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Artificial Intelligence Reshaping  
Finance: Redefining Institutions,  
Processes and Decision-Making

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## **Introduction**

Artificial Intelligence (AI) is not just a simple technical tool but an element capable of radically transforming economic, institutional, and decision-making processes.

The transformation affects all levels of the financial system: from production to consumption, from data analysis to policy formulation, from private finance to public decision-making.

The evolution of AI is characterized by its rapid, persuasive impact, not only on the operational dimension but also on the epistemic and normative dimension of economic power.

Within this framework, the present thesis stems from the desire to investigate how the evolution of Artificial Intelligence is transforming the European financial system, with particular attention to the effects it generates in the main decision centres: central banks, commercial banks, and public administrations. While Europe is today being asked to strengthen its competitiveness in the global context and at the same time to defend the values of transparency, legality, and democratic accountability, an understanding of the impact of AI on the financial sector involves much more than just an analysis of new frontiers in technology; it goes to the extent of redefining the nature and the functions of public and economic institutions in their day-to-day operations.

The selection of the topic comes from a medley of personal, academic, and topical interests. Personal curiosity relates to complex decision-making processes, macroeconomic dynamics, and how technology is altering delimitation within public/private and human/artificial worlds. Academic interest aligns at the intersection across economy, politics, and innovation, which in the context of the European Union increasingly finds itself in synthesis against the backdrop of recent adoption of the AI Act and the numerous national plans for adopting AI in the public sector. Finally, the relevance of the topic is linked to its topicality and its strategic character for the future of the continent: AI applications in the financial sector are not only already producing measurable effects, but also raise urgent ethical questions, the regulation and sustainability of decisions taken by more algorithmic actors.

The research question which guides this thesis can be formulated as follows: how is Artificial Intelligence reshaping the European financial system, redefining the roles,

processes, and decision-making of central banks, commercial banks, and public financial institutions?

Starting from this question, some interpretative hypotheses are articulated that will accompany the analysis.

The first hypothesis is that, in the central banking sector, AI is emerging as an essential tool for improving the quality of macroeconomic forecasts and supporting monetary policy making through Machine Learning techniques, able to analyse large volumes of data with greater accuracy and timeliness.

The second hypothesis states that with AI technology, the entire banking system is undergoing profound changes in respect to risk analysis, credit rating, service delivery, and customer relationship management. While such changes in the banking sector will lead to the achievement of efficiency and cost-effectiveness, they also raise pertinent questions regarding transparency, algorithm accountability, and data privacy.

Hypothesis number three addresses the matter of public administration and, in particular, the Ministries of Economy and Finance, in which AI is becoming more commonly used for economic forecasting, analysis of fiscal dynamics, optimization of public debt management, and planning of medium-to-long-term economic policy. Within this context, Artificial Intelligence becomes a strategic lever that can enhance the effectiveness of public decisions and their ability to adjust to complex and rapidly changing scenarios.

The aim of the thesis is to provide an in-depth and up-to-date analysis of the information currently available. It also aims to stimulate wider reflection on the political and economic significance of intelligent models, their potential and limitations, the need for democratic governance of technology and the role that Europe can play in this transition.

The methodology is mainly based on documentary research, conducted through the analysis of institutional reports, official sources, documents, scientific papers, and press articles. Through the study of these sources, an attempt has been made to build a comprehensive framework which includes technical aspects and policy implications, concrete cases, and future scenarios.

The thesis is divided into four chapters, each addressing a specific dimension.

The first chapter offers a theoretical and conceptual introduction to the topic, defining the main types of Artificial Intelligence, their characteristics, and applications. The aim is to clarify how these technologies work and their potential impact on financial institutions.

The second chapter analyses the role of central banks, with the case of the European Central Bank (ECB). It is specified how the forecast models used are contributing to improving the accuracy and responsiveness of macroeconomic dynamics.

The third chapter looks at the impact of new technologies on the commercial banking system. It addresses the influence of Artificial Intelligence in banking business models, reshaping the relationship between institutions and clients, but also raising new challenges.

The fourth chapter is dedicated to public administration, with attention to the Italian case and the use of AI by the Ministry of Economy and Finance (MEF). We dwell on the case of Italy, which in this context represents an interesting example of experimentation and adaptation, where technological innovation is integrated within an administrative apparatus still partially linked to traditional processes.

In conclusion, in a world where economic decisions are increasingly automated, it is essential to understand the logic and tools underlying them so as not to remain passive spectators of the ongoing transformation. The hope is that this work can contribute, even in its small way, to strengthen a critical and informed awareness on an issue that, today more than ever, touches closely the present and future of the economy, politics and European society.

## 1. AI IN THE FINANCIAL SECTOR

### 1.1 Definition, Importance, and Key Abilities of AI in Finance

How is Artificial Intelligence (AI) reshaping the financial sector? Over the past decades, AI has been changing financial institutions' operations and regulations, bringing relevant benefits while posing considerable challenges and threats to stability.

Artificial Intelligence (AI), one of the most intricate areas of contemporary technology, is defined as “the use or study of computer systems or machines that have some of the qualities that the human brain has, such as the ability to interpret and produce language in a way that seems human, recognize or create images, solve problems, and learn from data supplied to them”<sup>1</sup>. This definition gives us an interesting insight into how AI can replicate or exceed human cognitive capabilities, especially in complex and data-driven domains such as finance.

#### *1.1.1 The Importance of AI in the Financial Sector*

Artificial intelligence is now at the heart of a radical transformation that is profoundly redefining how financial services work. Its strength, as anticipated by the definition cited above, is its adaptive and cognitive nature: not only is it able to learn and adapt, but also to improve its performance through continuous data processing. This is precisely why it is considered strategic in a sector such as finance, where decisions must be fast, informed, and increasingly accurate.

In the European context, AI has been implemented because of the need to manage large volumes of data generated daily by the industry. Digital transactions, stock exchanges, balance sheet data, market news, and regulatory documents are all part of this huge amount of information that only intelligent models can interpret in real time.

The widespread use of AI models is due to the fact that these systems allow for data in strategic knowledge. The financial institutions operating in the European Union are gradually moving from a logic of reaction to a logic of forecast. Using predictive tools such as Machine Learning and Deep Learning, they can anticipate market movements, identify hidden patterns, and improve risk management. According to a study conducted in 2023, the integration of AI into forecasting models improves the accuracy of market

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<sup>1</sup> Cambridge Dictionary. "Artificial Intelligence." Cambridge University Press.  
<https://dictionary.cambridge.org/us/dictionary/english/artificial-intelligence>.

dynamics analysis. In particular, the Estimated Annual (EST-ANN) hybrid model, combining statistical and neural components, is efficient for forecasting the volatility of European indices such as the German DAX<sup>2</sup>, the French CAC40<sup>3</sup>, or the UK FTSE<sup>45</sup>.

As regards the modernisation of the European financial sector, AI assumes a systematic importance, allowing for structural change that involves rethinking business processes, organisational models, and skills required. This implies the need to develop and update digital infrastructures, adopt secure cloud platforms, and update governance strategies in a data-driven perspective. AI is a tool for accelerating innovation, promoting greater transparency, wider accessibility of services, and better responsiveness to macroeconomic changes.

A concrete example of the European approach to AI in the financial sector is the study conducted by the European Commission on the use of neural networks for forecasting the spread of Italian government bonds. Integrating information from information databases such as the Global Database of Events, Language, and Tone (GDELT), which analyses in real-time the emotional and thematic content of economic news, the researchers were able to improve the prediction of differential variations between Italian and German stocks, through the use of Recurrent Neural Networks (RNN) to analyse and predict time series. This approach demonstrates how AI can not only improve predictive capacity but also integrate qualitative and behavioural factors into risk models, exploiting new unconventional sources of information.

In conclusion, Artificial Intelligence is an indispensable resource for the European financial sector, providing an effective response to structural challenges. Moreover, its impact is not limited to technical aspects, but contributes to redesigning the relationship between financial institutions, customers, and regulators, paving the way for a more transparent model, intelligent and resilient public and private financial management.

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<sup>2</sup> Deutscher Aktienindex, Germany's blue-chip index of 40 top Frankfurt-listed stocks, calculated with dividends reinvested.

<sup>3</sup> Cotation Assistée en Continu-40, France's blue-chip index of 40 major Paris-listed stocks, weighted by free-float market capitalisation.

<sup>4</sup> Acronym for Financial Times Stock Exchange 100 Index, is the main stock index of the London Stock Exchange and brings together the 100 largest capitalised British companies.

<sup>5</sup> Ampountolas, Apostolos. "Comparative Analysis of Machine Learning, Hybrid, and Deep Learning Forecasting Models: Evidence from European Financial Markets and Bitcoins." *Forecasting* 1, no. 1 (2023): 1–15.



### *1.1.2 Applications of AI in Financial Services*

The transformative process of Artificial Intelligence in finance has provided solutions to improve operational efficiency, optimize risk management, customize customer services, and automate complex processes.

This process has particularly affected central banks, commercial banks, insurance companies, and public authorities, giving rise to a data-driven ecosystem, speed of response, and prediction of future scenarios.

AI is used today in a large number of fields. First, one of the main areas of development is operational automation. According to an OECD analysis reported in a CEPS study, banks, followed by insurance companies and asset managers, are the financial institutions that use or experiment with these new models most intensively<sup>6</sup>. Similarly, many institutions also use algorithms to facilitate regulatory compliance by analysing complex legislative documents and regulatory requirements and offering support to operators.

Predictive analysis, which is constantly evolving, allows you to anticipate the evolution of market variables, assess credit risk, estimate the probability of default, and even monitor signs of systemic instability. As mentioned above, studies on European indices such as DAX, CAC40, and FTSE have shown improved forecasting capacity compared to traditional approaches<sup>7</sup>.

In addition, AI has greatly helped the customer experience, particularly in the wealth management sector<sup>8</sup>, improving the field of customisation of services. Through the analysis of data such as portfolios, preferences, and past behaviour, you are able to offer personalized investment advice, automate portfolio rebalancing and provide predictive risk assistance<sup>9</sup>. The aim is to offer tailor-made services, increasing customer confidence and quality of financial relationship.

However, this major technological development brings with it significant challenges. Among the most important obstacles are transparency and interpretability of algorithms,

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<sup>6</sup> Arnal, Judith. AI and Credit: Addressing the Still Open Questions to Prevent Innovation Paralysis. Centre for European Policy Studies, December 2024. [https://cdn.ceps.eu/wp-content/uploads/2024/12/20240805-AI-in-the-financial-sector\\_edited.pdf](https://cdn.ceps.eu/wp-content/uploads/2024/12/20240805-AI-in-the-financial-sector_edited.pdf)

<sup>7</sup> *Ibid.*, 8

<sup>8</sup> Customised management for high-net-worth clients, including investment, taxation and estate planning.

<sup>9</sup> PricewaterhouseCoopers. "AI Is Transforming Asset and Wealth Management." Accessed April 4, 2025. <https://www.pwc.com/gx/en/issues/c-suite-insights/the-leadership-agenda/ai-and-wealth-management-a-new-era.html>

especially when it comes to high-impact processes such as credit rating. In terms of reliability, human control, and fundamental rights, the problem is caused by the difficulty of understanding the reasons for the decisions taken, which function as "black boxes". The risk, in fact, is that of amplifying existing inequalities, for example, through algorithmic discrimination. In this respect, CEPS points out that poorly trained systems can perpetuate historical and social biases when based on incomplete or distorted data<sup>10</sup>.

From the regulatory point of view, currently central, the European Union has established a risk-based regulatory framework, introducing on 1 August 2024 the AI Act. According to this legislation, the uses of AI classified as "high risk", that is the systems used to assess people's credit worthiness and to calculate premiums in life and health, are required to comply with strict requirements regarding risk management, data quality transparency, and cyber security. In addition, institutions using the new algorithms must carry out a prior assessment of their impact on fundamental rights.

In conclusion, the implementation of Artificial Intelligence represents an extraordinary opportunity to make the system more efficient, predictive, inclusive, and secure. However, it is essential that this transformation be guided by the principles of accountability, transparency, and ethical care.

## **1.2 Explanation of Different Types of AI Used in this Sector**

### *1.2.1 Machine Learning*

Machine Learning (ML) is a model that allows you to train systems progressively with historical data, adapting over time through the analysis of patterns, correlations, and behaviours. This learning can take place in a supervised way, instructing the model through labelled data to learn a specific relationship (how to predict if a client is at risk of default). On the other hand, learning can take place in an unsupervised way, when the algorithm autonomously detects hidden structures of data (for example, in fraud detection)<sup>11</sup>.

Thanks to the versatility and exponential increase in data, ML algorithms have been increasingly implemented in recent years to assess credit risk, determine product pricing,

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<sup>10</sup> Arnal, Judith. "AI and Credit: Addressing the Still Open Questions to Prevent Innovation Paralysis." Centre for European Policy Studies, December 2024. [https://cdn.ceps.eu/wp-content/uploads/2024/12/20240805-AI-in-the-financial-sector\\_edited.pdf](https://cdn.ceps.eu/wp-content/uploads/2024/12/20240805-AI-in-the-financial-sector_edited.pdf).

<sup>11</sup> IBM. Artificial Intelligence in Finance. December 8, 2023. <https://www.ibm.com/it-it/topics/artificial-intelligence-finance>.

monitor markets in real-time, optimize investment portfolios, and especially to predict relevant economic events such as inflation, credit demand or the probability of default<sup>12</sup>.

ML models can integrate multiple variables, even non-linear ones, into robust predictive models. The main models include decision trees, random forests, and gradient boosting to classify customers or assess investment risk. Second, advanced logistic regression models are important in estimating the probability of an investment being risky (e.g. probability of default). Another model is the ensemble, which thanks to the combination of several algorithms improves its precision. Finally, the isolation forests, are useful for automatic detection of anomalies in data flows.

For example, the FinTech sector makes extensive use of ML to offer more flexible and personalised products: loans with instant risk assessment, digital insurance, robo-advisors, and automated tools for asset allocation are obvious examples<sup>13</sup>.

In the European financial landscape, the integration of ML is expressed in the increasingly widespread adoption of Long Short-Term Memory Networks (LSTM), an evolution of recurrent neural networks, designed to manage temporal sequences and to store information about past events over long periods. An example is the DeepAR model, which exploits the LSTM model to create probabilistic forecasts in unstable economic scenarios, as in the case of Italian government bonds <sup>14</sup>.

