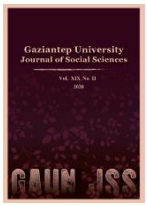

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Araştırma Makalesi ● Research Article

The Role of Artificial Intelligence in Investment Decisions and Applications in The Turkish Finance Industry

Yatırım Kararlarında Yapay Zekanın Rolü ve Türk Finans Sektörü Uygulamaları

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ÖZ

Yapay zeka (AI) teknikleri, otomatik (kendi kendine) giden arabalar, karanlık fabrikalarda gerçeklesen üretim, sohbet robotları ve robo-danışmanlar gibi birçok amaç için kullanılmaktadır. Yapay zekanın finans sektöründe artan kullanımına paralel olarak, ampirik çalışmalar da yapay zeka tekniklerinin geleneksel modellerden (regresyon) daha iyi performans gösterdiğini ortaya koymaktadır. Bu çalışma, Türk finans sektörü örneğinde yapay zeka tekniklerinin yatırımcıların karar verme süreçleri üzerindeki etkilerine ışık tutmayı amaçlamaktadır. Çalışmanın ana amacı, yapay zekanın ve seçili bazı uygulamalarının finansal karar verme konusundaki önemi ve üstün yanları ile ilgili bir anlayış geliştirmektir. Bu amaçla, finansta yapay sinir ağları, genetik algoritmalar ve Robo danışmanlar gibi seçili bazı Yapay zeka uygulamaları gözden geçirilmektedir. Çalışmada ayrıca politika önerileri geliştirilmesi amacıyla Türkiye ve Avrupa Birliği (AB) uygulamaları karşılaştırılmakta ve Türkiye finans sektöründeki çeşitli yapay zeka uygulamaları da gözden geçirilmektedir. Çalışmada ulaşılan ilk gözleme göre, çok sayıda çalışma yapay zeka uygulamalarının geleneksel modellere kıyasla, bir portföyün optimize edilmesi ve dengelenmesi, hisse senedi fiyatlarının, döviz kurlarının, iflasların ve ya diğer finansal başarısızlıkların tahmin edilmesi konularında daha üstün olduğunu göstermektedir. Bir politika önerisi olarak, politika yapıcılar bazı kilit politika alanlarına odaklanabilirler. Bu alanlar: veri toplama, firma ve endüstri düzeyinde yapay zeka performansını ölçme, farkındalık yaratma, eğitim ve olası firma ve sistem genelindeki riskleri tespit etme.

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ABSTRACT

Alan Turing was not the first one to ask whether machines can think, but he might have been the closest one with a positive answer. Artificial intelligence (AI) techniques are used for many purposes, such as self-driven cars, manufacturing in dark factories, chatbots, and Robo-advisors. In line with the increasing use of AI in the financial sector, empirical studies also reveal that AI techniques perform better than conventional models (regression). This study aims to shed light on the effects of AI techniques on investors' decision-making process in the case of the Turkish finance industry. The main purpose of this study is to develop an understanding of the importance and the superiority of AI and its selected applications in financial decision-making. With this purpose, the applications of selected AI techniques such as neural networks, genetic algorithms, and Robo-advisors in finance have been reviewed. The EU regulatory framework has also been reviewed and compared with the applications in Turkey to develop some policy suggestions and also investigate industry practices in the Turkish finance industry. As the first observation of the study, numerous studies reveal that AI techniques are superior to conventional models to optimize and balance a portfolio, and predict stock prices, exchange rates, bankruptcy, or other financial failures. As a policy suggestion, Turkish policy-makers may focus on the following key policy areas for further development in AI applications: data collection, measuring the industry and firm-level AI performance, awareness, education, and possible firm and system-wide risks.

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Introduction

"But, it is possible to design a machine consummating itself."

Arf (1959, p. 93)

If we start from the beginning of the inventions of humanity it sounds like a very long story when we come up with thinking and the learning machine which we call artificial intelligence (AI). Early humans invented some stone tools such as hand axes or hammers two million years ago having no clue that they were the first ones among us to take the first step of this story. A stone hand axe has been transformed into a robot in the hands of early humans. That's what happens when information cascades through long ages and today scientists use the same cumulative information as an input to create a thinking machine to do many things to ease our lives and solve our problems.

