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ANALYSIS OF THE APPLICABILITY OF DESIGN OF EXPERIMENTS IN THE FINANCIAL MARKET: SYSTEMATIC LITERATURE REVIEW

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Abstract: The financial market, specifically the stock market, is a sector that suffers from the uncertainty factor and the constant economic instabilities of countries, where it would be ideal to use a tool that assists in the analysis of different probabilities and scenarios and that makes -if possible, introduce variables and situations that could or could not materialize, greatly facilitating the decision to invest or not. One of the experiment analyses tools that has become popular among managers is the Design of Experiments, which can be implemented in the development and optimization of systems, processes and products, however it is underused in the financial area. The general objective of this work is to identify as many areas as possible in which the Design of Experiments is being applied. And specifically, that of synthesizing the works published in the last 10 years, listing by region, language and authors, highlighting the most relevant scientific articles based on the volume of citations and discussing the applicability of the DOE exclusively in the financial market. As a methodology, the Systematic Literature Review (RS) was chosen, through bibliometric analysis. It is hoped that this work can bring another tool to financial professionals to help analyze risks and trace probabilities, increasing its use.
Keywords: Design of Experiments; Applicability; Innovation management; Probability Analysis; Financial market.

INTRODUCTION

Currently, there is a growing demand by companies for tools that help in optimizing their processes with a focus on cost reduction, waste elimination, problem solving and even new product launches or study theories. When we turn our eyes to the financial market, it is not much different. It is a sector permeated by the uncertainty factor, which constantly deals with the economic and financial instabilities of countries and companies, also requiring a tool to analyze various probabilities and scenarios and that would make it possible to introduce variables and situations that could or could not materialize. The tool could also contribute to the adjustment of routes, leading to a more assertive decision-making for investment or not.

One of the tools in this sense that has become popular among managers and increasingly gaining new supporters is the DOE, Design of Experiments (DOE). Durakovic (2017), explains that Design of Experiments is a statistical tool deployed in various types of design, development and optimization of systems, processes and products, which is used to plan and conduct experiments, as well as analyze and interpret the data obtained in the experiments. In other words, it is an extremely useful tool for companies, as part of their decision-making process.

Given these perspectives and as the demand for the use of experimentation tools increases both by companies and researchers, would it really be possible to apply Design of Experiments in any area without distinction, even in an area as unstable as the financial market? And what benefits could they bring to application in the financial area?

The general objective of this work is to identify as many areas as possible where Design of Experiments is being applied. And specific, to synthesize the works published in the last 10 years, listing by region, language and authors.

Highlighting the most relevant scientific articles based on the volume of citations, and, finally, discussing the applicability of DOE in particular in the financial market.

As a methodology, the Systematic Literature Review (RS) will be used, through a bibliometric study using the Web of Science database and "Design of Experiments" as a keyword, with the last ten years as a time frame.

It is hoped that this work can bring one more tool to professionals in the financial area that will help in the analysis of risks and trace probabilities, increasing its use.

THEORETICAL FOUNDATION

DOE – DESIGN OF EXPERIMENTS

HISTORICAL PERSPECTIVE

Telford (2007), in his work, developed a chronological order on the historical perspective of DOE, in which they were:

Invented by Ronald A. Fisher in the 1920s and 1930s at the Rothamsted Experiment Station, an agricultural research station 40 kilometers north of London.

In his first book, Fisher showed how valid conclusions can be efficiently drawn from experiments with natural fluctuations such as temperature, soil conditions, and precipitation in the presence of uncomfortable variables. Known nuisance variables often cause systematic deviations in groups of results (e.g. batch-to-batch variation). Unknown nuisance variables usually cause random variability in results and are called inherent variability or noise. Although the experimental design method was first used in an agricultural context, the method has been successfully applied in the military and industry since the 1940s.

Besse Day, working at the U.S. Naval Experimental Laboratory, used experimental design to solve problems such as finding the cause of bad welds in a shipyard during World War II. George Box, employed at Imperial Chemical Industries before coming to the United States, is a leading developer of experimental design procedures to optimize chemical processes.