The use of ML has transformed the regulatory analysis of the banking system. When it comes to financial supervision, nowcasting, or real-time forecasts on economic indicators, it allows crises to be anticipated and corrective measures to be activated in time. According to the International Monetary Fund, ML tools have been implemented to analyse systemic financial stress by analysing hidden correlations between banking performance and macroeconomic variables<sup>15</sup>.

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<sup>12</sup> International Monetary Fund. “Artificial Intelligence and Its Impact on Financial Markets and Financial Stability.” September 6, 2024. <https://www.imf.org/en/News/Articles/2024/09/06/sp090624-artificial-intelligence-and-its-impact-on-financial-markets-and-financial-stability>.

<sup>13</sup> Paolini-Subramanya, Mahesh. The Evolution of Artificial Intelligence in the Fintech Sector. AI4Business, March 7, 2024. <https://www.ai4business.it/intelligenza-artificiale/evoluzione-dellintelligenza-artificiale-nel-settore-del-fintech/>

<sup>14</sup> Consoli, Sergio, Luca Tiozzo Pezzoli, and Elisa Tosetti. Neural Forecasting of the Italian Sovereign Bond Market with Economic News. European Commission, Joint Research Centre, March 2022.

<sup>15</sup> *Ibid.*, 11

Of course, the effectiveness of such algorithms depends on the quality of the data: misuse or lack of transparency can lead to bias, discrimination, or incorrect results. To solve this problem, an explainability logic is being developed, which makes it possible to explain in a comprehensible way the operation of the algorithm and the reasons for its decisions<sup>16</sup>.

### *1.2.2 Deep Learning and Natural Language Processing*

Deep Learning (DL), unlike ML, is based on simple algorithmic structures and uses the architecture of deep neural networks, composed of hierarchical layers, which process data in a progressive and multilevel way. In this way, they are able to identify very complex relationships, even without clear input data.

In the European financial sector, this technology is being used in areas requiring the processing of unstructured data such as text documents, images, audio, or market signals.

This model is used for market sentiment analysis, which is the automated measurement of investor mood, expectations, and reactions through sources such as news articles, financial reports, social media, and institutional statements. By exploiting these data, the DL can identify declines in investor confidence or negative reactions to a monetary policy decision and translate them into predictive indicators<sup>17</sup>.

The DL is also used in automated credit risk assessment. For example, by processing numerical, documentary, and behavioural data, it is able to cross the balance sheet of a company, its financial history and news, producing an accurate personalized and dynamic predictive score.

On the other hand, Natural Language Processing (NLP), is a technology that understands, interprets, generates, and manipulates human language. Being built on deep neural networks, it can read texts such as supervisory reports, company balance sheets, insurance contracts, or minutes of meetings, extracting the necessary information. NLP is used in many financial contexts: from intelligent conversational interfaces (such as banking

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<sup>16</sup> Surkov, Alexey, Val Srinivas, and Jill Gregorie. "Explainable AI Unleashes the Power of Machine Learning in Banking." *Risk & Compliance Journal*, July 26, 2022. <https://deloitte.wsj.com/riskandcompliance/explainable-ai-unleashes-the-power-of-machine-learning-in-banking-01658847560>.

<sup>17</sup> Bahoo, Salman, Marco Cucculelli, Xhoana Goga, and Jasmine Mondolo. "Artificial Intelligence in Finance: A Comprehensive Review Through Bibliometric and Content Analysis." *SN Business & Economics* 4, no. 23 (January 20, 2024)

chatbots or digital assistants for private clients) to advanced document analysis tools for compliance and risk management teams<sup>18</sup>.

It is also used in personalised communication strategies in the financial sector. By understanding the tone, content, and context of messages, it can generate personalised emails, tailor-made offers, and dynamic answers to complex questions.

In the regulatory field, the NLP allows to monitor regulatory consistency and practice, analysing documents produced by financial institutions, speeding up controls. Moreover, by integrating it with Named Entity Recognition (NER) models, it can identify names, legal entities, products, and risks within regulatory texts.

By combining DL and NLP, analysis in the financial system takes a predictive and proactive form. This transition is also supported by the growing use of pre-trained models, such as BERT and RoBERTa, which can be adapted to specific financial contexts with relatively low computational costs<sup>19</sup>.

Again, there are challenges to be faced: the need for large quantities of quality data, the risks of over-fitting (overfitting), the lack of transparency of some models ("black boxes"), and the energy requirements of large-scale operations. In these cases, complementary models such as the Explainable AI are essential.

### *1.2.3 Generative Artificial Intelligence and Explainable AI*

Generative Artificial Intelligence (GenAI) could create innovative content, such as texts, simulations, images, personalized recommendations, and code. These extraordinary skills are made possible by advanced technologies such as the Large Language Models (LLMs) - including ChatGPT, Claude, and LLaMA - and the Generative Adversarial Networks (GAN), which operate through self-regulated learning mechanisms between two competing networks.

According to a recent analysis by McKinsey in collaboration with the Financial Times, the global finance industry is evolving from an experimental phase to a strategic

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<sup>18</sup> IBM. "AI vs. Machine Learning vs. Deep Learning vs. Neural Networks: What's the Difference?" IBM, July 6, 2023. <https://www.ibm.com/think/topics/ai-vs-machine-learning-vs-deep-learning-vs-neural-networks>.

<sup>19</sup> *Ibid.*, 12

implementation phase of GenAI. In particular, a strong emphasis is being placed on the automatic creation of content and the personalisation of services<sup>20</sup>.

One of the areas of use of GenAI is the automation of internal and external reporting. Banks and companies can automatically generate summary documents, market scenario forecasts, asset analyses, and periodic updates to send to clients. This reduces manual work and speeds up financial communication processes.

In addition, GenAI enables customers to interact with systems, creating intelligent conversation. The answers will, in this case too, be natural and personalised<sup>21</sup>.

The risks of this intelligent algorithm include questions about veracity, reliability, and safety.

As anticipated, the answer to these criticalities is Explainable AI (XAI), which can provide transparency, traceability, and comprehensibility of automated decision-making processes. This means, for example, explaining how a risk score was calculated<sup>22</sup>.

In short, GenAI and explainable AI are today a crossroads between the power of creativity and the need for decision-making responsibility. On the one hand, the ability to produce advanced content, simulations, and interactions opens up extraordinary opportunities for the entire financial system. On the other hand, the increasing emphasis on transparency and explicability ensures that these tools are used in a compliant, fair, and respectful manner of social and regulatory expectations. In the following chapters, we will explore these two approaches in detail within different institutional contexts, highlighting their strengths, areas of application, and potential risks.

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<sup>20</sup> Brown, Solly, and Enoch Chan. "From Experimentation to Value Creation: How to Navigate the Generative AI Journey." Financial Times, date not specified.  
<https://www.ft.com/partnercontent/mckinsey-and-company/from-experimentation-to-value-creation-how-to-navigate-the-generative-ai-journey.html>

<sup>21</sup> *Ibid.*, 9

<sup>22</sup> *Ibid.*, 12

## **2. AI IN CENTRAL BANKING**

### **2.1 The role of AI in Transforming Data Analysis, Monetary Policy, and Financial Supervision**

#### *2.1.1 AI and the Evolving Role of Central Banks*

Due to profound economic changes, central banks have adopted new instruments to address emerging challenges, using new tools.

One of these instruments is AI, which made central banks' cooperation fundamental. Artificial Intelligence has a significant impact on the main functions of central banks, influencing core activities, stimulating productivity, consumption, investment and labour markets.

Artificial Intelligence (AI) is getting increasingly relevant for central banks, which must ensure economic and financial stability. In fact, it is affecting various dimensions of economy, such as business productivity, consumer behaviour, investment, and the labour market. Consequently, all these factors will directly affect price stability and the financial system equilibrium, for example, giving the possibility to change prices quickly in response to economic changes, with direct implications for inflation.

In the last few years, central banks have been slowly changing their way of operating, employing AI to improve their services. These institutions are called upon to use AI tools to improve the implementation of monetary policy, financial supervision, and the stability of the economic system.

On the one side, central banks have to monitor the economic impact of AI on supply and demand. On the other side, they must develop skills to integrate AI into their analysis models, using new data and advanced tools. Additionally, central banks need to evaluate strategically the use of Artificial Intelligence and data management models, redefining their traditional functions as collectors, analysers, and information providers.

In particular, cooperation between central banks will be incrementally more essential in order to optimise resources and reduce costs related to the technology used and the training of personnel through the sharing of tools and knowledge.

### *2.1.2 AI Applications in Economic Analysis, Monetary Policy, Supervision, Payment Oversight and Financial Stability*

How has ML and AI been involved in central banks more specifically? We can divide it by categories: information collection and improvement, support for monetary policy, oversight of payment systems, and supervision and financial stability.

First, it is used for information collection, which includes gathering data from various sources, such as commercial banks, financial markets, businesses, households, and international institutions, to monitor financial stability and regulate the financial system. However, it is difficult for central banks to guarantee the availability of high-quality data for economic analysis and the compilation and production of statistics: the main challenges are data cleaning, sampling, representativeness, and matching new data to existing sources<sup>23</sup>.

Thus, central banks need new quality tools to give high-quality micro data, which are increasing in volume and getting more complex.

Central banks mainly use tools such as isolation forests, mainly employed to check and analyse large volumes of data. This system benefits financial analysis, by finding outliers in large data sets, without any further information on how these data are distributed. It is, though, necessary to combine AI and human experience. For this reason, this operates by letting the algorithm analyse data and finding irregularities. Afterwards, experts will audit the collected data, to refine the system.

One of the main challenges of this use of ML is the “black box”, which relates to AI’s lack of transparency: this means, experts should utilise this system just as a support for more detailed manual inspection.

Secondly, ML helps boost economic and financial analysis for monetary policy decisions. One of the main challenges is data mining, which involves the vastness of sources and data. As a result, models such as the Neural Networks, Random Forest, and LLMs are employed.

For example, neural networks are AI mechanisms that help better understand inflation in the service sector. More specifically, they can investigate and find which factor is most

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<sup>23</sup> Bank for International Settlements. Generative AI in Finance: Use Cases and Emerging Risks. BIS Bulletin No. 84, January 23, 2024. <https://www.bis.org/publ/bisbull84.htm>



influencing the increase of prices: within the causes, there are the inertia effect (increase in prices in the previous months), consumers and businesses expectations (how they expect prices to rise), the relationship between production and demand (if companies cannot meet demand, prices rise) and the trend in international prices (such as the cost of imported raw materials).

Unlike traditional methods of economic analysis, this tool has the capability of scrutinizing larger amounts of material and more detailed information, rather than relying only on general averages or aggregate statistics.

Another key benefit is the ability of this model to identify intricate, nonlinear correlations in data, detecting impacts that conventional models overlook, such as the impact of low interest rates (when interest rates are close to zero, the economy behaves differently compared to when they're high).

An additional example used for real-time estimates to consider is the Random Forest model, which implies the analysis of social media posts regarding prices to make predictions on inflation. Subsequently, another algorithm classifies these posts based on the content, making a distinction within inflation, deflation, or other economic expectations. For instance, if the majority of the posts talk about an increase in inflation, one can deduce that inflation is rising. On the other side, central banks can monitor public perception on the policy's credibility, through posts supervising.

Lastly, LLMs help consider economic and financial news. LLMs monitors and interprets interviews redacted by economists, entrepreneurs, and market experts, to give more accurate forecasts about future economic trends. Furthermore, these techniques support “nowcasting”, models used to get almost real-time estimates of the economy.

By elaborating the information, the model gives a sentiment index, an indicator that measures whether the opinions expressed in the texts are positive or negative regarding the economic situations. Such an index can be used to estimate the Gross Domestic Product (GDP; used to see if the economy is growing or not) or predict the risk of recession (identifying early signs of economic crisis)<sup>24</sup>.

The idea is to use new technologies to update these data rapidly, adding new information from time to time. These models bring together a lot of inputs, from company production

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<sup>24</sup> *Ibid.*

to knowledge found online. Advanced techniques allow large amounts of data to be analysed and reduced to key indicators to facilitate forecasting. The only limitation is the late availability of certain statistics, which delays ‘real-time’ estimation. This is where LLMs come in, which allow information to be collected automatically from texts, as mentioned above. Through news texts and posts on social media, images (e.g. photos of shopping centre car parks), or other sources, numerical data can be created that can be applied to nowcasting models. In addition, ‘sentiment’ can be identified through the attitude or tone of a text or speech, which can be used to improve the prediction of variables such as unemployment, GDP growth, and inflation.

A final advantage is the ability of LLMs to generate forecasts from few or no initial examples: in the past, estimates such as GDP or financial risks were developed through the creation of very customized models by experts, each time variables or parameters had to be changed. Nowadays, LLMs are originally trained to predict the next word by adapting historical data to a word-like format. This can be applied to a wide range of prediction tasks without the need for further modification, often with better results than traditional models. This capability is referred to as ‘few-shot learning’<sup>25</sup>.

Finally, training AI in central bank-specific language models can improve their effectiveness. A project of the Bank for International Settlements (BIS) has introduced a model called CB-LM, which is based on official speeches and documents from central banks. As a result, the accuracy in interpreting central bank technical thermals has increased from 50-60% to 90%, making analysis of monetary policy decisions and market reactions more accurate<sup>26</sup>.

Another fundamental use of AI by central banks can be found in the oversight of payment systems. The control of payment systems is essential to guarantee financial stability. Despite that, the presence of many data on transactions makes it hard to identify suspicious transactions. It is crucial to recognize unusual payments at an early stage to prevent critical situations such as bank failures, cyber-attacks, or illegal activities. In particular, money laundering poses a threat to the security and reliability of the entire global financial system.

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<sup>25</sup> Bank for International Settlements. Artificial Intelligence and the Economy: Implications for Central Banks. In BIS Annual Economic Report 2024, 91–112. Basel: Bank for International Settlements, 2024. <https://www.bis.org/publ/arpdf/ar2024e3.htm>

<sup>26</sup> *Ibid.*

An example that can be used to illustrate this application is the Project Aurora, developed by the BIS Innovation Hub to improve the fight against money laundering through the use of advanced technologies and collaboration between financial institutions. Money laundering is a global issue that compromises the global financial system's safety and integrity.