A machine is not a human so an investor can beat these biases by making decisions considering a Robo-advisor. Robo-advisors -digital investment management systems- can digitalize the entire investment management process which is previously conducted by the investor himself or a human advisor (Jung et al., 2018; Rühr, 2020). However, how can a machine decide whether a low price means an opportunity to buy the stocks or bankruptcy of the firm? The answers to these questions lie in the application of AI technology to financial transactions. AI technology is not new but drawing attention gradually. Panel 1/a of Figure 1 shows the statistics of how many times the phrase "AI" has been searched on Google since 2004. The trend is again moving up since 2013. The top country is Ethiopia where people are more curious about this mind-blowing technology. As it can be seen from Panel 1/a of Figure 1, the list is full of undeveloped countries except for Canada and South Korea[1] which is also interesting. Besides its benefits in many fields, AI is also widely used in the finance sector in the form of chatbots, digital assistants, and Robo-advisors. It helps investors to pick the right stocks at the right time, optimize their portfolio and balance, for asset allocation, to decide to buy or not to buy insurance, for planning retirement, predict the stock prices, exchange rates, the value of properties, to take advice on financial plans (also see, Maedche, 2019; Shanmuganathan, 2020). The investors who are capable of using this technology benefit from this advice. AI and its techniques help investors to optimize their preferences considering market conditions. Banks and financial institutions provide Robo-advisory to their customers and they work on making it more user-friendly to reach more customers. Panel 1/b of Figure 1 illustrates how much people are interested in "Robo-advisor" according to google statistics. It also demonstrates the prevalence of this technology in the world. The concept of Robo-advisor has also drawn considerable interest since 2013. Contrary to the results of "AI" web search, "Robo advisor" is being searched mostly in developed countries (see, Flavián et al., 2021). This may imply that AI as a phenomenon may be attention-grabbing for people who do not experience it normally, however, Robo advisor is a more actual application that draws the attention of people who normally use or have the chance to use it.

[1] Based on United Nations Country classification, see: https://www.un.org/en/development/desa/policy/wesp/wesp_current/2014wesp_country_classification.pdf (accessed on 03.10.2021).

Figure 1: Google Trend Statistics
Note:Panel 1/a: for "Artificial Intelligence" **,** Panel 1/b: for "Robo advisor"
Source: Retrieved 3 November 2021 from:
https://trends.google.com/trends/explore?date=all&q=Artificial%20intelligence;
https://trends.google.com/trends/explore?date=all&q=Robo%20advisor .

The main purpose of this study is to develop an understanding of the importance and the superiority of AI and its selected applications in financial decision-making. I utilize literature review and case study analysis as the research method. This paper contributes to the field by identifying aspects that need to be further investigated to understand if and how the finance industry may respond to the applications of AI and how AI applications in the Turkish finance sector may develop. I also review existing AI application practices and AI policy frameworks in the Turkish finance industry to develop suggestions for policymakers.

The rest of the study is organized as follows. The second section presents the history of AI which is important to understand the main idea behind this technology and its various benefits. In the third section, by reviewing the literature, the most used applications of AI are explained and the studies are compared and discussed to analyse the difference between conventional methods and AI applications in the case of investor preferences. Section 4 investigates AI applications in the Turkish finance industry. This section also develops a policy framework comparison between the EU and Turkey to show possible gaps between the two. Finally, the conclusion gives a summary and critique of the findings. This study has also an Appendix involving a Robo-advisory case study, namely Maxi of Is Bankası.

A Review of the Literature

The Role of AI Prediction in Financial Decision-Making

As noted by Galbraith (2012) companies add a new strategic dimension to their strategy and structure about every 30 years, thereby requiring the creation of new integrating mechanisms. It seems that the information age and Industry 4.0 bring into consideration the role of data in the last two decades. The input of an AI is "data" and its output is a "prediction". The quality of the data determines the power of the prediction and it reduces the uncertainty in the process of decision-making. However, a decision is one move ahead of a prediction. In a financial system, all agents make decisions consistently and they face some uncertainty in all cases. The purpose of AI techniques is to gather all available data and after data processing makes predictions. An agent gets the prediction and evaluates all possible outcomes and makes a decision by considering the awards and payoffs in all scenarios. The decision depends on the agent's risk preferences, judgments, and biases. Hence, even with perfect data processing and a realistic prediction, still, there is a

probability of making a wrong choice. Nevertheless, AI techniques help to better understand the huge amount of data we receive from the markets and cannot handle to analyze it in time.

