

## MACHINE LEARNING FOR FINANCIAL APPLICATIONS – A MINI-REVIEW

**Claudiu Clement<sup>1</sup>**

<sup>1)</sup> *University of Alexandru Ioan Cuza, Iasi, Romania*

E-mail: office.claudiucllement@gmail.com

**Please cite this paper as:**

**Clement., C., 2020.** Machine Learning for Financial Applications – a Mini-Review. In: R. Pamfilie, V. Dinu, L. Tăchiciu, D. Pleșea, C. Vasiliu eds. *6<sup>th</sup> BASIQ International Conference on New Trends in Sustainable Business and Consumption*. Messina, Italy, 4-6 June 2020. Bucharest: ASE, pp. 306-312

---

### **Abstract**

There is an increasing interest in utilizing machine learning in financial applications, with an increasing number of researchers contributing to the literature. Considerable amount of research has been published from academics and industry and there has been a constant focus on which is the best tool to be used for specific applications. The momentum of research on this topic does not mean that it is not faced with challenges. This paper, through a mini scoping review of a number of 342 texts published in the year of 2019 on Scopus, aims at providing academics and practitioners with a broad overview picture of the current literature on machine learning applied in finance. The review shows that even though the focus is on the techniques applied in the field of finance, most papers are published in computer science or engineering thematic journals, with economics, econometrics or finance researchers on the fifth place with a mere 4.2% of papers published. Finally, it is concluded that the interest in machine learning for financial applications is undoubtedly continuously increasing with still room for research on the area, being it research or review papers.

### **Keywords**

machine learning, financial applications, finance, scoping review

### **JEL Classification**

C15, C40, C80, G00

---

### **Introduction**

The financial sector always was an important driver of social well-being and economies are highly dependent on it. It is extremely important that financial institutions function well for the capital accumulation and economic development to happen (Bahrammirzaee, 2010).

With the help of researchers from various domains, machine learning techniques are positively reshaping the financial sector like never before. All applications of machine learning methods in areas such as algorithmic trading, risk assessment, fraud detection, portfolio management, asset pricing and derivatives market, cryptocurrencies and

blockchain, financial sentiment analysis and behavioral finance (Ozbayoglu, Gudelek and Sezer, 2020) have presented an immense amount of interest from researchers.

Moreover, the interest on research is constantly increasing every year. Consequently, a vast amount of methods has emerged in conferences and journals with the goal of either better operationalizing the day-to-day activities of financial institutions or improving the accuracy and effectiveness of their existent models used. Considering the momentum of the information published on the subject, the abundance of information makes it hard for researchers to keep up the pace thus, a need for a brief presentation of the literature is a very valuable tool.

For this study, available papers from Scopus database available for the search keywords *machine learning in finance* were assessed using the scoping review approach. A number of 342 papers were found as published in the year of 2019. Papers were not filtered by their JEL code as the theme of journals publishing the papers is for the interest of this study. Moreover, only papers written in English were selected for review, all including the terms *machine learning* as their leitmotif or treated the theme in respect to the field of finance.

The idea of a scoping review was first introduced by (Arksey and O'Malley, 2005) and it aims at providing an overview of a broad field, in this case finance, rather than giving detailed answers to specific questions (Moher, Stewart and Shekelle, 2015). In this type of research, quality assessment is not conducted. This type of review shares much of the characteristics of systematic literature review, being systematic, transparent and replicable but it does not make practice recommendations. In this case, the goal of this paper is to help in providing ground for a full systematic review. This type of review is relatively new but increasingly common for mapping broad topics (Pham *et al.*, 2014).

Although the literature on machine learning and applications in finance is very abundant in studies, the same thing can not be said about the literature reviews on this topic. There are very few studies summarizing the state of the domain in specific areas such as financial market prediction (Henrique, Sobreiro and Kimura, 2019), banking and risk management (Leo, Sharma and Maddulety, 2019), energy economics (Ghoddusi, Creamer and Rafizadeh, 2019) or financial time series forecasting (Sezer, Gudelek and Ozbayoglu, 2019), moreover specific review studies covering finance in general and not niche topics could not be found.