This project has been divided into two parts: a first part concluded in 2023 and a new phase that gained traction in 2024. In the 2023 BIS Report, it is stated that money laundering accounted for 2-5% of global GDP (\$2-5 trillion), yet less than 1% of these funds were seized annually. It is also claimed that a collaborative, data-driven approach was needed since Anti-Money Laundering (AML) siloed efforts were ineffective as criminals exploited financial networks.

The initial part of Project Aurora showed that technologies like AI and ML can increase the effectiveness in detecting complex money laundering schemes since Collaborative Analysis and Learning (CAL) is more effective than siloed methods. CAL enables financial institutions and regulatory bodies to collaborate while maintaining privacy, data protection, and security. As a result, the use of ML models assisted in identifying up to three times more recycling schemes than traditional methods, reducing false positives by up to 80%<sup>27</sup>.

The second phase, launched in 2024 and currently ongoing, focuses on: enhancing public-private stakeholder engagement and governance, conducting research, analysis, experiments, and learning initiatives, and developing real-world proofs-of-concept that could scale to a potential pilot. Consequently, specific results from this phase have not yet been published<sup>28</sup>.

The results so far have emphasised the necessity of practical proofs of concept, tackling technical, legal, and regulatory issues while guaranteeing privacy protection. Additionally, under Project Hertha, the BIS Innovation Hub London Centre will investigate privacy and financial crime prevention in greater detail.

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<sup>27</sup> Bank for International Settlements. Project Aurora: The Power of Data, Technology and Collaboration to Combat Money Laundering Across Institutions and Borders. Basel: Bank for International Settlements, May 2023. <https://www.bis.org/publ/othp66.htm>

<sup>28</sup> *Ibid.*

Furthermore, AI is utilized by central banks for financial supervision and system stability, which are crucial for operating in a safe and reliable environment. To do so, supervisors analyse a huge quantity of data from different sources, such as newspaper articles, internal bank documents, and assessment reports. Throughout the years, this work has become increasingly difficult, because of the size and time required. To make this process easier, central banks like the European Central Bank (ECB) are using AI and ML, developing platforms analysed in the next pages.

In short, Artificial Intelligence offers central banks a more effective way to monitor and understand economic trends, being able to process numerical data and less structured information more quickly. This approach gives banks a deeper insight into economic reality.

## **2.2 Practical Applications of AI in Central Banks and the Case of the ECB**

The ECB is primarily concerned with analysing large amounts of data, in order to be able to make informed decisions and maintain price stability within the European Union, as well as ensuring the safety and reliability of the European banking system. According to Myriam Moufakkir, the ECB's Chief Services Officer, said on the bank's website blog, in 2023 the ECB would start to explore the opportunities and challenges of AI in cooperation with other central banks of the European System of Central Banks (ESCB) and the relevant national authorities of the Single Supervisory Mechanism (SSM). ECB also participates in initiatives such as the Innovation Hub of the BIS<sup>29</sup>.

In a 2024 article published by Elizabeth McCaul, Member of the Supervisory Board of the ECB, for *Revue Banque*, it was confirmed that AI is a useful tool to improve customer experience and increase operational efficiency. Nevertheless, it was emphasized that these new technologies can still entail “risks which are not yet fully understood.”<sup>30</sup>, including data governance (confidentiality and reliability of data used to train AI models), liability issues, and emerging operational risks.

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<sup>29</sup> Molinengo, Pierpaolo. "La Bce pronta ad utilizzare l'intelligenza artificiale. Ecco come." *Wall Street Italia*, September 29, 2023. <https://www.wallstreetitalia.com/bce-intelligenza-artificiale/>

<sup>30</sup> McCaul, Elizabeth. "From Data to Decisions: AI and Supervision." *European Central Bank*, February 26, 2024.

<https://www.bankingsupervision.europa.eu/press/interviews/date/2024/html/ssm.in240226~c6f7fc9251.en.html>

### *2.2.1 Practical Applications and SupTech Tools, Future Strategy and Collaborations*

The main uses of LLMs, similar to ChatGPT, can be summarized in three main points.

First of all, new technologies are used about data classification. This is an essential task, which allows economic and financial decisions to be made within the ECB. In the past, statisticians were responsible for collecting and analysing data from more than ten million legal entities in Europe, such as financial institutions or the public sector. Thanks to the advent of new technologies such as ML, automating data classification is now possible.

Secondly, the ECB employs web scraping technologies (a technique used to extract data from web pages and then collect them in local databases or tables for analysis<sup>31</sup>) and ML, to detect and understand unstructured and difficult data, advantageous for inflationary dynamics and price behaviour. With the Price-setting Microdata Analysis, the ECB, together with other economists and researchers in the euro area, is investigating how AI can accurately and precisely provide such data.

Finally, AI is applied to review and analyse a large number of documents, e.g. internal documents of the banks themselves. Athena has been created for this initiative.

Another key point is the European Banking Supervision, whose job is to make sure that European banks remain strong and safe, which also exploits AI to improve both efficiency and quality, making the work of supervisors quicker. Indeed, the ECB's Banking Supervision has adopted AI models to rapidly analyse large amounts of data and identify risks. To address these challenges, the ECB has invested in the development of a portfolio of Supervisory Technology (SupTech) devices to help supervise the vast and complex banking sector. In the last three years, 14 applications and platforms have been developed and used by more than 3,500 users across ECB and the national supervisors<sup>32</sup>.

Daniela Schackis, Deputy Director-General for Governance at the SSM, underlines the importance of Artificial Intelligence: "In the age of information, embedding AI in our day-to-day work is essential."<sup>33</sup>

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<sup>31</sup> Fumagalli, Andrea. "Web scraping: cos'è, perché si usa e come difendersi da 'intrusioni' indesiderate." Agenda Digitale, 23 aprile 2021. <https://www.agendadigitale.eu/sicurezza/web-scraping-cose-perche-si-usa-e-come-difendersi-da-intrusioni-indesiderate/>

<sup>32</sup> *Ibid.*, 21

<sup>33</sup> Popowicz, Joasia E. "Artificial Intelligence Initiative: European Central Bank." Central Banking, June 14, 2023. <https://www.centralbanking.com/awards/7958739/artificial-intelligence-initiative-european-central-bank>

The vision and action plan that are leading this transformation are laid out in the SSM Digitalization Blueprint, adopted in 2020. This is a strategic plan for implementing digital tools and technology into the banking supervision process within the Eurozone. Supervisors should implement this digital innovation to be able to handle large volumes of data, improve customer interactions and support, and ultimately, fraud detection. In addition, from 2020, more than 2,600 people have been trained through comprehensive training programmes to be able to manage and use these systems.<sup>34</sup>

The ECB organises courses with prestigious institutions such as Coursera and the Institut Européen d'Administration des Affaires (INSEAD) Business School and, every year, a conference on digitisation, bringing together experts from the banking sector, academia, and technology industry. Crucial components of the training architecture include the Data Science School, created in association with the famous Coursera and Banco de Portugal, alongside training preparations dedicated to digital transformation and AI taught by institutions such as INSEAD. Essential rudimentary training is covered under the European Union's AI Act, ensuring personnel is aware of the present regulations relating to Artificial Intelligence. The second pillar of the supplement is composed of leadership sessions, which offer one-on-one coaching and specific training in particular areas, including GenAI and its role in digital transformation. These again are availed by the leading institutions, among them INSEAD.

Specialised training extends to advanced resources such as the Massachusetts Institute of Technology (MIT) CISR Virtual Library and highly interactive e-learning modules hosted by platforms like Mia and Netcompany. These include focus on practical applications comprising use of AI across the SSM, supporting and enabling employees to effectively apply new technologies to supervisory tasks. In promoting a more comprehensive digital culture within the ECB, membership encourages attendance to events like the Supervision Innovators Conference and promotes internal sharing of knowledge and experience through formats such as Suptech talks and blogs. Furthermore, new internal platforms SSMnet and ECB Banking Supervision website would give an added avenue of

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<sup>34</sup> McCaul, Elizabeth. "SSM Digitalisation – From Exploration to Full-Scale Adoption." Speech presented at Central Banking's Summer Meetings, June 12, 2024. European Central Bank. [https://www.bankingsupervision.europa.eu/press/speeches/date/2024/html/ssm.sp240612\\_1~a3ace1ed8e.en.pdf](https://www.bankingsupervision.europa.eu/press/speeches/date/2024/html/ssm.sp240612_1~a3ace1ed8e.en.pdf)

continuous access to relevant contents and updates, further contributing to improving the digitally aware and AI-literate workforce<sup>35</sup>.

Among the main SupTech tools developed and used for banking supervision are GABI, NAVI, Heimdall and Medusa, and Athena<sup>36</sup>.

First, it is mentioned the Virtual Lab, a collaborative cloud platform, which has improved collaboration within European banking supervision and integrated new technologies, including GenAI. The latter is used in various ways, including automated responses on supervisory methodologies, with clear references to internal guidelines, and automatic translation of natural language queries into code, to query complex databases without the need for programming knowledge.

One of the most interesting applications is Agora, the ‘data lake’ of European banking supervision. Through GenAI, supervisors can formulate questions in natural language and obtain the required data directly, simplifying the process.

The NLP tool Athena was introduced in 2023 by the ECB to improve supervisory and regulatory processes, in cooperation with Squirro, a company specialising in data analytics. Athena allows more than 5 million SSM documents to be analysed efficiently, identifying key information, risk trends, and anomalies in the banking sector, enabling a more proactive approach. This platform collects and analyses bank articles and documents, allowing bank inspectors to access credit files in digital format and distinguish more targeted strategies by quickly identifying risks and market trends. In addition, it gives the possibility to simplify regulatory controls, ensuring consistency with European standards<sup>37</sup>.

GABI is a big data analysis platform, allowing more data to be analysed and compared in more detail.

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<sup>35</sup> *Ibid.*

<sup>36</sup> European Central Bank. "Suptech: Thriving in the Digital Age." Supervisory Newsletter, November 15, 2023. [https://www.bankingsupervision.europa.eu/press/supervisory-newsletters/newsletter/2023/html/ssm.nl231115\\_2.en.html](https://www.bankingsupervision.europa.eu/press/supervisory-newsletters/newsletter/2023/html/ssm.nl231115_2.en.html)

<sup>37</sup> Araujo, Douglas Kiarely Godoy de, Sebastian Doerr, Leonardo Gambacorta, and Bruno Tissot. "Online Annex for 'Artificial Intelligence in Central Banking'." BIS Bulletin, no. 84, January 23, 2024. [https://www.bis.org/publ/bisbull84\\_annex.pdf](https://www.bis.org/publ/bisbull84_annex.pdf)

NAVI is a network analysis tool that facilitates the understanding of complex bank ownership structures by creating diagrams of the relationships between different financial institutions.

Heimdall helps to assess the suitability of members of banks' boards, while Medusa helps to transcribe and check reports on investigations of banks' internal models.

Lastly, Atlas, a digital solution for the decision-making process is depicted. This is a Project realised with the BIS, De Nederlandsche Bank, and the Deutsche Bundesbank. The aim of this project is to design and develop a data platform to analyse the economic impact of cryptocurrencies and centralised finance (Defi). In this context, Artificial Intelligence is therefore mainly used for data analysis, processing and visualisation<sup>38</sup>.

Complementing on-chain and off-chain data, Atlas verifies and organises information, filtering and organising large amounts of data, reducing errors. Secondly, the system can track cryptocurrency movements between different countries and capital movements, useful for understanding the macroeconomic impact of crypto assets. This data is represented through an interactive globe, which facilitates the visualisation and interpretation of flows between different countries. Furthermore, this platform, through AI algorithms, allows transactions to be classified and verified, distinguishing them into different categories. Although still in its early stages, AI is being used to identify trends and predict developments in cryptocurrency markets, providing specific statistics based on the needs of central banks<sup>39</sup>.

The SSM innovation ecosystem of the ECB is sustained by a partnership strategy with a variety of actors, including peer authorities, academics, the industry, and start-ups. These collaborations aim to strengthen supervision by applying new tools, methods, and expertise from various fields.

It works with top academic institutions and research centres like INSEAD, MIT, and Eidgenössische Technische Hochschule Zürich (ETH) to develop the cutting edge of innovation in financial supervision. Simultaneously, it works with an array of start-ups to develop specialised tools and studies with the Initiative for Applied Artificial Intelligence, Alexander Thamm, and Squirro, which support its supervisory mandate.

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<sup>38</sup> *Ibid.*, 21

<sup>39</sup> Bank for International Settlements, De Nederlandsche Bank, and Deutsche Bundesbank. Project Atlas: Mapping the World of Decentralised Finance. October 4, 2023. <https://www.bis.org/publ/othp76.htm>.



From the industry perspective, the ECB engages with big technology firms like International Business Machines Corporation (IBM), Amazon Web Services (AWS), and Microsoft to develop and run cutting-edge digital solutions specific to supervisory needs. The collaborations with the industry give access to scalable and secure technologies which will allow the ECB to react to the rapidly changing financial landscape.

With great emphasis on maximizing its collaborative approach, the ECB maintains strong partnerships with international authorities as well as the local innovation leaders across Europe and the globe. Coordinated efforts in regulatory innovation are facilitated under the ECB's partnership with the European Banking Authority (EBA), the Bank for International Settlements (BIS), the Financial Stability Board (FSB), and the Monetary Authority of Singapore (MAS). Last but not least, the ECB advances cooperation with other major institutions, including the Bank of England, the U.S. Federal Reserve, and the Central Bank of Brazil, further contributing to transparency, knowledge sharing, and the global alignment of supervisory practices.

In conclusion, the SSM Tech Strategy intends to consolidate IT systems and to enhance supervisory analytics and automating process to improve collaboration by 2028. To do this, partnerships with international authorities, industry players, academia, and startups will be indispensable, ensuring that the European banking sector remains robust and resilient amid technological advancements<sup>40</sup>.

Despite the great importance of using AI, the ECB emphasises human judgement in supervision. Ioana Karger, leader of the ECB's SupTech team, explains: “We are committed to keeping the human in the loop. It is the supervisor who can go to the text, read the context, assess it, and provide feedback on these enrichments, creating an iterative ML process informed by users’ expertise.”<sup>41</sup>

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<sup>40</sup> *Ibid.*, 22

<sup>41</sup> *Ibid.*, 22

## **2.3 Challenges and Risks of AI Implementation in Central Banks**

### *2.3.1 Opportunities, Risks, and Benefits of AI in Central Banks*

In recent years, the use of AI has been transforming the financial sector, with the potential to generate significant economic benefits by performing tasks that would traditionally require human cognitive capacity.

