2019-2024. The research results were based on secondary data analysis using descriptive analysis, deduction and induction.

4. Results

The analysis of the use of artificial intelligence by key banks operating in Poland aims to determine AI categories and methods and identify the key fields of AI application.

PKO Bank Polski SA (PKO BP), the largest bank operating in the Polish banking market, currently utilises the services of 19 automated customer service agents. Artificial intelligence is employed in several ways within the context of customer service. These include the use of chatbots to contact customers on the hotline, the analysis of customer feedback on products and services, the administration and collation of customer surveys, the issuing of reminders about overdue obligations, and the protection of customers' financial interests. Additionally, AI technology is employed in the voice assistant system, which is accessible via the bank's mobile application. The system is referred to as "Talk to IKO." The application assists clients in managing their financial affairs, including analysing their expenditures and savings. The assistant enables customers to ascertain their account balance, effect payments via the BLIK (a Polish mobile payment system) and conventionally transfer funds. The system utilises natural language processing to enable responses to simple queries and commands, such as: "What is the expenditure on food?", "Transfer ten to Zuzia", "Pay the electricity bill". Moreover, customers can utilise the “Investomat” tool, which assists in selecting an appropriate investment fund that aligns with the client's specific needs and preferences. In the domain of risk management, the bank has adopted a machine learning operations platform (MLOps) based on Google Clouds. This enables the creation of sophisticated risk assessment models. These models facilitate the prediction of diverse customer scenarios and behaviours. Additionally, AI was employed in the recruitment process. The bank has collaborated with the startup Emplocity to utilise a chatbot for preliminary conversations with prospective employees to profile candidates and match their profiles to recruitment requirements.

The second bank, PeKaO SA, applies AI to support customers, employees, and society. In the field of customer relationships, the bank uses biometrics to open a bank account remotely using a photo (”selfie”) and ID, access an account, and authenticate transactions (FaceI D or fingerprints). The bank connects AI techniques for business process automation and big data analysis to improve the service quality. The bank also offers customers an EmpatAI mobile application to share opinions and comments. AI tools are used to analyse them and draw conclusions about customers’ needs and preferences. Bank’s employees can participate in the Robotics Academy and develop digital competencies and the ability to design robots. The robots they created supported their everyday work. They can also use ZapytAI, a search engine that intuitively helps them quickly find the information they need or a ready answer to a question asked by the client. The last area of AI usage by PeKaO SA was education. The objective of the educational activities conducted by the bank in collaboration with Synerise SA and Microsoft was to enhance the collective understanding of new technologies, including AI. The AI Schools and Academy, accessible to children and adolescents, was designed to educate them about artificial

intelligence. The second project targets small and medium-sized enterprises to increase their awareness of the Internet of AI in data distribution.

Similarly, Santander employs biometrics for authentication purposes within its mobile application, which is analogous to PeKaO. Additionally, the institution developed a marketing campaign entitled "Communication by AI", created using artificial intelligence.

In turn, ING SA uses the voicebot Inga as a virtual customer assistant. Inga supports call centre employees by answering simple questions and responding to simple comments. More complicated issues are forwarded to employees. The bank also offers “Investomat Robot Consulting”, which is supported by artificial intelligence algorithms. It advises which investment funds to choose, depending on the accepted level of risk. This service is available online and through mobile banking. Similar to other banks, these applications implement AI (biometrics) for authentication. The other AI systems help employees (Intelligent Assistant) manage risks related to financial frauds(behavioural biometrics) and marketing (campaign titled “Me in the future. Powered by AI & ING”).

The last bank analysed– mBank - used AI in a voicebot and chatbot. Both are treated as customer service support. Owing to AI, the first system can communicate like a human being (using a human voice), answer simple questions, and react to simple comments. The chatbot is available on the bank’s messenger and Facebook “mFinance”. Customers communicate via chat with a bot that offers simple financial solutions such as calculating creditworthiness or future loan instalments. The bank uses biometrics in mobile applications for the same purposes as other banks and, similar to ING, uses behavioural biometrics to detect fraud.

Table 5 presents the synthesis of the analysis of the artificial intelligence methods used by the five largest banks in Poland: PKO Bank Polski S.A., Bank Pekao S.A., Santander Bank Polska S.A., mBank S.A., and ING Bank Śląski S.A.