This mini scoping review aims at understanding what is the current state of the literature of machine learning techniques specifically on finance, by presenting what is the thematic of journals publishing studies on the matter, what are the research affiliations and what type of documents were published. The journal's theme is a debatable subject as more and more cross-domain studies are published and even though the topic of one paper might seem as belonging to a clear identifiable niche, researchers lately publish papers in related topic papers, for example, finance oriented papers being published in computer science journals. The affiliation of researchers is very important for identification of certain hotspots of research, if the case. Also, for an understanding of the type of research developed what type of papers get published constitute an important factor. This being only a mini review paper, no attention has been paid to the methods, data set, feature set, method or performance criteria. An in-extenso paper including the before-mentioned information will be published afterwards.

The rest of the paper will present a short literature review on similar studies, the results found in the analysis followed by summarizing our findings and making suggestions for further research.

## **2. Literature review**

It all started in the sixties, when (Keenoy, 1958) first published his concept of *office automation* and since, there has been an increasing amount of interest in the field of

intelligent techniques used in finance. Given the abundance of information and accessibility restraints the need for summary papers is self-explanatory.

One of the key literature review research paper in the field of intelligent techniques used in finance is (Bahrammirzaee, 2010). The author has done a comparative review of three main artificial intelligence techniques (i.e. artificial neural networks, expert systems and hybrid intelligence systems) and their applications on financial markets. It was proven that the accuracy of intelligent techniques is better than that of classical statistical methods in dealing with financial problems, especially when involving nonlinear data.

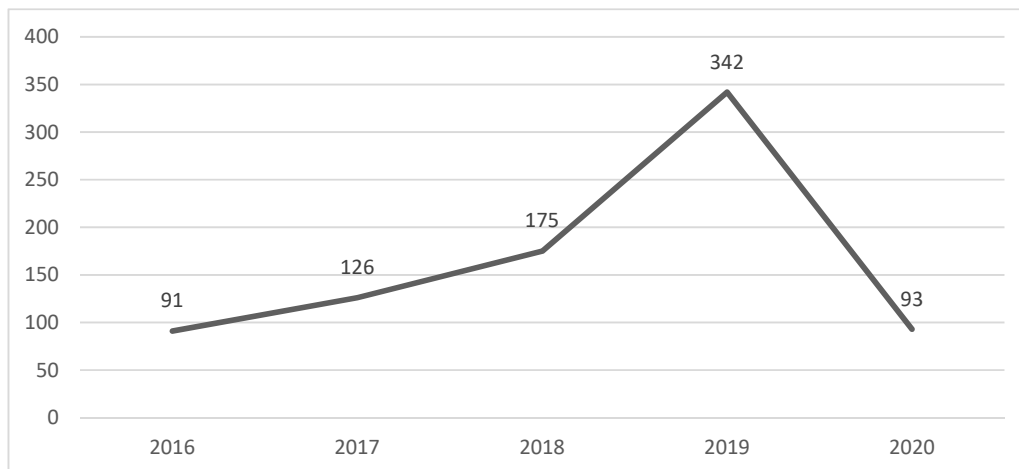
Six years earlier, (Zhang and Zhou, 2004) approached the literature from a data mining perspective reviewing techniques such as genetic algorithm, rule-based systems and neural networks and their applications in financial applications. The authors final conclusion was that there were still many unsolved issues and challenges in the context of data mining applications in finance at the time of writing the paper but they also previsioned the great potential of the techniques and their increased adoption on the premises of the knowledge-economy. Also from a data mining perspective, but 9 years after the paper of Zhang and Zhou, (Pulakkazhy and Balan, 2013) provide a new overview over the data mining techniques and procedures and conclude that there is an increasing trend in financial institutions investing in data mining technologies to be more competitive.