According to McMullen's analysis (2023), there are top five benefits of AI adoption: greater efficiency in customer service, better debt collection management, faster risk assessment, and a personalised customer experience.

First of all, in the area of customer services, AI offers the possibility to improve operational efficiency and reduce costs. This is achieved by automating answers to frequently asked questions with quick and accurate answers, reducing the workload of human operators. Furthermore, banks can leverage chatbots and virtual assistants to drive personalised and targeted customer conversations. Lastly, it reduces waiting times and improves the overall customer experience.

Secondly, AI provides advanced tools to optimise debt collection, allowing them to anticipate risks and act promptly to mitigate losses.

Furthermore, AI can improve risk management and regulatory compliance by identifying in more detail customers who may not be eligible for certain financial products.

With regard to loans, ML and process automation make it possible to speed up the evaluation of loan applications, reducing the time needed for approval and disbursement.

Finally, the customer experience is improved by harnessing Artificial Intelligence to anticipate their needs and propose tailor-made services.

While the benefits of using AI are manifold, the risks also need to be considered, risks that amplify those that already exist.

According to the Organisation for Economic Co-operation and Development (OECD, 2023), incidents attributed to GenAI exponentially increased between December 2022 and September 2024, reaching 730 cases in June 2024<sup>42</sup>.

First, it can cause problems coming from model bias and transparency of decisions made. Furthermore, it can cause complexity in legal and regulatory management and compliance. Data governance becomes complex due to the large amount of data provided by AI, requiring increased attention to its quality, security, and management. Moreover, the lack of proper governance can introduce significant vulnerabilities, as AI systems, in the presence of excessive authorisations and functionalities, may perform unnecessary operations, such as modifying and deleting data.

A further risk concerns information security and privacy: outputs may not comply with regulations, such as copyright laws, and may contain confidential information, introducing the risk of data leaks and privacy violations. These new systems expand the possibility of cyber-attacks, which include threats of input manipulation (prompt injection), corruption of training data (data poisoning), and model theft. AI could be exploited to conduct fraud, scams, or phishing attacks. Moreover, through the creation of deepfakes with AI, central banks have already had to counter the creation of fake content.

Central banks rely on external providers for the creation and management of Artificial Intelligence models, with consequences for security and privacy. A heavy reliance on a small number of companies could lead to an increased risk of operational disruptions, should the supplier encounter difficulties. Consequently, central banks have little room for manoeuvre, as it is more complex to customise and strategically update the systems used.

The reliability of these new models depends on the quality of the data used: incomplete or incorrect information may create unreliable forecasts, and the use of generic datasets may not be suitable for dealing with more specific and complex issues.

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<sup>42</sup> Bank for International Settlements. Governance of AI Adoption in Central Banks. Consultative Group on Risk Management. Basel: BIS, January 2025. <https://www.bis.org/publ/othp90.htm>

Phenomena such as so-called AI hallucinations, especially evident in generative models, lead to baseless results and misleading correlations (overfitting phenomenon) due to the large amount of data.

A further problem concerns the consistency of the answers provided by AI, which vary depending on when and how the query is formulated, raising doubts as to their reliability.

In conclusion, the possibility of one or more of the problems described above materialising can generate controversy and amplify the consequences, damaging the image and credibility of the institutions that use them. Risks represent identifiable and manageable challenges, consequently, central banks could transform the essential AI models in their processes, through correct and transparent use, demonstrating their reliability and effectiveness.

For effective risk management in AI adoption, central banks need to follow a strategy that includes defining the risk profile of AI, selecting the most suitable projects, adapting existing governance structures, and protecting data.

### **3. AI IN COMMERCIAL BANKING**

#### **3.1 Role of AI in Traditional Banking Services**

##### *3.1.1 The Digital Shift in the Banking Sector*

The banking sector is characterised by competition and an accelerated evolution of Artificial Intelligence, pushing traditional institutions to a rapid adaptation. To meet the needs of customers who require tailored services, immediate access, and efficiency at any time and place, banks must embark on a complex digital transformation journey. On a par with their customers, banks using AI provide more credit at lower rates than other banks in normal times; however, this difference is not seen during the pandemic crisis. Moreover, banks that use Artificial Intelligence are less affected by large-scale economic changes (macroeconomic fluctuations), such as those of the pandemic, helping to reduce negative impacts on investment and business occupations<sup>43</sup>.

Commercial banks must transform their current operating model to become relevant in a more technologically oriented and competitive world. This transformation rests upon four absolute pillars: a customer-centric digital strategy, modernization of the IT infrastructure, development of a digitally oriented corporate culture with training of talents, and reinforced both cyber security and data protection.

At the heart of transformation is the necessity to adopt a customer-centric approach or, needs based on customers rather than banking products. The new bank will demand products that support their needs for personalized, immediate access across multiple channels, such as mobile applications, websites, or even physical branches. Such techniques as AI and data analytics are also applied to understanding the behaviour and needs of clients, thus presenting appropriate solutions to enhance engagement, satisfaction, and loyalty.

Modernising technological infrastructures is another important aspect. Many banks still operate old systems that limit responsiveness and safety. Moving to technologically advanced solutions such as cloud computing allows banks to function in a flexible, safe, and effective manner. The cloud also eases the integration of the latest technologies

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<sup>43</sup> Gambacorta, Leonardo, Fabiana Sabatini, and Stefano Schiaffi. Artificial Intelligence and Relationship Lending. Temi di Discussione (Working Papers) No. 1476. Rome: Bank of Italy, February 2025.

such as big data analytics, blockchain, and Artificial Intelligence, speeding up their decision and enhancing service quality.

Digital innovation should include creating a digitally oriented organizational culture. It implies investment in both technical and soft-skills training for employees. Banks have to train their workforce on issues such as data analytics, information security, and digital marketing but also build capabilities, such as critical thinking, flexibility, or the ability to collaborate. Finally, be able to attract and retain such professionals with world-class conditions in the new-age workplace.

Last but not least, in a situation where banking operations are becoming more and more digitalized, strengthening the systems and protecting personal data proves indispensable. Electronic threats are counting to increase steadily, and banks should equip advanced tools such as encryption, multi-factor authentication, and real-time monitoring systems to prevent violations and ensure the trust of customers<sup>44</sup>.

### *3.1.2 AI Applications in Banking Operations*

These days, AI is not merely improving internal processes; it is enhancing customer experience personalization, efficient operations, human resource value, and risk management.

The most important aspect of AI is the personalization of services, which leads to an increase in customer satisfaction and loyalty. By analysing considerably large data wherein the preferences, behaviours, and financial histories are considered, these intelligent tools are capable of recommending customized products in real time, improving the relationship of the customer with that institution. Conversational technologies such as chatbots and virtual assistants help to offer continuous personalized assistance and resolve requests quickly and efficiently without any human intervention.

Through this integration of AI, deep operations are automated and the need for manual processes is greatly reduced, thereby significantly reducing the associated costs and shrinking the margins of error. Data-entry tasks, transaction processing, or compliance regulation checks are sped up and simplified. AI is also used in streamlining major

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<sup>44</sup> Tian, Xuanning. The Role of Artificial Intelligence in the Digital Transformation of Commercial Banks: Enhancing Efficiency, Customer Experience, and Risk Management. SHS Web of Conferences 208, DSM 2024. EDP Sciences, 2024.

strategic processes, such as loan clearance, risk assessment, and fraud detection, by quickly analysing huge amounts of data to provide accurate and timely responses.

Also, another area that exposes AI as having a very salient effect involves maximizing human capital. With the monotonous tasks automated, personnel are freed to engage in strategic activities such as managing client relationships or developing innovative solutions. With fruitful data-backed decisional capability, productivity improves while creating a much more versatile and exciting work atmosphere.

### *3.1.3 Challenges of AI Adoption in Banking, Regulation and Ethical Frameworks*

Even though Artificial Intelligence could save a lot on efficiencies, personalizing service, and risk management; there are still critical problems that an AI integrated into a commercial bank will face. Digital transformation demands that complex questions concerning data privacy, ethics, transparency, and the workforce be addressed. These highlight how using AI does not have critical implications in the banking sector.

Among the most important problems is that of data privacy and security management. Using AI involves processing huge bulk of personal and financial information like transaction histories or identifiers of customers. Even if for the purpose of providing customized services, storing and analysing this information increases risks from cybercrimes, unauthorized access, or data leaks, loss or misuse of information could very well damage the institution's reputation and the trust of users, making data protection number one priority for any bank adopting AI-based solutions.

Another noticeable challenge stems from ethical and moral issues that linked use of Artificial Intelligence. AI models are usually trained on historical datasets which often have bias in them, leading to skewed and discriminatory results. A good example of this is in loan assessment tests where certain groups of people might suffer disadvantage due to biased data. These situations can raise legal and reputational questions in addition to burgeoning effect on the principle of fairness regarding financial service accessibility.

Moreover, how many AI technologies operate happens to pursue very complex and non-transparent logics so generating what is called the "black-box problem": it is very difficult to detail why an algorithm has taken some decision. Thus, this black box situation may complicate accountability toward clients and authorities raising doubts about reliability and responsibility for automated choices.

Finally, the widespread implementation of AI has raised alarms regarding the future of work within the banking industry. The automating of repetitive tasks such as customer service, processing loan applications, or monitoring transactions may create traditional job loss on a considerable scale. This scenario raises crucial questions regarding job security, balance between technology and workforce, and dependency on machines<sup>45</sup>.

With the growth of Artificial Intelligence in the banking processes, it has given birth not only to benefits but also to very complex liabilities, especially about data privacy, ethical implications, and impact on employees. It is important for banks to think in a holistic manner about those aspects if they want to provide a transformative digital experience.

Legislatively, data privacy is increasingly becoming a global priority, especially in Europe and the United States, where regulations such as the General Data Regulation (GDPR) impose serious standards for organizations. Banks must guarantee that their AI systems are compliant with such legislation by implementing advanced protocols in terms of information protection, transparency in the use of data, and higher access to their customers' private data. The real goal is to achieve a balance between the strategic use of AI for the tailoring of services and the legal adherence to the norms so that customer trust is not compromised.

Besides this, the banks need to develop fair, responsible and transparent AI systems. Inequitable results can occur through the monitoring of algorithms for bias identification and correction, by using diverse datasets and adopting explanation-tools that clarify automated decisions. Such ways of improving responses to inquiries from customers and regulators are consequently great in reducing risks associated with the concern about the opacity of algorithmic decisions.

Another important thing is the change management of the workforce. The introduction of AI in banking processes almost always necessitates the restructuring of the organization along with the elimination of repetitive functions as well as the emergence of new opportunities for result achievement. In handling these changes, the banks are required to introduce reskilling for their employees and also provide training on digital, technical, and supervisory skills. In a more automated environment, the demand for

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<sup>45</sup> Svoboda, Andreas. "The Impact of Artificial Intelligence on the Banking Industry." *Journal of Banking and Finance Management* 4, no. 1 (2023): 7–13.



human intervention in cases of system failures, errors, or hacking increases, thus necessitating a reorganization of work where human monitoring turns out to be crucial for the efficiency, reliability, and safety of operations<sup>46</sup>.

A digital transformation in banking should, therefore, be consistent with responsible management of such transformations through the AI environment. This is the only approach which can ensure a balanced response to the regulatory, ethical, and employment-related challenges that innovation poses while carrying through the needed technological transformations in line with core values of transparency, fairness, and security.

### **3.2 AI-Based Credit Scoring Models**

#### *3.2.1 The Role and Evolution of Credit Scoring*

In modern banking, credit scoring has become an essential tool to manage credit risk effectively, as banks must adapt to constant market changes.

Credit scoring is a tool to test a customer's creditworthiness from a financial point of view by analysing their credit history, money management, and other relevant factors, thereby optimising the decision-making process and reducing time and resources.

Through this system, banks are able to estimate the probability that a customer will fail to repay a loan and make more confident decisions. With advances in data analysis and technology, credit scoring models have become increasingly sophisticated, using variables and statistical tools to be more accurate and efficient.

One of the advantages of credit scoring is its ability to improve risk management.

Banking institutions can more accurately estimate the probability of default, and the level of risk associated with each loan by analysing credit scores. In this way, banks can allocate their resources appropriately, taking preventive measures to reduce potential losses.

In addition, the use of this tool makes lending decisions more objective: as it is based on standardised criteria, it favours a fairer, risk-based determination of interest rates.

Customers with a higher credit score can obtain more advantageous terms, while those with a riskier profile may be charged higher interest rates.

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<sup>46</sup> *Ibid.*, 30

In addition, credit scoring is a fraud prevention tool. Banks, through sophisticated mechanisms, can detect suspicious behaviour and potentially fraudulent activities, protecting the institution and the customer from financial losses.

Another key aspect concerns the optimisation of the loan portfolio. Monitoring credit scores allows banks to individualise potential concentrations of risk, reducing exposure to unreliable borrowers and ensuring a balance between risk and return.

Credit scoring is also a key element in meeting the regulatory requirements imposed in the banking sector. Regulators increasingly require credit scoring models to ensure that lending practices are transparent and fair. By using these tools, banks can demonstrate compliance with applicable regulations, strengthening their reputation and enhancing investor confidence.

From an operational perspective, the use of credit scoring significantly improves the efficiency and productivity of financial institutions. Indeed, banks can process more requests in less time and reduce operational costs. This allows for more accurate management of customer relations, enabling them to offer personalised financial products to customers.

Since its introduction, credit scoring has undergone an important historical evolution, mainly due to the integration of Artificial Intelligence into credit assessment processes. Its origins date back to the mid-20th century, when financial institutions began using manual systems based on predefined rules to assess an individual's creditworthiness. The first models, simple and inflexible, assigned scores to criteria such as income, employment history, and outstanding debts, which allowed lenders to estimate the risk of granting a loan.

Later, the models became more obvious but still static and unable to update with real-time data. This rigid and standardised approach led to inaccurate evaluations, penalising or unfairly excluding certain parties. Moreover, the models in question limited financial inclusion, not adapting to situations where applicants did not have a traditional credit history.