It is crucial to forecast disequilibrium and price movements in asset markets. Despite usual constraints, an algorithm may help to forecast by using several AI techniques such as neural networks, genetic algorithms, expert systems, fuzzy logic, hybrid systems, etc. In this respect, the artificial neural networks method is used for many purposes such as credit scoring, bankruptcy prediction, stock market prediction, pricing initial public offerings, exchange rate forecasting, risk management, etc. (see, Bartram et al., 2020; Becalli et al., 2020). These are all affecting the investors' preferences for picking the right stock at the right time and for all other financial decisions.

Selected AI Applications in Finance

In this section, we briefly review the applications of selected AI techniques such as neural networks, genetic algorithms, and Robo-advisors in finance. In this review, I also ask whether these AI applications outperform the traditional approaches.

Neural networks

The brain of both human and animal consist of cells namely "neurons". The computations of the brain are done by a highly interconnected network of neurons, which communicate by sending electric pulses through the neural wiring consisting of axons, synapses and dendrites. The demonstration, in particular by Rosenblatt, that simple networks of such model neurons called 'perceptrons' could learn from examples stimulated interest in the field, but after Minsky and Papert (1969) showed that simple perceptrons could solve only the very limited class of linearly separable problems, activity in the field diminished. Both the simple perceptron with a single unit and the multi-layer network with multiple units can easily be generalized to prediction of more than two classes by just adding more output units (Krogh, 2008). In an average person, it is estimated that 100 billion neurons exist in the brain and they are connected. These neurons do not have a storage capacity but they carry information among all neurons and this group of neurons' activity generates a network. Thinking, learning, and memorizing is being controlled by the brain, and when the interaction among neurons increases, intelligence, reasoning, and creativity also increase. The more information the more interactions among neurons. The more interaction the more intelligence. What researchers do by develop a new model called artificial neural networks (ANN) to imitate the neural network activity of the brain. The more information (inputs) the more activity (hidden layers). The more activity the more realistic predictions (outputs). Even though there is extensive research on neurobiology and psychology it is still incomprehensible to figure out how the brain works. Therefore, the ANN model is incomplete and far from being the same as a biological brain. Nevertheless, neural networks (NN) are of utmost importance for modelling a decision-making process.

A great number of researches have been carried out on ANN and how they can be a useful tool to ascertain investors' preferences on risk, portfolio optimization, etc. For instance, Solin et al., (2019) investigate the portfolio optimization problem by using a sample of 38 stocks from 45 stocks listed in LQ45 (Indonesian Stock Exchange) which consists of a company with high liquidity for the past 10 years. For stock price prediction, both ANN and genetic algorithm methods have been employed. According to the results, the ANN method is successful to predict the daily closing prices accurately (0.98) and the genetic algorithm method also succeeded in optimizing the index of stocks in comparison with the Single Index Model. Thus, by offering a condition of a portfolio of stock combinations in the future, predicting the stock portfolios support investors in making investment decisions. In other words, accurate predictions help investors to build good optimal portfolio predictions and make optimal decisions.

Another study by Hosaka (2019) examines bankruptcy which is also crucial for investment decisions. Hosaka (2019) applied a convolutional neural network (CNN) which is more suitable for application to images but less suitable for general numerical data including financial statements. In the study, as many financial ratios as possible have been calculated from the financial statements of each firm in each fiscal year and reported a set of 160 ratios as a single grayscale image. To achieve this, each financial ratio is made to correspond to a specific pixel position in an x, y-coordinate system and the pixel's brightness value is set based on the corresponding financial ratio's value. Then the images are used as inputs to employ the CNN method which was generated with this process (Hosaka, 2019). Despite the method performing well to predict bankruptcy, in contrast to a variety of conventional methods, the CNN method does not provide information on which of the financial ratios has more power to predict bankruptcy. Therefore, it doesn't serve for analyzing the underlying reasons for bankruptcy. Hence, neural networks methods also have their pros and cons like all other conventional methods. Nevertheless, there are numerous studies (Ellis and Wilson, 2005, p. 109; Zimmermann et al., 2001, p. 1465; Yamamoto et al., 1993, p. 88, among others) that confirm that NN models perform better compared to conventional models to solve the portfolio optimization problem. Bahrammirzaee, (2010) argues that NNs often outperform the more traditional and statistical approaches however, there are also some studies in which other traditional methods or intelligent approaches outperform NNs. The author emphasizes that the success of NN models is related to some unique characteristics of NNs in financial markets like their numeric nature, no requirement for any data distribution assumptions (for inputs) and model estimators and finally, their capability to update the data.