Another important review paper on the subject was (Mochón *et al.*, 2008) that summarized the information present in the research area from a soft computing perspective, considering neural networks, fuzzy logic and probabilistic reasoning. Finance being a field where often information is either imprecise, hard-to-be-learned or uncertain, the use of soft computing is instinctive and as the authors proved it provides researchers with great results showing a very promising future as well.

The academic coverage is vast and above there is presented just a small part of it, some of the most representative papers in the area from the perspective of machine learning in finance applications.

### 3. Findings

In this paper, we reviewed 342 papers published on Scopus in the year of 2019 from various financial application areas. Each paper is analyzed according to its journal of publication topic, document type and affiliation.

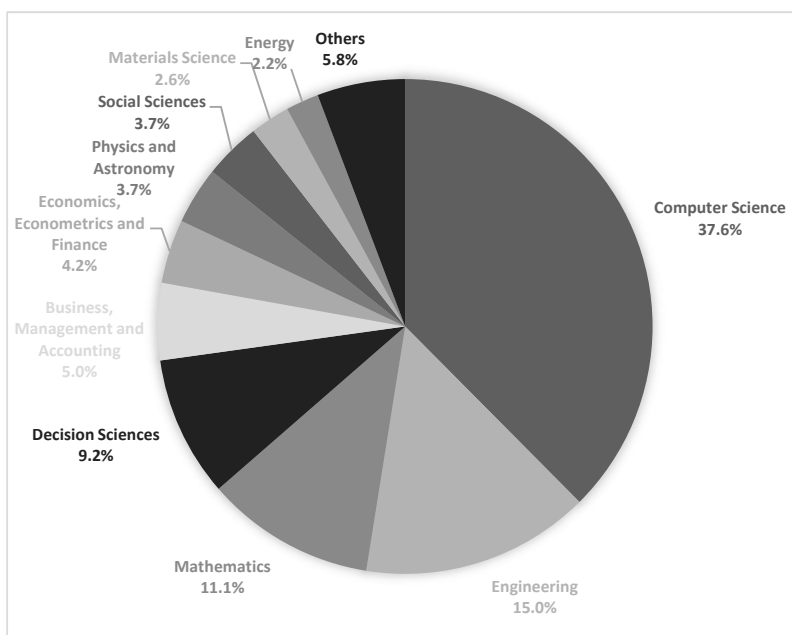


**Fig. no. 1 Number of papers published on Scopus yearly**

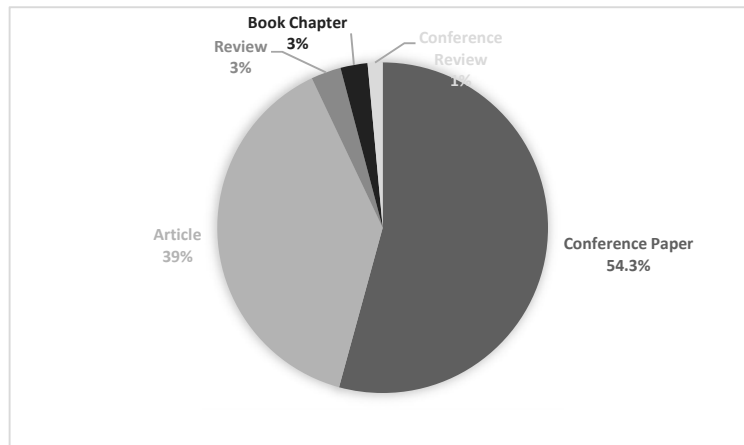
Source: Scopus, registered trademark of ELSEVIER B.V. <http://scopus.com/search>

First and foremost, in (fig. no. 1) the number of papers published in each of the last years and current year is presented. The figure shows us that interest in the domain is abruptly increasing with papers already published in 2020 overcoming the number of papers published in the whole year of 2016. This sustains the idea and need of an in-extenso paper on this subject as the information being published is already becoming overwhelming to be read by academics or professionals. Due to accessibility restraints only Scopus papers have been analyzed but the trend is present on the other databases as well as presented by (Ozbayoglu, Gudelek and Sezer, 2020).