With the integration of Artificial Intelligence came a radical change in credit scoring. ML algorithms have made it possible to overcome the limitations of the old models by introducing an approach based on data analysis. These algorithms have made it possible

to analyse vast amounts of data, detect patterns, and make predictions with much greater precision and efficiency than traditional systems. As a result, credit risk assessment has become more detailed, including more factors in addition to the conventional ones.

The rigidity problems of previous models have been solved with the introduction of neural networks, decision trees, and ensemble methods, capable of adapting to changes updating with real-time data, and learning new patterns. Furthermore, the use of alternative sources, such as social activity and online behaviour, has further expanded the possibilities of credit scoring, making assessments more inclusive<sup>47</sup>.

AI in credit scoring has made the risk assessment process more precise and adaptable to changing market conditions.

### *3.2.2 AI Techniques in Credit Scoring*

One of the most popular approaches is regression models, which aim to establish the relationship between several independent variables and the dependent variable, represented by credit risk.

However, for situations in which there are two possible outcomes, such as determining the probability of a customer's default, logistic regression is used, which offers more accurate results and is easier to interpret.

These models provide insight into which factors most influence an individual's ability to repay a loan.

Another widely used technique in credit scoring is decision trees, which divide the scoring process into several sequential steps based on financial characteristics such as income and payment history. An evolution of this technique is the Random Forest, which combines several decision trees to improve the accuracy of forecasts and reduce the risk of errors due to excessive sensitivity to training data.

Artificial neural networks have helped to further develop this field. These data networks, structured on different levels of interconnected nodes, arrive at a final prediction of the credit score through in-depth analysis. Among the most widely used

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<sup>47</sup> Addy, Wilhelmina Afua, Adeola Olusola Ajayi-Nifise, Binaebi Gloria Bello, Sunday Tubokirifuruar Tula, Olubusola Odeyemi, and Titilola Falaiye. "AI in Credit Scoring: A Comprehensive Review of Models and Predictive Analytics." *Global Journal of Engineering and Technology Advances* 18, no. 2 (2024): 118–129.

neural networks in the field are the Multi-Layer Perceptron (MLP), which allow their weights to be adjusted during the learning phase and, consequently, refine the accuracy of the predictions.

Furthermore, DL techniques such as RNNS are useful when it comes to analysing large unstructured datasets, detecting complex correlations between various financial variables.

Finally, ensemble models with techniques such as boosting, bagging, and stacking manage to combine multiple algorithms to increase the reliability of forecasts. Boosting includes techniques such as Adaboost and Gradient Boosting, which optimise the model and correct errors in previous forecasts. Bagging, as in Random Forest, trains multiple models and aggregates the results for a more stable evaluation. Stacking, on the other hand, combines several models such as regression and neural networks, exploiting their strengths to improve forecast quality<sup>48</sup>.

### *3.2.3 Implications for Financial Inclusion and Risk Management*

The increasingly widespread adoption of AI by financial institutions has concrete implications, offering significant benefits, but also affecting consumers' perceptions of trust.

As far as real-world implications are concerned, one of the most significant aspects relates to financial inclusion, which has widened access to credit to categories of people who have traditionally been excluded. Indeed, traditional credit scoring models have not always been able to make accurate assessments due to the limited amount of data. Instead, AI examines data from alternative sources, allowing lenders to analyse multiple factors. For example, those with a limited credit history or from marginalised communities can now be assessed more fairly.

The implication of AI also helps limit discrimination in the credit allocation process, as these models are based on objective data rather than demographic information, ensuring more impartial evaluations.

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<sup>48</sup> *Ibid.*

In addition to financial inclusion, AI improves the accuracy of credit risk forecasts by identifying complex patterns and subtle correlations between financial information, providing a more accurate and detailed analysis.

Moreover, a limitation of traditional models is their rigidity, which is overcome by AI. The latter introduces a dynamic approach to risk assessment, constantly updating forecasts based on new data. This approach ensures greater responsiveness to economic changes and enables rapid adaptation to market fluctuations and changes in customers' credit profiles.

AI models also make it possible to anticipate possible defaults by identifying emerging trends. Thanks to this, banks are able to take preventive measures to reduce losses and maintain portfolio stability. In addition, by optimising decision-making processes and thus accelerating risk assessment and loan approval, customer satisfaction can be achieved.

When developed in a transparent and fair manner, these models ensure more objective and consistent decisions. This minimises the influence of subjective assessments, reducing the risk that human biases may influence the outcome of credit applications.

#### *3.2.4 Challenges, Regulations, and Ethical Considerations*

Nevertheless, the use of AI is not without its criticalities. One of the main problems is the lack of transparency of some models, which may be difficult for consumers to understand. If people find it difficult to clearly identify the criteria underlying their credit assessment, they may develop distrust of automated credit scoring systems. To avoid this problem and maintain user confidence, it is necessary for financial institutions to ensure that models are adequately explained.

Another crucial challenge concerns the protection of personal data. AI models rely on the analysis of large amounts of financial and personal data to produce a more accurate result. However, the use of this sensitive data raises privacy and security concerns.

Therefore, effective measures must be taken to protect the information from unauthorised access, data breaches, and possible misuse. Furthermore, regulations such as the GDPR ensure that financial institutions implement transparent data management policies, obtain users' explicit consent before using the information, and adopt strict data governance practices.

For example, from a regulatory point of view, the Banca d'Italia follows the European guidelines to ensure the reliability and transparency of AI models. Financial intermediaries must comply with a few regulatory requirements including data quality, internal controls and governance, traceability and transparency, and supervision of authorities (to demonstrate compliance with EU regulations).

In addition, the EBA Guidelines require supervised entities to adopt policies to detect and prevent distortions by ensuring the quality of the data used and regularly evaluating scoring models. These measures are needed to balance technological innovation with consumer protection<sup>49</sup>.

Another problem is the possibility of algorithms reproducing and amplifying pre-existing biases in historical data. Training models on distorted datasets means risking injustice and discrimination against certain groups. Indeed, it is necessary to constantly monitor the models, detect any bias, and apply corrective measures to eliminate disparities. This is a complex problem, as on the one hand, the models must be as precise as possible, while on the other hand, they must avoid unfairly penalising certain categories of applicants.

As a result, financial institutions must establish clear ethical guidelines for the use of AI in credit scoring, effectively balancing predictive accuracy with the need to prevent discriminatory practices.

Techniques such as XAI can help make the decision-making process more transparent, allowing unfair patterns to be identified and corrections made.

XAI is the set of techniques and methods developed to make models of Artificial Intelligence more transparent, interpretable, and understandable. For example, if a client is refused a loan, an XAI system could explain that the credit score has been negatively affected by income too low compared to the requested amount or delayed payments in recent months. This explanation would allow the client to understand the reasons for the decision and, if necessary, improve their financial profile to obtain credit in the future<sup>50</sup>.

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<sup>49</sup> Bonaccorsi di Patti, Emilia, Filippo Calabresi, Biagio De Varti, Fabrizio Federico, Massimiliano Affinito, Marco Antolini, Francesco Lorizzo, Sabina Marchetti, Ilaria Masiani, Mirko Moscatelli, Francesco Privitera, and Giovanni Rinna. Artificial Intelligence in Credit Scoring: Analysis of Some Experiences in the Italian Financial System. Banca d'Italia, Questioni di Economia e Finanza (Occasional Papers) No. 721, October 2022.

<sup>50</sup> *Ibid.*

In conclusion, credit scoring has established itself as an essential tool in managing credit risk, evolving from simple fixed rule-based models to sophisticated AI-powered systems. The use of ML and neural networks has improved its accuracy and speed of assessments, but also introduced challenges related to transparency and data protection. To ensure trust and regulatory compliance, financial institutions must balance innovation with ethical accountability, ensuring fair and secure models<sup>51</sup>.

### **3.3 Customer Experience and the Use of Chatbots and NLP**

#### *3.3.1 Enhancing Customer Experience through AI*

In the digital age, it's critical to deliver personalised and functional experiences to ensure you meet your customers' high expectations. In this respect, Artificial Intelligence is offering tools and solutions that allow to better understand its customers, even anticipating and satisfying their needs in real-time.

Artificial Intelligence and Customer Experience (CX) have become closely interconnected through technologies such as chatbots, predictive analytics, and NLP. According to a study by McKinsey & Company in 2023, AI improves customer service through real-time personalisation, predictive analytics, and operational efficiency, while also helping to reduce costs and strengthen customer loyalty.

This trend is confirmed by a Salesforce survey, which confirms that 63% of customer service professionals believe GenAI will help them support customers more effectively. This data demonstrates the growing importance of AI in customer experience, underlining its role in transforming customer service and driving innovation across industries<sup>52</sup>.

In this regard, one of the most significant impacts of AI on the digitization of banks is the strengthening of customer loyalty.

As the demand for more personalised and accessible services increases, commercial banks need to develop a better understanding of their needs and preferences. To meet

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<sup>51</sup> Moghe, Meeta Sharma, and Shiva Johri. "The Role of Credit Scoring in Modern Banking: An Overview of Methodology & Implementation." UNNAYAN 16, no. 1 (January 2024): 209–226.

<sup>52</sup> SmartDev. "Personalizing Customer Experience Through AI: How Virtual Assistants Create Tailored Interaction." SmartDev, [n.d.]. <https://smartdev.com/personalizing-customer-experience-through-ai-how-virtual-assistants-create-tailored-interaction/>

these needs, the use of data-driven approaches is becoming more widespread, enabling customers' behaviour to be analysed and their future actions predicted.

Being able to accurately anticipate clients' goals enables institutions to offer precise incentives, improve customer satisfaction, and strengthen loyalty. In an increasingly competitive environment, this ability becomes essential to maintain a strong and stable relationship with customers.

As mentioned above, one of the key points of introducing AI in commercial banks is to strengthen customer loyalty. In fact, thanks to the capabilities of analysis and autonomous learning, Artificial Intelligence can detect trends, predicting behaviours, and offering personalised services, through the detailed analysis of huge amounts of customer information.

As a result, the ability to respond to individual needs improves the customer experience. For example, AI tools can offer tailored financial solutions by carefully studying the customer's financial history, preferences, and expenses.

Second, commercial banks can make use of chatbots, and virtual assistants powered by AI, offering instant support and availability 24/7. This feature ensures fast and accurate responses, as they use data from previous interactions to offer customised proposals<sup>53</sup>.

In more depth, banking chatbots are digital assistants created to communicate with customers through different channels, such as websites and phone apps. Using ML, these assistants can understand customer requests and then help them effectively. Initially designed to answer simple questions, these tools have now become more sophisticated, being able to handle banking transactions, provide financial advice, and support users in emergency situations.

First, one advantage of chatbots is their ability to respond in real-time to customer needs. For example, the chatbot can follow step by step, without the need of an operator, a customer who must re-import a password or access an online service. In urgent situations, when a customer needs assistance outside of office hours, they can rely on AI to reduce waiting times and improve their experience.

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<sup>53</sup> *Ibid.*



Second, chatbots can perform real-world operations such as making payments, initiating transactions and importing automatic payments for subscriptions and bills. They are also able to send notifications when a service is about to expire, so that the customer can quickly identify errors.

In addition to this, AI chatbots are responsible for monitoring transactions and analysing users' spending habits. If, for example, suspicious behaviour such as abnormal account activity is monitored, the system may alert the customer or bank of possible fraud.

As discussed above, AI is able to analyse a client's financial profile to assess its credit score. By examining the user's economic conditions, chatbots can propose investment strategies adapted to their needs, showing financial opportunities. This enables clients to better manage their funds and make more informed investment decisions.

With the ability to examine customers' spending habits and activities, chatbots can recommend specific products based on the user's profile. For example, if a customer has just bought a trip, the chatbots will recommend insurance to protect their booking. Similarly, based on transaction history, may recommend a credit card with benefits for frequent purchases<sup>54</sup>.

### *3.3.2 Challenges, Innovations and Future Outlook*

In the last few years several European banks have implemented AI-based chatbots to improve customer interaction.

The Dutch neo-bank Bunq announced in 2023 the launch of its new GenAI platform, called Finn, designed to revolutionize personal financial management.

Finn works with advanced technologies from OpenAI and Meta, two of the most influential companies in the technology sector and helps users with its support to organise their budget, monitor expenses, and locate specific transactions with extreme ease.

In addition, unlike the traditional search functions present in banking apps, it can interpret and contextualise user questions, providing detailed and personalised answers.

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<sup>54</sup> Neontri. "Best Chatbots in Banking to Transform Financial Services." Neontri, March 24, 2025. <https://neontri.com/blog/best-banking-chatbots/>

The goal of the neo-bank is to simplify and make more intuitive financial management, transforming the app into a real digital consultant always available. Eliminating the need for long manual searches between transactions, this innovation is a further step forward compared to solutions offered by traditional banks<sup>55</sup>.

As banks adopt AI-based solutions, they must also consider the risks associated with this transformation, which must be carefully managed to ensure that it is used effectively and safely.

Banks face several key issues related to the implementation of chatbots.

First, chatbots process and store large amounts of sensitive information. As a result, they are the target of potential cyber-attacks that could cause serious privacy consequences. By adopting advanced security systems, such as data encryption and multi-factor authentication, these risks can be prevented.

Secondly, AI chatbot integration is subject to regulations such as GDPR (personal data protection), Know Your Client (KYC, for customer identification), and AML (Anti-Money Laundering, for money laundering prevention). If banks do not comply with the rules, they will be subject to economic sanctions as well as damage to their reputation and loss of customer confidence.

In addition, if a chatbot does not properly understand the requests, it will cause frustration to customers who would prefer to turn to financial institutions that offer more human and effective assistance.

Finally, Artificial Intelligence models may have algorithmic biases, that is, distortions in decision-making processes due to the data with which they were trained. Therefore, it is essential to provide constant human supervision, with regular updates.

In conclusion, according to Inkwood Research, a company specialising in the production of research and consulting reports, the European Artificial Intelligence market is expected to grow by 44.45% by 2026.

According to research conducted by Autonomous NEXT, the most widely used AI applications in the European banking sector are customer service and document

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<sup>55</sup> Ahlgren, Linnea. "Meet Finn — bunq's New GenAI Chatbot." The Next Web, December 19, 2023. <https://thenextweb.com/news/bunq-new-generative-ai-chatbot-finn>

retrieval. Advances in NLP have made it possible to analyse unstructured financial documents in multiple languages, making information management easier for financial institutions. However, AI applications in debt recovery are still at an early stage<sup>56</sup>.