Genetic algorithms and hybrid techniques

The genetic algorithm (GA) which was introduced by John Holland ([1960], 1992), is an adaptive heuristic research method based on population genetics. Depending on the mechanics of natural genetics and natural selection, GA starts with a set of solutions called population and a solution is represented by a chromosome (Kumar et al., 2010, p. 452). The method is used to analyze the risk preferences of investors, portfolio optimization, and asset allocation. Miri et al., (2020) aim to examine whether or not one of the algorithms of NSGA-II (Non-dominated Sorting Genetic Algorithm II) and SPEA-II (strength Pareto evolutionary algorithm) is superior to others in the stock market in different months. Based on investor risk-taking behaviour and momentum, it is also explored which of the two optimized portfolios can achieve better results (Miri et al., 2020, p. 5). The SPEA- II and NSGA-II were compared using the performance indicators (set coverage and mean ideal distance). The results of the study reveal that the SPEA-II algorithm provided better solutions than the NSGA-II algorithm. Miri et al., (2020) state that due to the results the strategy of selection based on the risk-taking level of an investor could gain a return of up to 9.5% in the 3 months and it could also achieve an annual return of 22%. Moreover, findings imply that the investor could obtain better returns in the recession period in conjunction with less loss and proper returns.

Another study by Chen et al., (2020) investigate portfolio selection problems with higher-order moments by using data from the Shanghai Stock Exchange of China. The results imply that the performance of the optimal portfolio provided by the GA model on risk management and yield is superior to those widely used approaches for nonlinear programming, simulated annealing algorithm (SA), and the mixed penalty function method (MPFM). To verify the effectiveness of the multi-channel convolutional neural networks CNNs model by using a genetic algorithm (GA), Chung and Shin (2019) compare the prediction results with standard ANN and CNN methods. The purpose of the study is to predict the stock market prices despite the efficient market hypothesis (Malkiel and Fama, 1970, p. 391) which suggests that it is impossible to forecast the price in stock markets hence the price already reflects all the

available information. According to the findings, GA-CNN outperforms the comparative models and it is found to be more effective as a hybrid approach of GA and CNN. GA models also have better performance as well as NN models when it is compared to conventional models for risk prediction and management, stock market prediction, and portfolio optimization.

Both GA or NN models have been applied to predict the prices of different asset classes such as crude oil price (Elaziz et al., 2019, p.11) and bitcoin price (Han et al., 2019, p. 9). Because investors prefer to diversify risk into several assets, no matter which one has been chosen, it is vitally important to ascertain the trends and future prices of assets. Elaziz et al. (2019) emphasize that oil prices are the most important source for commodity price changes because oil is considered a commonly used source as a crucial part of numerous production processes in the world. Therefore, Elaziz et al., (2019) develop a model to predict the crude oil price which provides valuable information to stakeholders about market trends in the future for making the right decisions to prevent possible risks. Findings imply that the GA-SSA-ANFIS (genetic algorithm (GA)- salp swarm algorithm (SSA)- adaptive neuro-fuzzy inference system (ANFIS) model provides some results for commodity price forecast with high quality. Han et al. (2019) use the optimal NARX neural network model selected by the GA to predict the daily average price of bitcoin. Results of the study indicate that the model can properly predict the tendency of the data and also the hybrid model outperforms the feed-forward model in forecasting the geometric return of Bitcoin. One may speculate that AI techniques outperform conventional methods according to the numerous studies in the related literature, moreover, hybrid techniques such as GA-ANN, GA-SSA-ANFIS, etc. appear to be more effective than classical NN or GA methods to predict future prices and market trends which help investors to make better investment decisions. However, we should also note that problems with AI algorithms may set limits on their forecasting capacity. For example, as one of the most common problems for AI algorithms, over-fitting, defined as a lack of good generalization of the model from observed data to unseen data, may set a limit on the efficiency of AI applications (see, Ying, 2019; Roelofs, 2019).