When the papers were clustered by the topic of the journals they were published in (fig. no. 2), we observe the predominant presence of papers published in areas as computer science or engineering detrimental to the science to which its focus is at. This is an interesting indicator of the fact that even though financial industry is adopting more and more machine learning techniques, the researchers that are still interested in their performance or applications are not specifically from financial field. This can constitute a problem on the long run, these applications being multidisciplinary, they need attention from both the beneficiary parts (i.e. financial professionals) and the implementing party (i.e. machine learning researchers).

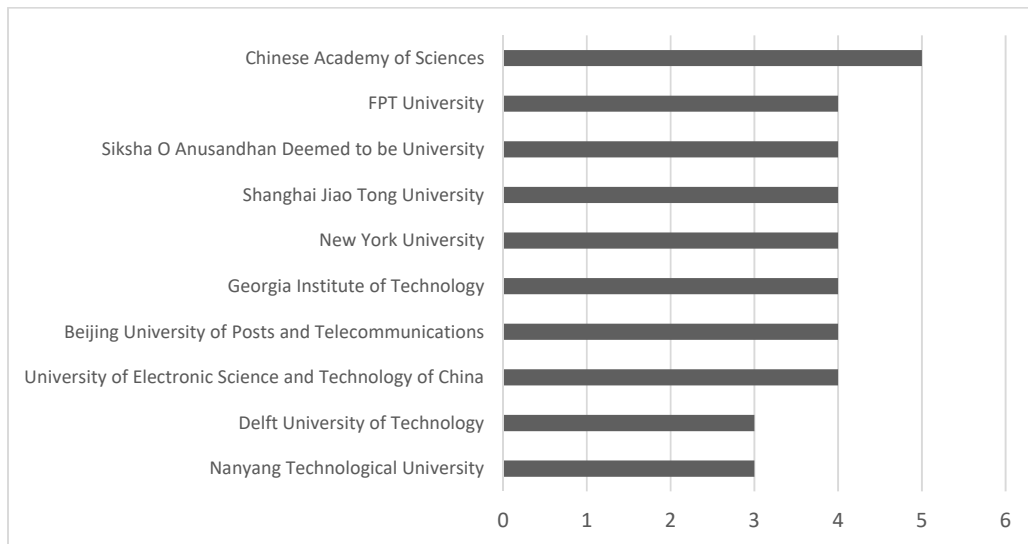


**Fig. no. 2 Percentage of papers published on Scopus by subject area**  
Source: Scopus, registered trademark of ELSEVIER B.V. <http://scopus.com/search>



**Fig. no. 3 Percentage of papers published on Scopus by type**  
 Source: Scopus, registered trademark of ELSEVIER B.V. <http://scopus.com/search>

In (fig. no. 3) the type of documents of the papers published is presented. It can be observed that the majority of papers were published in conference proceedings. The difference in quality between conference and journal articles has been long debated but there is a threshold identified by (Chen and Konstan, 2010) stating that in case where the conference has an acceptance rate of lower than 30% papers show the same or more citations as journal ones. In the same time (Freyne *et al.*, 2010) argued that the case of computer science papers, which is the case for the majority of our papers selected, papers in leading conferences show an impact in terms of Web of Science citation index, similar to that of mid-level journal papers. Unfortunately in the present case, information about the conferences at which the papers were presented is not available and thus the information should be taken as is.



**Fig. no. 4 Top 10 authors affiliations**  
 Source: Scopus, registered trademark of ELSEVIER B.V. <http://scopus.com/search>

Meanwhile, in terms of authors affiliation, (fig. no. 4) shows that the highest number of papers come from Chinese Academy of Sciences but with only 5 published out of 342 it can not be considered as a main focal point of research on the matter. In the same time, what can be observed from the analysis of all papers is that there was an important amount of research coming from Asian countries (China, South Korea, Japan).