Among the various proposals offered to executives in the European banking sector, it is possible to identify the proposals of Atos, ING, CogniCor, CollectAI and Eigen Technologies.

First, Atos, a company based in France, offers a platform called Atos Codex AI Suite, designed to enable banks to develop Artificial Intelligence products to improve customer service. Atos uses ML to implement advanced applications such as predictive analytics, video analytics, cyber security and more.

According to Atos, banks can use the platform to enhance customer service. In addition, by having historical data on their customers, banks have the possibility to create customised profiles that can be consulted directly from a web portal, improving the customer experience.

A second offer comes from ING, the Dutch financial services bank that developed Katana. Katana is an Artificial Intelligence system designed to support bond traders in buying and selling decisions by leveraging predictive analytics.

The system can create statistical forecasts on price quotations through the analysis of historical and real-time data on bond transactions. Traders, by integrating Katana into their own systems, can access the dedicated interface. Through ML, Katana is able to identify attractive purchase prices and sell selected titles by adding recommendations directly in the interface.

CogniCor, a Barcelona-based company that deals with chatbot-based solutions, claims that its solutions, through NLP, can improve the user experience. These virtual assistants, integrated into websites or apps, provide fast and relevant responses to customer requests.

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<sup>56</sup> Bharadwaj, Raghav. "AI for Banking in Europe – 3 Current Applications." Emerj, October 8, 2018. <https://emerj.com/ai-for-banking-in-europe-3-current-applications/>

Founded in Hamburg, CollectAI is a software company specialising in debt collection automation. Through ML and NLP, this company supports banks, credit unions and financial institutions in managing communication with debtors<sup>57</sup>.

By integrating the software into a bank's debt collection processes, the system can send notifications to operators, suggesting the best time, channel of communication and tone for contacting customers. All this is based on the analysis of historical data collected through channels such as e-mail, SMS, WhatsApp and paper letters. This will use the best communication strategy to receive a response from the debtor.

Finally, Eigen Technologies, a London-based company developing AI solutions for extracting data from unstructured documents, confirms that its NLP-based software can automate the process of analysing files in various formats.

This software allows to classify documents in different languages, analysing the contexts and assigning them to different categories, based on parameters imported by the bank through human intervention.

The ML implemented in the software identifies and provides insights useful for cost reduction, risk management, identification of new opportunities and compliance with industry regulations. Additionally, it provides an interactive dashboard that allows bank employees to search for information such as regulatory extracts, improving data access and operational efficiency.

### **3.4 Applications in Banking Security and Fraud Detection**

#### *3.4.1 The Evolving Threat of Financial Fraud*

Fraud prevention remains one of the most critical challenges for institutions, businesses and governments. With the advent of new technologies, more sophisticated fraudulent activities have emerged and spread.

In recent years, cybercrime has become more and more widespread, with fraudsters taking advantage of the loopholes in financial systems. These frauds range from phishing and identity theft to more complex methods such as bank account wiretapping and money laundering. Unfortunately, traditional detection and prevention systems are no longer able to deal effectively with the ever-evolving cybercrime.

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<sup>57</sup> *Ibid.*

The economic losses resulting from these activities have been substantial and have had serious consequences, adversely affecting financial stability and reputation. In addition, regulators have adopted and updated sophisticated measures over the years to prevent fraud, ensuring greater security and resilience of financial institutions.

#### *3.4.2 AI Methods for Fraud Detection*

The digital age has made fraud more complex, requiring innovative solutions to protect the financial system and maintain consumer confidence. In this regard, Artificial Intelligence has come into play to offer new innovative solutions to tackle this problem: thanks to ML, DL and NLP, it has revolutionized the detection and prediction of fraud.

AI systems can analyse huge amounts of data quickly, detecting hidden patterns and anomalies. AI helps prevent attacks in real time, improving the security of control systems.

AI techniques used to accurately and efficiently detect fraud include ML, Neural Networks, DL, and Anomaly Detection models.

Within the scope of fraud detection, ML models analyse transactions and identify fraudulent behaviour through the recognition of recurring patterns.

Supervised learning occurs when the model is trained with data that has already been labelled as fraudulent or legitimate and therefore can detect new cases with similar characteristics. Each input is associated with a known result, allowing models to detect fraud through historical data and identify similar behaviours in new data.

In parallel, unsupervised learning is used to identify new types of fraud that may not be present in historical datasets. For example, clustering algorithms analyse similar transactions and report those that do not fall into any known group. In addition, anomaly detection models such as K-Means Clustering, Isolation Forest and One-Class SVM are able to detect transactions that are rare or unusual compared to the usual user behaviour.

One of the most common models are decision trees, which classify transactions into various categories based on variables such as amount, time and geographical location, determining the likelihood that a given transaction is fraudulent.

Artificial neural networks, especially deep ones (Deep Neural Networks) could detect complex patterns in data, analysing large volumes of information in a more sophisticated way. As a result, they can identify connections that other models might miss. Neural networks are particularly effective at identifying non-linear relationships between variables and continually adapting to new fraudulent patterns. This enables it to detect complex, not immediately obvious, frauds.

DL is a branch of ML that uses deep neural networks to recognize complex patterns in data. For example, Convolutional Neural Networks (CNNs) are used to detect fraud by automatically identifying suspicious patterns across convolutional layers.

RNNs, processing sequential and time series data, store information from previous data and allow analysis of patterns repeated over time. Thanks to this, it is possible to detect fraudulent schemes that develop gradually, such as money laundering.

#### *3.4.3 Applications, Case Studies and Regulation*

Finally, NLP understands and analyses human language by processing written texts such as emails, chats, and transaction descriptions. By analysing them, they are able to detect suspicious terms and language patterns that could signal attempts at fraud. One of the main functions of the NLP is to analyse phishing emails and social engineering techniques, strategies used by fraudsters to trick users into providing sensitive data. Fraud attempts are detected by analysing the content, structure, and context of communications. The NLP is also able to analyse transaction descriptions and identify any irregularities<sup>58</sup>.

Among the various uses of Artificial Intelligence in fraud prevention is the monitoring of credit card transactions. By analysing financial transaction data in real time, algorithms can detect abnormal behaviour compared to the customer's usual spending habits. This refers, for example, to sudden changes in transaction amounts, purchases at unusual locations, or a high frequency of short-term payments. In such cases, the IA may temporarily block the transaction or send a report for further checking.

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<sup>58</sup> Bello, Oluwabusayo Adijat, and Komolafe Olufemi. "Artificial Intelligence in Fraud Prevention: Exploring Techniques and Applications, Challenges and Opportunities." *Computer Science & IT Research Journal* 5, no. 6 (June 2024): 1505–1520.

The ability of IA to distinguish between legitimate and suspicious financial transactions is also crucial. The combination of AI models allows for the recognition of habitual patterns of behaviour and anomalies indicative of fraud.

Furthermore, AI is a valuable ally in the fight against money laundering. Through the analysis of cash flows, suspicious patterns of transactions are identified, often fragmented between different bank accounts or financial institutions to conceal the origin of illicit funds.

The use of AI in fraud prevention presents challenges, including data protection, quality of information used, and transparency of models<sup>59</sup>.

In recent years, several European banks have started using AI to detect and prevent fraud.

These include Revolut, a UK-based neobank that has implemented an AI-based feature to protect customers from card-related scams. Using ML, it analyses transactions and detects potentially fraudulent transactions, blocking them automatically. In these cases, the user receives a notification from the application and is guided through a verification process, which includes additional questions to ensure that he or she is not acting under the pressure of a scammer. In addition, the app provides educational information on types of fraud and redirects you, if necessary, to a consultant for further clarification.

Since the introduction of this update, Revolut has seen a 30% decrease in amounts lost due to scams in high-risk sectors<sup>60</sup>.

In conclusion, international regulations, such as those established by the Financial Action Task Force (FATF) and the Bank Secrecy Act (BSA), require financial institutions to monitor and report suspicious transactions. AI-based AML systems automate these processes, generating detailed reports on potentially illicit transactions and providing in-depth information on the subjects and money flows involved. This not

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<sup>59</sup> Revolut. "Revolut Launches AI Feature to Protect Customers from Card Scams and Break the Scammers 'Spell'." Revolut News, February 15, 2024. [https://www.revolut.com/it-IT/news/revolut\\_launches\\_ai\\_feature\\_to\\_protect\\_customers\\_from\\_card\\_scams\\_and\\_break\\_the\\_scammers\\_spell/](https://www.revolut.com/it-IT/news/revolut_launches_ai_feature_to_protect_customers_from_card_scams_and_break_the_scammers_spell/)

<sup>60</sup> LaMiaFinanza. "Revolut Uses Artificial Intelligence to Protect Customers from Card Scams and Break the 'Spell' of Fraudsters." LaMiaFinanza, February 15, 2024. <https://www.lamiafinanza.it/2024/02/revolut-utilizza-lintelligenza-artificiale-per-proteggere-i-clienti-dalle-truffe-sulle-carte-e-rompere-lincantesimo-dei-truffatori/>

only helps companies comply with regulations but also improves their ability to respond quickly to regulatory investigations and audits.

The adoption of AI in fraud prevention therefore represents a crucial breakthrough for the financial sector. From predictive analytics and real-time monitoring to cybersecurity and regulatory compliance, these technologies offer advanced solutions to protect businesses and consumers. As fraudsters' strategies evolve, the integration of AI systems into anti-fraud policies will become increasingly essential to ensure the security of the global financial system.



## 4. AI IN THE PUBLIC SECTOR

### 4.1 Integration of AI into the Public Sector

#### *4.1.1 Types of AI Used in Public Administration*

In addition to the aforementioned sectors, interest in AI has also grown since 2010 in the public sector, which includes areas such as healthcare, transport, education, public safety, communications, and weighing the armed forces.

According to leading industry studies, the use of AI is growing, with a Compound Annual Growth Rate (CAGR) of 26.1 % and a forecast of the global AI market growing to 45 billion in 2020 to around 167 billion by 2026<sup>61</sup>. At the European level, there is a significant expansion of investments in AI, which is expected to exceed EUR 45 billion by 2025<sup>62</sup>.

Its transformative potential is reflected in many areas, such as the simplification of bureaucratic practices, the more rational distribution of public resources, and the adoption of predictive systems to improve urban planning and emergency response.

Despite the upgrades in recent years, many public services continue to be offered in traditional ways, due to the distribution of resources in public budgets, which are often allocated to the maintenance of old IT systems. This leads to a lower quality of public services than private services, which can have a negative impact on public trust and satisfaction.

On the contrary, the introduction of new digital services could make public administration (PA) more efficient and effective, increasing user satisfaction. Moreover, these tools could improve communication between citizens and institutions, making procedures simpler and faster.

Therefore, many Pas have increasingly started to adopt systems based on Artificial Intelligence. For instance, in Italy, this digitisation process has been boosted by services such as the Carta d'Identità Elettronica (CIE, Electronic Identity Card), the Sistema

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<sup>61</sup> Mordor Intelligence. "Artificial Intelligence (AI) Market Size & Share Analysis - Growth Trends & Forecasts (2025 - 2030)." Mordor Intelligence, 2025. <https://www.mordorintelligence.com/industry-reports/global-artificial-intelligence-market>.

<sup>62</sup> International Data Corporation (IDC). "European AI Market to Reach \$17 Billion in 2021, According to IDC." IDC, June 22, 2021. <https://www.idc.com/getdoc.jsp?containerId=prEUR148297521>.

Pubblico di Identità Digitale (SPID, Public System for Digital Identity), and the Anagrafe Nazionale della Popolazione Residente (ANPR, National Register of Resident Population), which enables citizens to dialogue more easily with the PA<sup>63</sup>.

However, there is still a need to better understand how these technologies are changing the functioning of the public sector, as research in this area is still limited.

An analysis conducted by the AI Watch initiative mapped 230 instances of the use of Artificial Intelligence in public services, providing a significant picture of the technologies adopted, the sectors involved, and the purposes pursued. The survey involved PAs from EU Member States and revealed how many government agencies are experimenting with and implementing solutions based on these technologies.

Among the most commonly adopted technologies in European PA are NLP, chatbots and virtual assistants, ML and DL, Computer Vision (to interpret images and videos), Predictive Analytics (to predict future scenarios), and LLMs.

The main types of AI used in the public sector can be grouped into ten categories, depending on the functions performed.

Firstly, audio processing and speech recognition, which includes systems used to identify sounds and words, to transcribe public speeches, or to offer automatic subtitling services in institutional content.

Secondly, digital assistants, chatbots, and recommendation systems have been implemented, which simulate conversations with users to provide them with information, personalised advice, or assistance on digital platforms.

Cognitive robotics and process automation include physical robots, used for precision surgery, and software systems capable of automating recurring bureaucratic tasks, such as handling forms or requests.

Next, applications that analyse images and videos to identify people, objects, or behaviour, used for example for traffic management or access control.

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<sup>63</sup> Altalex. "Public Administration and Artificial Intelligence: The Future of Digital Government." Altalex, October 30, 2024. <https://www.altalex.com/documents/news/2024/10/30/pubblica-amministrazione-intelligenza-artificiale-futuro-governo-digitale>.

Decision-making systems are solutions designed to support or automate complex decision-making processes, for instance in the allocation of benefits or the evaluation of requests.

In addition, AI is used to create intelligent archives to support analysis and technical advice.

ML and DL, on the other hand, refer to tools that enable systems to learn from data and progressively improve their performance, without needing to be explicitly programmed.

Another category is predictive analysis, simulation, and data visualization tools, which are used to identify patterns in the available data and predict future scenarios. For instance, they are used in urban planning or healthcare management.

Finally, there are applications that deal with security analysis and threat intelligence. They deal with monitoring computer networks and systems to prevent or identify attacks, thus enhancing cybersecurity in the public sector.

Among these categories, the most prominent are chatbots and virtual assistants, predictive analysis and simulation technologies, followed by automated decision-making systems<sup>64</sup>.

The main objectives of government with the use of new technologies can be summarised in turn in five main purposes, each linked to specific government functions.

First of all, in the area of regulatory enforcement and control (Enforcement), AI is used to monitor compliance with existing regulations or to identify potentially irregular behaviour. Reference is made, for instance, to systems that automatically detect number plates of parked vehicles or that detect fraud attempts in tax and social security systems.