Robo-advisors

A Robo-advisor can be defined as a set of algorithms. Based on the customer's goals, risks, and information about the income, age, gender, and assets of the customer, a Robo-advisor is used to calibrate an investment portfolio and exclude emotionally biased decisions (Ivanov et al., 2018, p. 199; Tertilt and Scholz, 2018, p. 82). Chatbots or digital assistants may also perform some similar functions to the Robo-advisor. After a simple questionnaire, the Robo-advisor recommends specific investment options to the customer. Assets under management in the Robo-Advisors segment are projected to reach US$1.79tn in 2022 and the highest assets under management is reached in the United States (US$1,230.00bn in 2022) (Statista, 2022). Compared to traditional human advisors Robo-advisor presents numerous advantages such as diminishing the fees of management significantly and providing broader options for investment (Belanche et al., 2019, p. 1422). By using web survey data which consists of 765 customers' information from Portugal, the UK, and the US, Belanche et al. (2019) targeted potential users of Robo-advisors to investigate the benefits of Robo-advisor. The results of the research reveal that consumer attitudes toward AI systems have a key role in the intention to use them; thus, the design of a user-friendly platform is fundamental to shaping users' favourable predisposition toward the use of Robo-advisors. To increase the number of users of Robo-advisor, financial institutions, companies, and banks must be able to mitigate customers' doubts and intensify their perceptions of these systems.

A great number of studies attempted to develop a better model for optimal portfolio selection to make available to Robo-advisors instead of traditional models such as the mean-variance model or CAPM. Ahn et al. (2020) aim to develop an asset allocation model for a

Robo-advisor by applying more advanced techniques and comparing its performance with those of conventional models. It is suggested in the study that the proposed asset allocation model could be used as an algorithm for portfolio management and automated investment advice by a Robo-advisor. Tertilt and Scholz (2018) analyze how the Robo-advisors evaluate the risk tolerance of their clients by using the data of thirteen anonymized Robo-advisors: seven German Robo-advisors and six market-leading ones from the United Kingdom and the United States. After analyzing the quality of the questionnaires it is found in the study that the Robo-advisors pose around ten questions, but only approximately sixty percent of questions affect the risk categorization. Therefore, it is suggested that Robo-advisors should consider different perceptions of goal-specific risk tolerance because it may lead to inferior risk assessment if a failure occurs to ascertain the real risk preference of the investor.

The literature also reveals some risks for robo-advisory. For example, Litz (2017: p. 291) discussess that they are simply an automated system offering advice and cannot take into consideration the entirety of their client's ever changing needs. However Maume (2019) underlines that robo-advisory result in persisting legal uncertainties in practice and required regulatory change does not seem likely in the near future. Jung et al. (2019) underline that regulatory authorities have raised concerns for robo-advisors regarding conflict of interests, the poor assessment of risk tolerance, the missing personal contact and consequentially the unfulfilled fiduciary duty towards investors and regulatory authorities. Gurrea-Martínez and Wan (2021) discuss that regulatory challenges for the robo-advisory industry, including privacy & security and and the need for interdisciplinary cooperation for the regulation.

Artificial Intelligence Applications and Policy Framework in Turkey

AI Application in the Turkish Finance Industry

The Finance industry is the major user of digital technologies and AI applications globally. OECD (2017; 2021) suggests that AI is increasingly being used the financial services providers in all sub-sectors such as in banking (tailored products, chat boxes for client service, credit underwriting, and scoring, credit loss forecasting, fraud monitoring, and detection, customer service); asset management (Robo-advice, management of portfolio strategies, risk management); trading (algorithmic trading); insurance (Robo-advice, claims management). Anecdotal evidence suggests that AI is also growingly used in the Turkish Finance industry. Below I briefly investigate the recent improvements of AI applications in banking, capital markets, and insurance sectors as the leading sub-sectors of the Turkish finance industry.

According to TÜBİSAD and Deloitte (2020), the market value of the Turkish informatics industry is 26,7 billion USD as of 2021, and digital transformation has accelerated during the 2019-2021 period (TÜBİSAD, 2021, p. 41). The Turkish AI Initiative also suggests that the AI ecosystem in Turkey has shown improvement recently. In this respect, the number of firms in the Turkish AI ecosystem is increased from 64 in 2018 to 226 as of 2022[2] (see, Figure 2).

[2] Retrieved 8 April 2022 from: https://www.aa.com.tr/tr/bilim-teknoloji/turkiyedeki-yapay-zeka-ekosistemi-buyumeye-devam-ediyor/2488653 . Also see Fintech Istanbul (2019) for the fintech firms in the Turkish Finance sector.