Table 5: The AI usage, method and categories applied in sample banks

Bank	AI solution	The field of AI usage	AI method	AI categories
PKO BP	Voicebots	Customer service	Machine learning Speech recognition NLP	ANI (weak AI)
	Voice assistant	Customer service	Machine learning Speech recognition NLP	ANI (weak AI)
	Investomat Robot Consulting	Customer service	Robotics Machine learning	ANI (weak AI)
	MLOps platform	Risk management	Machine learning Big Data Expert systems	ANI (weak AI)
	Recruitment with chatbot	Human Resources	Machine learning Speech recognition NLP	ANI (weak AI)
PeKaO	Mobile application	Customer Service	Biometrics	ANI (weak AI)
	PekaoBiznes24	Customer service	Robotics Machine learning	ANI (weak AI)
	EmpatAI	Customer Service	Machine learning Big Data	ANI (weak AI)
	Robot DIY	Human Resources	Robotics	ANI (weak AI)
	ZapytAI	Human Resources	Machine learning Big Data	ANI (weak AI)
	Educational programs	Marketing/CSR	Machine learning	ANI (weak AI)

Bank	AI solution	The field of AI usage	AI method	AI categories
			Big Data	
Santander	Marketing campaign	Marketing/CSR	Robotics Machine learning Visualisation	ANI (weak AI)
	Mobile application	Customer Service	Biometrics	ANI (weak AI)
ING BSK	Voicebot Inga	Customer Service	Machine learning Speech recognition NLP	ANI (weak AI)
	Mobile application	Customer Service	Biometrics	ANI (weak AI)
	Investomat Robot Consulting	Customer Service	Robotics Machine learning Big Data	ANI (weak AI)
	Intelligent Assistant	Human Resources	Machine learning Big Data Speech recognition NLP	ANI (weak AI)
	Behavioural verification	Financial frauds	Behavioural biometrics	ANI (weak AI)
	Marketing campaign	Marketing	Robotics Machine learning Visualisation	ANI (weak AI)
mBank	Voicebot Marek	Customer service	Machine learning Speech recognition NLP	ANI (weak AI)
	Chatbot	Customer service	Machine learning Speech recognition NLP	ANI (weak AI)
	Mobile application	Customer Service	Biometrics	ANI (weak AI)
	Behavioural authentication	Financial frauds	Biometrics	ANI (weak AI)

The synthetic presentation of the research results in Table 5 shows that all AI systems applied in sample banks are “weak AI,” which enables the positive falsification of the first hypothesis.

Among the AI techniques used by the analysed banks were machine learning, speech recognition, NLP, robotics, Big Data, and biometrics (Figure 1). The most frequently used AI methods include machine learning, speech recognition and NLP, which are used in chatbots and robotics (H2 is falsified positively).

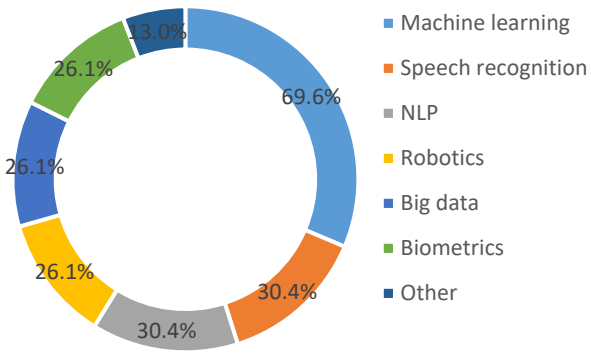

Figure 1: The AI techniques used by in sample banks

Over half of the AI solutions used by sample banks in the analysed period (13 out of 23) relate to customer service, four support the human resources field, and three to risk management. Two banks designed marketing campaigns using AI, and two used it for educational purposes. Considering that biometrics used for authentication in remote access to banking accounts and services also aim to decrease risk, the third hypothesis is also positively falsified.

5. Discussion and Conclusions

The global economy is becoming increasingly reliant on artificial intelligence (AI). The results confirm that the capabilities and potential of AI are of interest to Polish banks that utilise their solutions in their business activities, which is in line with research conducted in other banking markets (Dobrescu & Dobrescu, 2018; Ghandour, 2021; Paramesha et al., 2024).

Key banks operating in the Polish banking market employed the "weak" artificial intelligence category. The analysis of data collected for this study leads to the conclusion that the banks' most commonly used artificial intelligence methods include machine learning, speech recognition, NPL, automation of processes, and biometrics. They are primarily applied in the front office for customer service, help desks, and access authentication in solutions such as Voicebots, voice assistants, chatbots, and mobile banking. Payne et al. (2019) and Belanche et al. (2020) also analysed the AI application in mobile banking. They stressed the role of customers' attitudes and the perception of relative advantage as a success factor of AI implementation and recommended considering customers' level of familiarity with robots. In the middle office, the surveyed banks implemented AI for anti-fraud risk monitoring and the automation of legal and compliance works. Additionally, analysed banks used artificial intelligence in the field of marketing and human resources management. In the back office, the focus is on risk management, particularly in assessing credit risk. The advantages of using AI in credit risk management were also pointed out by Khandani et al. (2010) and Alborzi and Khanbabaei (2026).

The dynamic global development of the AI phenomenon and the diversity of its applications show the extensibility of its potential applications in the banking sector. Artificial intelligence systems are implemented in numerous areas of bank operations. Although the diverse nature of AI methods means that financial institutions adapt their selection to their specific needs, there are some similarities between banks operating in different markets.

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