Secondly, in the field of regulatory research and analysis, these intelligent models support the decision-making process of policy makers by providing aggregated data and simulations to improve the quality of public policies. AI helps identify social trends, estimate the impact of reforms, or suggest alternative scenarios based on the evidence gathered.

A further purpose concerns the allocation of benefits and rights (Adjudication), whereby AI can be used to facilitate or automate the granting of rights, subsidies, or benefits to

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<sup>64</sup> Misuraca, Gianluca, and Colin van Noordt. Overview of the Use and Impact of AI in Public Services in the EU. EUR 30255 EN. Luxembourg: Publications Office of the European Union, 2020.

citizens. Although less widespread for ethical and legal reasons, it is used while maintaining close human supervision. Examples include automated form verification systems.

In addition, public services and engagement include chatbots, virtual assistants, automatic transcription tools, and recommenders that improve access to services and communication between PA and citizens. Concrete examples are solutions used to make political proceedings understandable for those with hearing difficulties.

Finally, with regard to the internal management of the administration (internal management), Artificial Intelligence is used to optimise internal processes such as human resources management, digitisation of historical archives, and predictive maintenance of IT systems<sup>65</sup>.

The introduction of these new mechanisms in the public sector is not limited to modernising services or making internal management more efficient, but also to the production of public value, along four main lines. These four values can be summarised as the improvement of administrative efficiency, the quality of public services, the promotion of open government, and the protection of cybersecurity.

The main value pursued is performance, with the aim of improving the efficiency and effectiveness of public activities. For example, this is done through the automation of repetitive tasks (as in the case of chatbots), the prediction of future needs with predictive models, or the intelligent management of data and internal resources. AI makes it possible to speed up decision-making processes, reduce the administrative burden, and rational use of public resources.

Regarding inclusion, the implementation of new technologies makes public services more accessible and personalised. This is achieved through technologies that facilitate interaction with institutions for people with disabilities or offer easier ways to access information, even for those with limited digital skills.

The third contribution of AI concerns the transparency and openness of government, which is useful for increasing access to public information, involving citizens in decision-making processes, and making the functioning of the administration more understandable.

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<sup>65</sup> *Ibid.*

A further area of interest concerns cybersecurity, whereby intelligent models can anticipate, detect and neutralise cyber-attacks. For instance, cognitive technologies are used to analyse large volumes of data in real-time, detecting anomalies and strengthening the resilience of public systems.

A relevant aspect for understanding the use of AI in PA is the sectoral distribution of initiatives. Smart technologies are not concentrated in a single area but are distributed among different sectors of public authority.

These sectors include general public services, which include tax administration, human resources management, institutional communication, and intergovernmental coordination. As anticipated, through chatbots and virtual assistants, citizens' access to services and the functioning of internal activities have been improved, with the intelligent search of documents or the automation of bureaucratic tasks.

The public health sector follows, with prediction robotics and automated management of clinical data. In the field of economic affairs (agriculture, energy, transport, and industrial development), AI is used to monitor economic activities, detect fraud, optimise public transport, manage energy resources, or foster business creation.

There are also interesting cases of applications in areas such as public order and security, environment, education, and culture. For example, law enforcement agencies exploit these technologies to prevent emergencies or detect environmental anomalies. On the other hand, in the educational and cultural sphere, tools are reported for analysing training needs, enhancing digitised historical archives, or making museums more accessible.

It should be specified that the adoption of different types of AI varies according to the sector. For instance, chatbots and virtual assistants facilitate interaction with citizens, and Predictive Analytics are used in healthcare to analyse clinical data and in urban mobility optimisation. In addition, Computer Vision allows monitoring infrastructures or automating the control of crops (satellite monitoring systems of agricultural activities) and Algorithmic Decision-Making pins regulatory and fiscal contexts on supporting public bodies in the provision of benefits, the assessment of applications, and compliance with rules.

Ultimately, AI represents a driver of structural change for the public sector.

#### *4.1.2 Bureaucratic Simplification, Resource Allocation, Urban Planning, and Emergencies*

Artificial Intelligence is emerging as a central tool in e-government to overcome slow and fragmented traditional operating models and facilitate the automation of repetitive tasks, Predictive resource management, and early response capability in complex urban scenarios or emergency situations.

AI helps to reduce red tape. It is possible, through automation tools such as document management, automatic evaluation of requests, or semantic analysis of language, to streamline procedures that would require considerable time and human resources. In this way, the citizen's experience with services is improved, but it also gives public staff the opportunity to focus on activities of greater added value. In addition, the structural digitisation of administrations promotes cooperation between ministries and agencies and leads to a reduction in interpretative ambiguities and error margins.

At the same time, new technologies enable a better allocation of public resources through the analysis of large volumes of data, especially in highly complex sectors such as health, transport, education, and infrastructure management. This support is useful to anticipate the demand for services, identify critical issues, and redistribute resources in a more targeted manner, allowing a reduction of waste and an improvement in the return on public funds. For example, AI models can be useful in simulating different policy scenarios, testing the impact of new measures, and identifying the most cost-effective solution.

A major contribution of AI is also made to the rationalisation of public budgets, supporting planning, programming, and budgeting. The ML can analyse historical spending, identify hidden trends and suggest areas for improvement and investment, for a more strategic management of public money.

In the urban context, AI provides advanced tools for predictive planning of cities, particularly emergency management, traffic management, energy consumption, and climate resilience. For example, new technologies can be used to monitor traffic, optimise public transport, predict pollution peaks, or alert authorities to extreme weather events. This is the context of the "Mercè" project in Barcelona, which has collected environmental data through a citizen science logic thanks to the active contribution of the

population. These data, after being processed by intelligent algorithms, have been used to model future urban scenarios and to formulate more inclusive and active policies<sup>66</sup>.

From an organisational point of view, the proper functioning of AI models depends on the ability of administrations to manage new forms of public-private partnership. The integration of these technologies is a process involving PAs, technology suppliers, start-ups, and research centres. In this complex ecosystem, according to AI Watch, the interaction between actors manifests itself in three main forms: G2G (government-to-government), G2C (towards citizens), and G2B (towards enterprises). It is also important to note that around 45% of AI solutions directly support interaction with citizens and 45% deal with relations between public bodies. This is because AI is no longer considered merely a service technology, but rather a tool for transforming administrative processes at its roots.

At the same time, there is no lack of significant difficulties in slowing down the integration of intelligent models into public processes. The main shortfalls in skilled personnel are evident: many administrations do not yet have people with adequate skills in AI, data science, and systems engineering, or employees capable of interpreting and managing complex algorithms.

Another obstacle is the low degree of interoperability between systems, especially between different administrations or levels of government (central, regional, local). The lack of common technical standards and compatible digital infrastructures is likely to slow down the spread of AI-based solutions.

In addition, the quality of public data must be accurate, up-to-date, and well-structured to ensure that models are effective. The accuracy of algorithmic outputs can be compromised by disorganised and incomplete datasets. In addition, data-sharing initiatives between public authorities are hampered by fragmented digital infrastructures and the lack of common standards.

From a regulatory point of view, the absence of a harmonised and evolving regulatory framework represents a significant barrier. The risk is that automated processes will result in decisions that are not transparent or verifiable. In addition, the use of predictive or recommendation systems carries the risk of reinforcing pre-existing social biases, with

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<sup>66</sup> European Commission, Directorate-General for Communications Networks, Content and Technology. Adopt AI Study – Final Study Report. Luxembourg: Publications Office of the European Union, 2024.

discriminatory effects in sensitive sectors such as health care, selection for public services, or benefit allocation.

These risks require a conscious ethical and regulatory approach, which includes the transparency of automated decision-making processes, the traceability of algorithms, and the ability to challenge decisions made (or suggested) by machines.

To address these challenges, it is essential to adopt integrated public policies: investment in continuing training for staff, transparent data governance strategies, common technological infrastructures, and multi-level governance mechanisms, able to coordinate efforts between central, local, and European authorities. In addition, the territorial and digital divide between more advanced and less structured administrations needs to be bridged, so that innovation does not increase inequalities rather than reduce them.

#### *4.1.3 Macroeconomic Forecasting and Indicators*

AI is revealing a transformative potential for the economic forecasting sector, with particular reference to the estimation of indicators such as GDP. AI methods, due to their ability to process large volumes of data, detect hidden patterns, and dynamically adapt to scenarios, are gradually complementing traditional statistical tools and economic models.

In this regard, AI technologies are becoming increasingly important in the development of medium- to long-term economic forecasts, which are fundamental for the design of fiscal, monetary, and industrial policies. For example, the use of ML and DL makes it possible to estimate more precisely the evolution of GDP, taking into account a large number of real-time variables, such as consumption dynamics, social media signals, and fluctuations in climate and health data. These models are updated automatically as new data is received, improving the accuracy of forecasts. Due to their flexibility, they are particularly effective in a context of increasing global instability, where sudden events such as health or geopolitical shocks can drastically affect economic trajectories<sup>67</sup>.

Finally, Artificial Intelligence can be seen as a strategic ally of the state, enabling the development of more timely, targeted, and adaptable public policies that promote long-term resilient economic governance.

#### *4.1.4 Public Treasury: Automation, Liquidity Analysis, Compliance, and LLMs*

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<sup>67</sup> *Ibid.*



Treasury is one of the most sensitive and strategic functions of PA: it deals with liquidity management, cash flow monitoring, compliance with accounting and tax regulations, and support for financial decisions.

The introduction of Artificial Intelligence in this area is crucial given the increasing complexity of the economic environment and the amount of data to be processed quickly. The introduction of new models allows, in fact, to automate more repetitive activities, improve the quality of financial analysis, optimize liquidity management, and strengthen regulatory compliance mechanisms<sup>68</sup>.

The introduction of automated tools has made it possible to optimise liquidity management. Models such as ML, predictive models, and LLMs are able to anticipate situations of shortage or cash surplus, suggesting strategies for reallocation of funds, management of deadlines, or short-term investments. It not only improves operational efficiency but also reduces financial risks by identifying anomalies in flows or transactions at an early stage.

About the automation of the monitoring of regulatory compliance and the support for the drafting of regulatory reports, automatic analysis makes it possible to ensure adherence to transparency standards and current rules. Automatically generating risk or non-compliance reports, allowing to simplify and speed up internal audit processes<sup>69</sup>. Chatbots and virtual assistants improve customer interaction.

According to a study by LeewayHertz (2024), the integration of these models starts with the collection of data from heterogeneous sources (e.g. bank statements, public balance sheets, risk metrics, and regulatory documents), which are processed through pipelines that clean them up, structure and transform into numerical representations by embedding models. Afterwards, the processed information is stored in vector databases (e.g. Pinecone or Weaviate) that allow a quick access to data for complex queries. To coordinate the operation of the entire system there is an orchestrator, such as ZBrain, that manages the interactions between modules, API requests, and access to contextual data, also keeping memory of past interactions. The result is a treasury platform that can

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<sup>68</sup> Agenzia per l'Italia Digitale (AgID). *Piano Triennale per l'Informatica nella Pubblica Amministrazione 2024–2026: Aggiornamento 2025*. January 2025.

<sup>69</sup> LeewayHertz. "AI in Treasury Management: Revolutionizing Financial Operations." LeewayHertz, March 2023. <https://www.leewayhertz.com/ai-in-treasury-management/>

respond in real time to questions about liquidity, risks, compliance, and financial strategies, providing insights to support strategic decisions<sup>70</sup>.

The adoption of AI in public treasury management involves the participation of different actors. In particular, its implementation can follow different operational modalities: internal development of systems by the central administrations, outsourcing through contracts with specialised suppliers, and modular integration of solutions already existing on the market, possibly combined into a single complex system.

The use of GenAI also allows the customization of workflows, adapting the interface and functions of the treasury platform to the specific needs of each institution. These tools also enhance the ability to predict interest and exchange rates, which are essential for planning public debt strategies and assessing future scenarios. The integration of real-time data analysis, continuous KPI monitoring, and automatic model validation ensures proactive and resilient treasury management.

However, there are still significant structural barriers. Among the main problems, as highlighted by the Workshop on E-Government and Finance (2023), there is a lack of clarity on the targets for the adoption of intelligent technologies, since many administrations struggle to define precise use cases. Other recurring difficulties include the lack of internal technical expertise, fragmentation of technology markets, complexity of public tenders (too slow and expensive), and the risk of technological lock-in (data ownership problems and lack of interoperability between systems).

In conclusion, more efficient and transparent procurement strategies are being developed to address these challenges, such as specialised contractual frameworks for AI, ethical guidelines such as Assessment List for Trustworthy AI (ALTAI) in Ireland, and new tools such as regulatory sandboxes, public hackathons, and pre-commercial procurement. Finally, it is essential to invest in training public personnel, develop national and local strategies, and create community centres of practice between public bodies, universities, and technology companies, to facilitate the exchange of good practices and knowledge.

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<sup>70</sup> *Ibid.*

#### *4.1.5 Ethics, Limitations, Barriers, and Recommendations*

The adoption of new technologies promises significant benefits in terms of efficiency, accuracy, and predictive capability. Despite this, many technical, organisational, legal, and ethical issues remain.

In addition to the difficulties mentioned above, there are ethical limits, including algorithmic discrimination due to bias in training datasets or rigid coding of automated decisions. The use of "black box" AI models, lacking transparency, can lead to outcomes that are difficult to explain or challenge, threatening the principle of democratic accountability. In addition, there is the danger of dehumanising public services.

Another critical point is the lack of regulatory clarity. The lack of effective coordination among European regulations (such as the AI Act, the Data Governance Act, and the GDPR) creates confusion and ambiguity.

Regarding data sovereignty and citizens' trust, it is often not clear who holds the rights of access, control, and ownership of public data. This undermines transparency and hinders cross-sectoral cooperation. Furthermore, this lack of clarity can lead to mistrust of the administration and reduce citizens' willingness to collaborate with digital AI-based services.

From a technological and organisational point of view, insufficient data quality, low interoperability between systems, and lack of digital skills are recurrent barriers. It is difficult to recruit qualified experts because of high demand and less competitive wages.

To address these challenges in a systematic way, it is essential to adopt a forward-looking vision based on sound ethical principles and coherent operational tools. Through the so-called "ethics by design", which involves the participation and collaboration of different professional figures with technical, legal, and social skills, it is possible to create more effective and understandable models<sup>71</sup>.