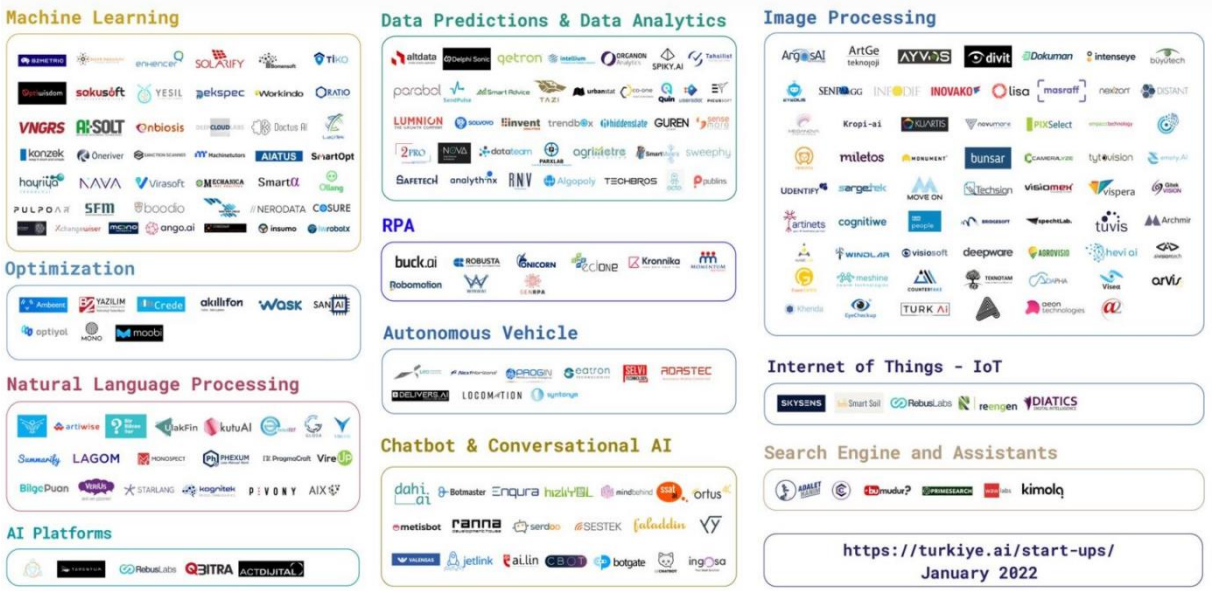

Figure 2: AI Ecosystem In Turkey (2022)
Source: https://turkiye.ai/en/start-ups/ (accessed on: 4 April 2022).

The fintech ecosystem in Turkey supports the adaptation of the latest finance technologies into the finance industry (see, Coşkun and Coskun, 2022). I review this process from the perspective of adaptation of AI in the Turkish finance industry. Although this study is one of the first attempt to examine the impacts of AI in the industry, I should note that the lack of industrial data and empirical evidence seems a serious limitation to our understanding. Despite this shortcoming, I attempt to analyze some available data and industry practices.

There are several methods to implement AI to analyze the investors' portfolio optimizing strategies as well as to predict stock prices, bankruptcies, or financial failures. AI applications further support the computerization of financial services in different sub-markets (i.e., see, Dirican, 2015; Malali and Gopalakrishnan, 2020). For banking, the Participation Banks Association of Turkey (2021) indicates that the use of modern fintech applications such as AI, ML, and Robo-advisory, has been evolving in Turkish participation banks. According to digital, internet, and mobile banking statistics of The Banking Association of Turkey (2021), the number of active digital customers in the Turkish Banking Industry has increased from 35 million to 78 million respectively in the years 2017 and 2021. The applications subjects of internet banking involve a wide range of investment subjects such as transactions in stocks and futures markets, mutual funds, foreign exchange, time-deposit, gold, repo, and government/corporate bonds besides fundamental banking transactions such as money transfer and payments. This statistic reveals that the volume of digital transactions in banking is 673 billion Turkish Lira representing a % 362 increase from 2017 to 2021. Although the statistics of the Turkish Banking Industry do not provide detail on the volume of AI applications, anecdotal evidence suggests that through mobile and digital banking channels AI applications have been actively used in the Turkish banking industry as suggested by various products offered by Turkish banks such as Robo-advisory, interactive voice response, or QR codes.[3] For example, by analyzing Isbank's Personal Assistant 'Maxi' added to Is Bankasi mobile