W. Edwards Deming taught statistical methods, including experimental design, to Japanese scientists and engineers in the early 1950s at a time when "Made in Japan" meant low quality.

Genichi Taguchi, the best known of this group of Japanese scientists, is famous for his quality improvement methods. One of the companies where Taguchi first applied his methods was Toyota.

Since the late 1970s, industry in the United States has again become interested in quality improvement initiatives, now known as "Total Quality" and "Six Sigma" programs. Experimental design is considered an advanced method in the Six Sigma programs that were pioneered at Motorola and GE.

THE DESIGN OFEXPERIMENTS (DOE) METHOD

Whitford, (2018) explains that Design of Experiments (DOE) is a technique for planning experiments and analyzing the information obtained. The technique allows using a minimum number of experiments, in which several experimental parameters are varied systematically and simultaneously to obtain sufficient information. Based on the data obtained, a mathematical model of the studied process (for example, the amount and timing of a feed component) is created.

The model can be used to understand the influence of the experimental parameters on the result and find an optimum for the process. Customized software can be used to create the experimental designs, to obtain a model, and to visualize the information generated. A DoE approach can greatly improve efficiency in screening suitable experimental conditions,

for example, for cell culture, nutrient complement, factor level, optimization of a process, or robustness testing.(WHITFORD, 2018).

HuairuiGuo (2012) points out that the application of DOE is not limited to engineering and that many success stories can be found in other areas. And that it has been widely used to reduce administrative costs, improve the efficiency of surgical processes, and establish better advertising strategies.

MAIN USES OF DOE

Computational power allows, through techniques of experiment planning, data mining, machine learning, and artificial intelligence, complex analyses of large volumes of data to be performed almost instantaneously when compared to the manual process;

According to Durakovic (2017), DOE is a multipurpose tool that can be used in a variety of situations to identify important input factors (input variable) and how they are related to outputs (response variable). Figure 1 presents an adaptation of the general process model presented by Montgomery (2017) with the components used in this work.

For Huairui Guo (2012), the main uses of DOE are:

1. Comparison - this is a factor among multiple comparisons to select the best option that uses t - test, Z - test or F - test.

2. Variable screening - these are usually two-level factorial experiments designed to select important factors (variables) among many that affect the performance of a system, process, or product.

3. Transfer function identification - if important input variables are identified, the relationship between the input variables and the output variable can be used to further explore the performance of the system, process, or product via the transfer function.

4. System optimization - the transfer function can be used for optimization by moving the experiment to the optimal configuration of variables. This way, the performance of the system, process or product can be improved.

5. Robust design - deals with reducing variation in the system, process or product without eliminating its causes. Robust design was started by Dr. Genichi Taguchi, who made the system robust against noise (environmental and uncontrollable factors are considered noise). Generally, the factors that cause product variation can be categorized into three main groups:

- external / environmental (such as temperature, humidity, and dust);
- internal (machine wear and aging of materials);
- Unit-to-unit variation (variations in materials, processes and equipment).

FINANCIAL MARKET

The financial market is composed of several segments, some examples are Stocks, Indices, Commodities, Funds and Foreign Exchange, the latter being the object of study of this project. Also known as forex or FX (Foreign Exchange), according to Gameiro (2004, p. 5), "this is the largest financial market on the planet. While the foreign exchange market operates a volume of more than $2 trillion dollars a day, in the same period the New York stock market operates $25 billion dollars".

The foreign exchange market, or forex, currencies are the basis of operation, that is, these are the instruments that must be traded to generate profits. In practice, when you are trading on the foreign exchange market, you are buying one currency against another (Calicchio, 2020).