It is also important to harmonise standards at the European level and train public staff, but also work on communication with citizens, promoting transparency and inclusiveness to rebuild trust. For example, through the experimentation of regulatory sandboxes, or

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<sup>71</sup> *Ibid.*, 55

protected spaces where the impact of technologies can be tested under real and controlled conditions.

In conclusion, in a context where Artificial Intelligence is about to become a key infrastructure of public governance, its use cannot be separated from an ethical, inclusive, and sustainable vision. The responsible adoption of AI in PA is not only a technical challenge, but above all a political and cultural choice that requires coordination, foresight and attention to democratic values.

## **4.2 The MEF's Italian Case**

### *4.2.1 MEF and Economic Forecasting: GDP, Growth, and Fiscal Revenues*

The MEF is the central body of the Italian state responsible for managing and coordinating the entire economic and financial policy of the country. It oversees economic and budgetary policies, manages government finances, supervises public expenditure, and regulates taxation. As a result, it plays a key role in maintaining balanced public accounts, the proper functioning of the tax system, and strategic planning of public investments.

In addition, it is responsible for the supervision of economic institutions and bodies, maintaining relations with the main control and regulatory authorities, both at national and international level<sup>72</sup>.

The adoption of Artificial Intelligence by the MEF can represent a strategic breakthrough to strengthen public decision-making, particularly in formulating more reliable and timely economic forecasts.

Thanks to the ability of intelligent models to process large amounts of data and identify complex patterns, it is possible to fine-tune prediction crucial sources for economic policy, such as the trend in GDP, the growth potential of the economy, and the forecast of tax revenues.

In the tax area, AI allows the state to estimate future revenues. While traditional forecasting models are based on relatively rigid econometric models, patterns such as ML, which combine historical data, real-time macroeconomic indicators, tax credits, financial movements and taxpayers' behaviour are used to generate more realistic and

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<sup>72</sup>Ministero dell'Economia e delle Finanze (MEF). "Mission and Functions."  
<https://www.mef.gov.it/ministero/ruolo/missione.html>

dynamic ratings. In addition, Artificial Intelligence not only reduces tax evasion and optimises tax collection but also creates useful scenarios for designing more effective and less distortive fiscal policies. Techniques such as predictive analysis and pattern recognition in data can, for example, anticipate taxpayers' behaviour or assess the effects of regulatory changes on tax revenues in real-time.

From a macroeconomic perspective, the MEF has already started to consider adopting AI-based systems for estimating the impact of public policies on productivity and growth. In fact, AI models, especially the LLMs ones, positively influence the potential growth rate of the economy through the increase of production efficiency, the continuous learning capacity of the structures, and the strengthening of innovative processes<sup>73</sup>. In this sense, AI can also be seen as a lever to stimulate new growth by reducing the uncertainty of forecasts and promoting more effective resource allocation.

The impact of GenAI patterns on growth is not only theoretical: according to a report published by Goldman Sachs, its adoption could increase global GDP by 7% in the next ten years, generating an economic value of about 7 trillion dollars. In addition, a study conducted by the Harvard Business School showed that the use of AI can increase the quality of performance up to 40%<sup>74</sup>.

It is also possible through Artificial Intelligence to create forecasting models that allow detecting deviations in real time between initial estimations and actual data to permit rapid corrections to policies adopted. ML simulations could test different scenarios of policies that would enhance public resource allocation and decrease uncertainty in the decision-making process. What can be done is estimate the 'tax demand curve', or the propensity of citizens to pay taxes, at different income brackets or territories through the integration of economics on behavioural and social data.

As specified in the Italian Strategy for AI 2024-2026, the planned objective is to integrate AI predictive tools into the economic planning of PA. The paper sees IA as a key tool to support decision-making and make transparent both ex ante and ex post public policy assessments, as well as improving forecasting by relevant government bodies. The

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<sup>73</sup> Catenacci, Anna Maria, and Gabriele Velpi. Economic Impact of New Artificial Intelligence Models: Challenges and Opportunities for the European Union. Thematic Note No. 3. Rome: Ministry of Economy and Finance – Department of the Treasury, June 2024.

<sup>74</sup> Dell'Acqua, F., Gino, F., Ipeirotis, P., & Mullainathan, S. (2023). Navigating the jagged technological frontier: Field experimental evidence of the effects of AI on knowledge worker productivity and quality (Working Paper No. 24-013). Harvard Business School Technology & Operations Management Unit.

strategy specifically promotes the development of interoperable tools to ensure data quality, security, and traceability, training of public staff, and continuous performance monitoring<sup>75</sup>.

#### *4.2.2 Issuance of Government Bonds and Public Debt Management.*

In public financial management, the issuance of government bonds and debt control are key tools for ensuring macroeconomic stability. AI is a strategic ally for public authorities, enabling them to plan more efficiently and dynamically their debt issuance and management operations.

Traditionally, decisions on securities issuance are based on analytical models that are inflexible to the unpredictability of global financial markets and expert valuations that take into account macroeconomic variables, Expected cash flows, and market conditions.

In this context, AI models based on ML make it possible to identify the most favourable times for issuing new government bonds, taking into account changes in interest rates, investor sentiment, of credit risk, and external factors such as inflation or geopolitical crises. Through the analysis of these identifiers, advanced simulations are provided to help select more advantageous time windows for issuance, helping to reduce the overall cost of public debt<sup>76</sup>.

Furthermore, smart technologies, by analysing market trends and evaluating alternative scenarios, can suggest whether to use short or long-term, indexed or fixed-rate securities. As a result, the financial administration can proactively adapt its choices, ensuring greater resilience to global economic and financial fluctuations.

The capacity to use AI in public finance to enhance the effectiveness and efficiency of spending through predictive simulations, scenario analysis, and real-time monitoring of resource allocations is one of the greatest promises of such an application. These instruments help governments in optimally managing their debts and in understanding the impact of their decisions in a much clearer way, as well as putting them in line with macroeconomic objectives<sup>77</sup>.

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<sup>75</sup> Agenzia per l'Italia Digitale (AGID), Dipartimento per la Trasformazione Digitale. Italian Strategy for Artificial Intelligence 2024–2026. Rome: Presidency of the Council of Ministers, 2024.

<sup>76</sup> Videgaray, Luis, Philip Aghion, Barbara Caputo, Tracey Forrest, Anton Korinek, Katja Langenbucher, Hiroaki Miyamoto, and Michael Wooldridge. Artificial Intelligence and Economic and Financial Policy Making: A High-Level Panel of Experts' Report to the G7. December 2024.

<sup>77</sup> *Ibid.*

Moreover, the use of AI to monitor on a continuous basis the development of debt cash flows and maturities allows for a more accurate management of liquidity risks and debt sustainability in the medium-long term. Thanks to anomaly detection and early warning systems, the authorities have the possibility to identify in advance risk situations such as excessive concentration of maturities or exposure to variable rates and to intervene promptly with rescheduling or re-issuance operations.

The MEF Thematic Note itself notes how the introduction of AI into economic governance augments the capacity of the state to guide structural transformation processes and fosters better public resource allocation. In this context, debt management is mentioned as one of the areas where predictive mechanisms and intelligent automation can assist in modernising and improving the efficiency of public financial management overall<sup>78</sup>.

A regulatory and supervisory policy must definitely accompany the use of AI technology in debt management. To make these tools effective and trustworthy, a controlling framework is needed that would guarantee fair and transparent decision-making, security of data, and interoperability of systems. In this sense, the most far-reaching European strategies conceive of an integrated frame comprising technological innovation, specialised training, and ex-post supervision to mitigate distortions and maximize AI's transformative potential in public finance.

#### *4.2.3 Guidelines for the Adoption of AI in the MEF and Public Administration*

Artificial Intelligence is a strategic tool for the digital transformation of the Italian PA and the MEF. As outlined in the "Italian strategy for Artificial Intelligence 2024-2026", the objective is to ensure a widespread and systematic adoption of AI in PA, valuing principles such as efficiency, security, transparency, interoperability, and ethics.

The guidelines for its adoption are intended to guide PAs in choosing and using intelligent solutions. The guidelines underline the need for a multidisciplinary approach, combining technical expertise, regulatory awareness, and risk awareness, with the aim of promoting interoperable and nationally developed applications, in accordance with shared functional standards<sup>79</sup>.

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<sup>78</sup> *Ibid.*, 61

<sup>79</sup> *Ibid.*, 62

The strategy also promotes a conscious and transparent use of AI in public procurement through specific guidelines that lead tenders towards solutions adhering to the principles of legality, security, and accountability. Administrations will need to know the AI products available, assess their potential and risks, and ensure their consistency with existing regulations, with particular reference to personal data protection and transparency of algorithms.

Another key aspect is the one that allows the administration to devise internal solutions, possibly in cooperation with public or private partners. The guidelines provide for the development of national solutions built on AI platforms developed in Italy that are scalable, certifiable, and shared at a systemic level. This is crucial to avoiding fragmentation of technology and integrating various levels of PA.

In order to optimise decision-making processes and improve internal efficiency, the strategy proposes targeted actions such as the development of AI systems for automatic support for the drafting of administrative acts and the digitisation of public contracts. The aim is to create an active national infrastructure, capable of improving the quality and timeliness of public decisions<sup>80</sup>.

The Italian vision fits into a broader international framework, which emphasizes the concept of "policy preparedness", as proposed by the G7 and taken up in the HLPE Report. This approach suggests the creation of a policy preparation matrix for AI adoption, capable of adapting to different technological scenarios, from more gradual ones to hypotheses of accelerated development of General AI (AGI). Each country, according to the report, should develop its own public policy mix, combining regulation, training, use of AI in governance, and strategic investments to promote innovation, resilience, and sustainability<sup>81</sup>.

This has to do with the acceptance of AI in the Italian PA, not merely as a technical process, but as a regenerative act on the entire systems-infrastructure, human capital, governance, and transparency. The national strategy envisages the establishment of an AI Department at the National School of Administration, with advanced training courses for public personnel. Furthermore, the interoperability and traceability of AI solutions are

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<sup>80</sup> *Ibid.*

<sup>81</sup> *Ibid.*, 62



seen as essential conditions for building public confidence and ensuring a balance between innovation and fundamental rights.

Finally, it is crucial that the AI adoption process be accompanied by inclusive and transparent governance, with mechanisms for continuous monitoring and impact assessment. This is the only way in which AI can make a significant contribution to improving public services, strengthening decision-making capacity, and building a modern, ethical, and citizen-oriented PA.

## Conclusion

This thesis sought to investigate how Artificial Intelligence is transforming European economic and financial institutions and the concrete implications in the operational and decision-making contexts of central banks, commercial banks and public administrations.

The three hypotheses formulated in the introduction have been progressively deepened and have been substantially confirmed.

The first hypothesis concerned central banks, in particular the ECB. The findings in the chapters showed how AI enables economic phenomena to be analysed in depth and quickly, enriching traditional analyses and facilitating data-driven policy development.

For example, models such as Agora and Athena, but also the integration of predictive models to analyse inflation, GDP and market expectations, demonstrate how European central banks are approaching a new analytical culture. However, as confirmed by several ECB officials, the new smart models are seen as a support tool, not a substitute for the critical capacity of policymakers.

The second hypothesis analysed the commercial banking system. Again, the information gathered confirms that the growing adoption of automated scoring systems, intelligent chatbots, NLP for document analysis and fraud prevention algorithms has redefined the operating models of European banks. Systems such as Finn and Katana and tools such as CogniCor and Atos Codex demonstrate a transition to a more personalised, predictive and efficient banking system. Despite this, there are relevant issues such as the issue of privacy, algorithmic bias, decision-making "black box" and replacement of professional figures, which raise ethical and social doubts and require careful and multi-level regulation.

The third hypothesis dealt with public administration, in particular the Ministry of Economy and Finance. The hypothesis is out of sync. For example, the Italian case demonstrates how the MEF is integrating predictive models to estimate growth, GDP and tax revenues, as well as experimenting with tools to analyse consumer and operator expectations. The automation of government bond issues, semantic data analysis through NLP and the use of GenAI and XAI tools outlines an ongoing evolution aimed at making public action more effective and informed.

Again, data quality, interoperability of systems, resistance to change and public staff skills are challenges that need to be overcome.

In light of what emerged, it can be said that Europe, while not at the forefront of the development of Artificial Intelligence technologies like the USA and China, is playing a leading role in defining a regulatory model, Institutional and ethical adoption of AI.

The European vision, based on values such as transparency, security, human-centricity, and respect for fundamental rights, is seen as an ambitious effort towards reconciling technological innovation with democratic accountability. The adoption of the AI Act, the European Digital Strategy and the national plans for implementing AI, such as the Italian one, show the will to build an Artificial Intelligence ecosystem that is at the service of the public good, and not vice versa.

However, the future of AI in European finance is not without uncertainties. Research findings highlight the urgent need to address some cross-cutting issues. First, the information asymmetry between those who design algorithms and those who use them requires a strengthening of digital skills within public and financial institutions. Understanding how technology tools function is essential for conscious governance by officials, regulators and policymakers. Second, it is important to ensure that the adoption of AI does not deepen existing inequalities: automation must not bring exclusion in either the labour market or access to financial services.

Strengthening mechanisms for monitoring, auditing and independent evaluation of AI-based solutions will positively contribute to the ethically sustainable use of new technologies. The so-called algorithmic "black box" poses risks to the legitimacy of public decisions and citizens' trust in institutions unless duly regulated. In this sense, the widespread adoption of XAI tools and open-source models would serve as an important step toward transparency, verifiability and accountability in AI.

From the perspective of future prospects, this research paved the way for further investigation, which could focus on two main directions. The first is the quantitative analysis of the impact of AI on aggregate economic variables (such as employment, productivity, growth) through econometric models or longitudinal case studies. The other deals with the legalities and ethical issues concerning the application of AI in economic governance, especially with regards to data protection, economic freedoms, and democratic participation.

In conclusion, Artificial Intelligence represents an epochal challenge and a historic opportunity: its integration into the European financial system, if guided by principles of equity, transparency, and public accountability, could strengthen the capacity of institutions to deal with present complexities and anticipate future changes. The hope is that this work may have contributed, in its small way, to illuminating some crucial aspects of this ongoing process, stimulating a conscious and informed reflection on what awaits us in the coming years.

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