[3] Retrieved 6 April 2022 from: https://l24.im/XZj ; https://l24.im/KVDwE1p ; https://l24.im/keoVb.

application in 2018, Memiş and Geylan (2021) conclude that this AI application has recorded an impressive number of queries, overwhelmingly positive feedback, and a very high percentage of accuracy. The banking industry utilizes AI applications for cybersecurity and fraud detection, loan and credit decisions, tracking market trends, compliance, and risk management. I review the case of Is Bankası Maxi in Appendix 1 as the case study.

AI applications are also actively used in pension/mutual fund transactions and stock market trading in Turkey. In this respect, it seems that the Turkish private pension sector attempts to use robo-advising applications. For example, Garanti Emeklilik and AvivaSA Emeklilik have already robo-advising tools.[4] It may interesting to note that, as one of the leading pension firms in Turkey, Anadolu Hayat Emeklilik indicates that the company received several international awards for her private pension robot fund consultancy service (what is called FonMatik ROBO).[5] Through colocation service, Borsa Istanbul (BIST) started to provide infrastructure for HFT (high-frequency trading) and algorithmic trading in 2015.[6] According to Ersan and Ekinci (2016), approximately 6% of the orders in BIST would be HFT. HFT involvement is higher in large orders (11.96%), in orders submitted by portfolio/fund management firms (10.40%), after the improvement of BIST's order submission platform and tick size reduction for certain stocks.

Although I have no detailed data on the volume, impact, and effectiveness of the AI application framework, I may cautiously conclude that the Turkish finance industry has already started employing AI tools in its operations.

Policy Framework of AI Application in EU and Turkey Context

Governments and international organizations have begun to think extensively about artificial intelligence (AI) and its economic and social implications. This is reflected in the preparation and publication of national AI strategies and reports and the formation of new government bodies and commissions (Diplo Foundation, 2019). According to European Innovation Scoreboard 2021, Turkey is classified as an "emerging innovator". However, it is indicated that the country's performance relative to the EU has decreased, in particular in 2021[7]. This picture brings into consideration of the AI market dynamics and policy effectiveness for his specific subject in Turkey.

Digital transformation is a leading subject all around the world thanks to the industry 4.0 revolution. For example, the European Commission proposed a path based on her 2030 Digital Decade targets. The Commission monitors the digital performance of each member country according to the Digital Economy and Society Index (DESI).[8] AI is classified as part of the leading digital Technologies in the DESI. In this respect, European Commission suggests that a quarter (25%) of enterprises use at least two AI Technologies in the member countries.

Focusing on enterprises using two or more AI technologies, the following country-level differences can be observed in the EU: the adoption of two or more AI technologies is highest in Czechia (40%), followed by Austria (37%), Greece, and Lithuania (both at 34%). The uptake of two or more AI technologies is the lowest in Ireland (14%), Slovakia, and Estonia (both at

4 Retrieved 8 April 2022 from: https://l24.im/2vud6 ; https://l24.im/4HVF.
5 Retrieved 8 April 2022 from: https://l24.im/41Or5j.
6 Retrieved 8 April 2022 from: https://l24.im/rp4ZE2; https://l24.im/dKAiEG.

[7] Retrieved 6 April 2022 from:https://ec.europa.eu/docsroom/documents/45939
8 Retrieved 6 April 2022 from: https://l24.im/Ym1tS2f ; https://l24.im/Ym1tS2f

15%). Regarding the plans to use AI technologies in the next two years (2021-2023), the most likely are enterprises in the finance and insurance sector (27%), waste management (27%) and education (21%) (see, European Commission, 2021: p.59-60). Moreover, the European Commission also presented the Artificial Intelligence Act on 21 April 2021. The EU AI Act sets out horizontal rules for the development, commodification, and use of AI-driven products, services, and systems within the territory of the EU. The draft regulation provides core artificial intelligence rules that apply to all industries.[9]