There are several factors that indicate possible impending behavior, such as chart patterns, political factors, and indicators. One of these factors is the RelativeStrength

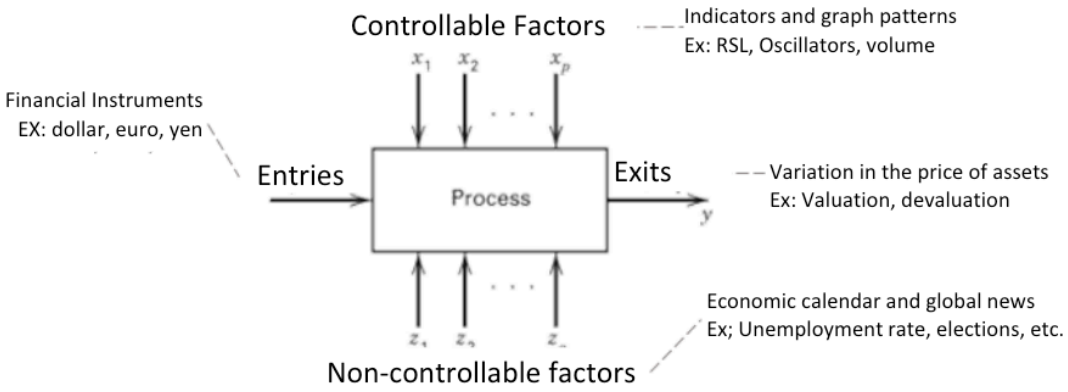

Figure 1: General process model and its inputs, controllable and uncontrollable factors, and outputs.

Source: Adapted from Montgomery (2017).

1. Formulate a research question	7. Data extraction
2. Produce a research protocol and register it (items 1 and 3 to 8 must be in the protocol for the preparation of the systematic review)	8. Synthesis of the data and evaluation of the quality of the evidence
3. Define the inclusion and exclusion criteria	9. Dissemination of results - Publication. All these steps must be explicitly described in the review.
4. Develop a research strategy and search the literature - find the studies	7. Data extraction;
5. Selecting the studies	8. Synthesis of the data and evaluation of the quality of the evidence;
6. Evaluating the quality of the studies	9. Dissemination of results - Publication.

Table 1: Systematic Review Stages (SR).

Source: Adapted by the authors, Donato (2019).

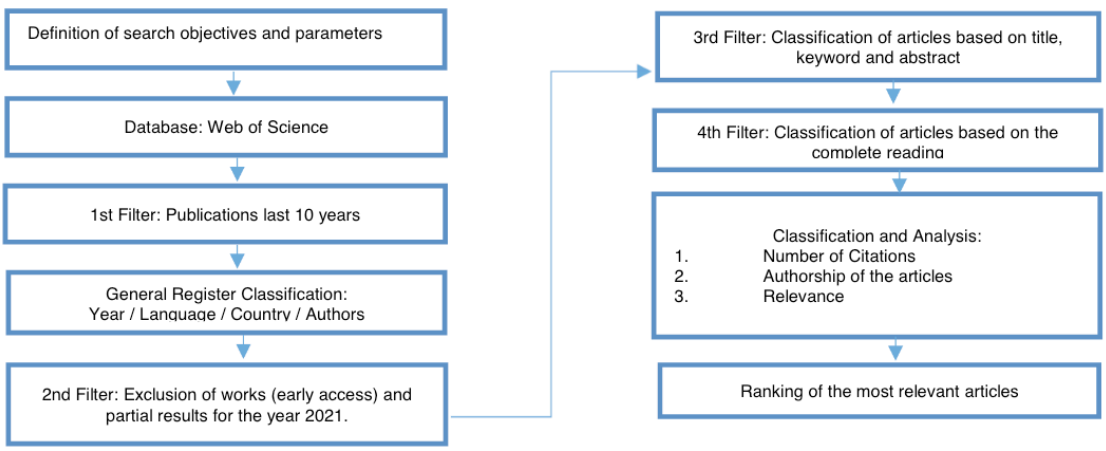

Figure 2: Flowchart of the bibliometric study.

Source: Adapted by the authors from Garcia et al (2017).

Index (RSI) indicator, which, as stated by Lemos (2015, p. 63), "is a buoyant oscillator that measures the speed and change of price movements. It compares the average price variation of periods of advances with the average variation of periods of declines". When the level of this indicator is below 20, it means that there is a situation of close appreciation, that is, in practice, a purchase of the asset under analysis is recommended because the price tends to rise. In addition to the RSI, other technical analysis variables can indicate a possible change in the behavior of the financial instrument, such as trend indicators, volume indicators, oscillators, chart patterns, among others.