### **Conclusions**

The interest in utilizing machine learning for financial applications is not a matter of debate anymore. The amount of research papers is increasing every year as showed in (fig. no.1). However, at least in what it concerns the financial sector, it is presented that the most amount of research is coming from papers published in computer sciences or engineering thematic journals, detrimental to finance journals, meaning that for an optimal approach in such a multidisciplinary domain, both parts should equally contribute to the domain and thus help on advancing the domain. This paper proved the need for a more deep-dive systematic review in order to identify if in these papers focal points were algorithms and their bolts and pieces solely or an approach towards better understanding of the applications was conducted as well.

Finally, it is concluded that, even though, the interest is massively increasing there is still room for new research, mostly coming from finance academics.

This work was cofinanced from the European Social Fund through Operational Programme Human Capital 2014-2020, project number POCU/380/6/13/125015 "Development of entrepreneurial skills for doctoral students and postdoctoral researchers in the field of economic sciences".

### **References**

- Arksey, H. and O'Malley, L., 2005. Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology: Theory and Practice*, 8(1), pp.19–32.
- Bahrammirzaee, A., 2010. A comparative survey of artificial intelligence applications in finance: Artificial neural networks, expert system and hybrid intelligent systems. *Neural Computing and Applications*, 19(8), pp.1165–1195.
- Chen, J. and Konstan, J.A., 2010. Conference paper selectivity and impact. *Communications of the ACM*, 53(6), pp. 79–83.
- Freyne, J., Coyle, L., Smyth, B. and Cunningham, P., 2010. Relative status of journal and conference publications in computer science. *Communications of the ACM*, 53(11), pp.124–132.
- Ghoddusi, H., Creamer, G.G. and Rafizadeh, N., 2019. Machine learning in energy economics and finance: A review. *Energy Economics*, 81, pp.709–727.
- Henrique, B.M., Sobreiro, V.A. and Kimura, H., 2019. Literature review: Machine learning techniques applied to financial market prediction. *Expert Systems with Applications*. 124, pp.226–251.
- Keenoy, C.L., 1958. The Impact of Automation on the Field of Accounting. *The Accounting Review*, 33(2), pp.230–236.
- Leo, M., Sharma, S. and Maddulety, K., 2019. Machine Learning in Banking Risk Management: A Literature Review. *Risks*, 7(1), Article Number: 29.
- Mochón, A., Quintana, D., Sáez, Y. and Isasi, P., 2008. Soft computing techniques applied to finance. *Applied Intelligence*, 29(2), pp.111–115.

- Moher, D., Stewart, L. and Shekelle, P., 2015. All in the Family: systematic reviews, rapid reviews, scoping reviews, realist reviews, and more. *Systematic Reviews*, 4(1), pp.183, Article Number: s13643-015-0163-7.
- Ozbayoglu, A.M., Gudelek, M.U. and Sezer, O.B., 2020. *Deep Learning for Financial Applications: A Survey*, [online] Available at: <<http://arxiv.org/abs/2002.05786>> [Accessed 22 March 2020].
- Pham, M.T., Rajić, A., Greig, J.D., Sargeant, J.M., Papadopoulos, A. and McEwen, S.A., 2014. A scoping review of scoping reviews: advancing the approach and enhancing the consistency. *Research Synthesis Methods*, 5(4), pp.371–385.
- Pulakkazhy, 2013. Data Mining in Banking and its Applications-A Review. *Journal of Computer Science*, 9(10), pp.1252–1259.
- Sezer, O.B., Gudelek, M.U. and Ozbayoglu, A.M., 2019. *Financial Time Series Forecasting with Deep Learning: A Systematic Literature Review: 2005-2019*, [online] Available at: <<http://arxiv.org/abs/1911.13288>> [Accessed 25 April 2020].
- Zhang, D. and Zhou, L., 2004. Discovering Golden Nuggets: Data Mining in Financial Application. *APPLICATIONS AND REVIEWS*, 34(4), Article Number: 513.