Turkey carries out various initiatives in digital transformation in several fields also involving big data, and AI (TÜBİSAD, 2021, p. 36). The Eleventh Development Plan (Plan) of the Ministry of Development for the period of 2019-2023 involves some principles to support AI applications. However, it seems that there is no specific and detailed focus on how to support AI applications in the finance industry in general despite the positive policy outlook for digitalization and some AI applications such as Robo-advisory and text-mining (see, Kalkınma Bakanlığı, 2018). As an interesting attempt to develop AI applications in the Turkish economy, the Presidency of the Republic of Türkiye Digital Transformation Office (PRTDTO) (2021) declared the National AI Strategy for the period 2021-2025. It is indicated in this report that the finance industry has successful AI applications comparing other industries. Policy suggestions available in PRTDTO (2021) also underline the approach of possible state initiatives soon in this particular field. According to this report, the National AI Strategy of Turkey defines the following strategic priorities with 24 objectives and 119 measures: training AI experts and increasing employment in the domain, supporting research, entrepreneurship, and innovation, facilitating access to quality data and technical infrastructure, regulating to accelerate socioeconomic adaptation, strengthening international cooperation, and accelerating structural and labour transformation.[10]

As implied in above official documents, a possible state intervention on AI market may indirectly help to develop its several applications such as robo-advisory. However, existing regulatory frameworks in capital markets, insurance and banking industry, do not suggest a specific incentive for the development of AI and/or robo-advisory applications. We suggest that relavant agencies such as Capital Markets Board of Turkey, Banking Regulatory and Supervisory Agency, and Insurance and Private Pension Regulation and Supervison Agency may focus on to develop some incentives for a broader use of AI and robo-advisory in Turkey.

Conclusion

There is a growing literature on artificial intelligence (AI) techniques such as neural networks, genetic algorithms, fuzzy logic, expert systems, or hybrid techniques. However, the importance of this state-of-the-art technology is still a black box for most people and also scholars in the field of economics and finance. By utilizing a literature review, this study investigates the superiority of AI techniques over conventional models in the context of neural networks, genetic algorithms, and Robo-advisors. I also examine AI applications and their policy framework in the case of the Turkish finance industry.

As the first observation of the study, numerous studies reveal that AI techniques are superior to conventional models to optimize and balance a portfolio, and predict stock prices, exchange rates, bankruptcy, or financial failures (i.e., see, Hosaka, 2019; Han et al., 2019, p. 11; Miri et al., 2020, p. 10; Chen et al., 2020, p. 14). Therefore, one may conclude that the

9 Retrieved 6 April 2022 from:https://l24.im/yIWLK; https://l24.im/R2zwv
10 Retrieved 5 April 2022 from: https://cbddo.gov.tr/en/nais.

power of these new models helps to forecast future trends of assets and guide investors to interpret the market signals to make better investment decisions. This result implies that there is a possibility to better understand the price movements in the asset markets and develop better forecasting. However, one should also note that explicit/implicit uncertainties in the asset pricing could not eliminate perfectly despite well-designed algorithms. Usually, very few researchers may estimate correctly the crisis or failures. Therefore, despite the vigorous efforts of scientists for outperforming algorithms, the unpredictability of nature will always remain.

AI techniques are widely used in many industries globally. The good news is that it now widely serves the average investors and its user-friendly adaptation contributes to increasing efficiency in the finance industry. It seems that the Turkish finance industry is also a mainstream example of this global fact. As the second observation, I may speculate further development in AI applications in the Turkish finance industry would mostly depend on market dynamics rather than an active policy response. The recent policy documents recognize the importance of AI applications for the Turkish finance industry, however, comparing the EU case, one should note that the development of AI applications based on a policy framework has serious limitations in Turkey. In this respect, Turkish policy-makers may focus on the following key policy areas for further development in AI applications: data collection, measuring the industry and firm-level AI performance, awareness, education, and possible firm and system-wide risks (see, Financial Stability Board, 2017). In line with the recent initiatives in the EU, Turkish policymakers may also develop an AI law to foster AI applications in Turkey. We also suggest that relavant agencies such as Capital Markets Board of Turkey, Banking Regulatory and Supervisory Agency, and Insurance and Private Pension Regulation and Supervison Agency may focus on to develop some incentives for a broader use of AI and robo-advisory in Turkey.

I propose that future research may concentrate on the empirical impacts of AI applications in the Turkish financial sector. The micro-level analysis would be better to solve the puzzle of data constraints in this specific field. In this respect, it would be of interest for future research to measure the benefits of AI in several finance fields such as trading and risk management.

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