This diversity of indicators can be fully applied to all existing financial assets in the foreign exchange market, with different parameters and levels of assertiveness in their results. To identify in which situations the application of these indicators has a higher level of assertiveness, this work proposes the application of Planning of Experiments, also known as DOE (Design OfExperiments). An experiment can be defined as "a test or series of tests in which purposeful changes are made to the input variables of a process or system so that we can observe and identify the reasons for the changes that can be observed in the output response" (MONTGOMERY, 2009, p.01, our translation).

METHODOLOGY

SYSTEMATIC LITERATURE REVIEW (SR)

Systematic Review (SR) is a review model that uses rigorous and explicit methods to identify, select, collect data, analyze and describe relevant contributions to your research. When SR uses statistical analysis, these reviews are called Meta-analysis. (CORDEIRO et al., 2007).

According to Siddaway, Wood, Hedges, (2019) Systematic Review (SR) is a less expensive scientific investigation with pre-defined systematic methods to systematically identify all relevant published and unpublished documents for a research question.

For Donato (2019), in the elaboration of the SR, the following steps must be explicitly described, Table 1.

In Figure 2, a flowchart was drawn up defining the path that the bibliometric analysis of this work followed to achieve its objectives:

Among the adaptations that were made between table 1 and figure 2, one can highlight as main, the formulation of the research question to guide the work, the definition of the Web of Science database and key words. The use of inclusion and exclusion criteria and the emphasis on the evaluation and analysis of the articles, identifying the most promising and relevant works involving DOE and Financial Markets.

RESULTS AND DISCUSSION

BIBLIOMETRIC ANALYSIS - WEB OF SCIENCE

In the first search, applying the 10-year time frame, 10,827 records were found, grouped among Scientific Articles, Book Chapters, Procedural Paper; Data Paper; Retracted Publication; Book Reviews; Letters, Meeting Abstracts, among others. In a general view, almost all correspond to documents in the English language, demonstrating the relevance of the language in the international scientific community, figure 3.

Using the second filter, the exclusion of unpublished papers named (early access) and partial publication results from the year 2021 was performed, excluding 266 records, however, there were still 10,561 papers left for analysis, Figure 4.

It is observed a continuous growth of publications, year after year in the researched subject about DOE and Financial Market.

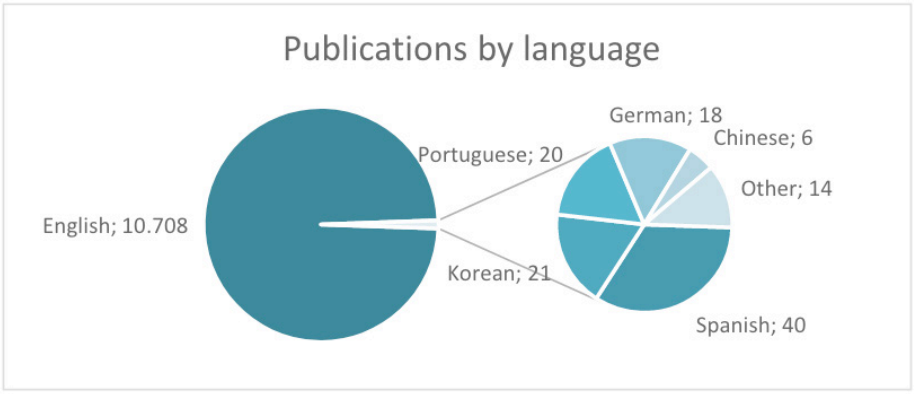

Figure 3: List of publications by language.

Source: The authors (2021).

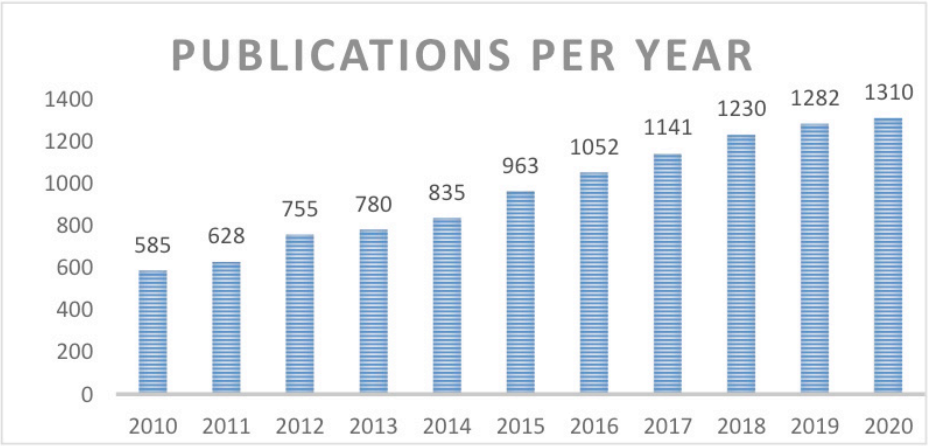

Figure 4: List of publications by year.

Source: The authors (2021).

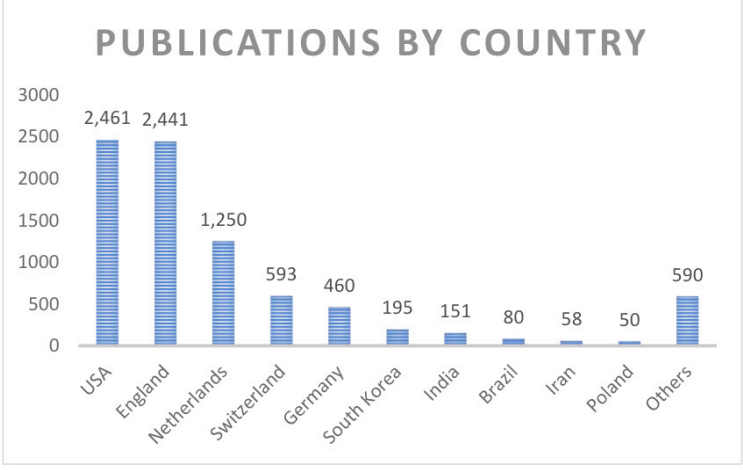

Figure 5: Publications by country.

Source: The authors (2021).

In terms of publications by country, we note that the countries that have published the most were the USA, followed by England, Holland, Switzerland, and Germany. Another interesting fact is that these are developed countries with higher per capita income, demonstrating that the care with the financial area is demanding additional attention from researchers in these nations, Figure 5.

Checking the applicability of DOE by area, it was possible to identify a reasonably large amount, permeating about 192 two areas during this period. The most published areas were Multidisciplinary Materials Science with 1,451 records, followed by Mechanical Engineering with 1,262 records, Chemical Engineering with 1,013 records, Engineering Manufacturing with 898 records and Electronic Electrical Engineering with 864. These areas together accounted for 50% of all records.

It was observed that among the 192 areas, none corresponds directly to the financial area, demonstrating that the DOE tool is underused in this sector.

ANALYSIS OF THE ARTICLES - TITLE, ABSTRACT AND KEYWORDS

Using the third filter of the methodological process, it was possible to classify the articles based on their title, keywords, abstract and number of citations. From a total of 10.8 thousand publications, it was possible to identify 22 (twenty-two) promising articles involving financial markets and DOE, Chart 3.

The authors who publish the most on DOE, among the analyzed articles are:Daniel Fernandes; John G. Lynch; Richard G. Netemeyer; Vicente García; Ana I. Marqués&; J. Salvador Sánchez; Isabelle Salle; ByranJ. Smucker; Timothy J. Robinson;Borja Ponte; José Costas; JulioPuche; Raúl Pino; David de la Fuente. And, of the twenty-two articles listed in table 3, made the last filter based on reading the abstract, identifying the articles that effectively used the Design ofExperiments in the financial market area, being them:

The articles highlighted in chart 4 demonstrate in practice the effectiveness of the application of the use of the tool in the financial market, showing countless possibilities:

- Article 01 (one):involves the application of DOE in stock market forecasting.
- Article 02 (two) uses the tool to build a basis of experimental design to be used in applications of credit scoring and bankruptcy prediction in the financial sector.
- Article 03 (three) brings the concern of financial risks of banks and financial institutions, using DOE to develop a risk assessment model.
- Article 04 (four) uses various techniques, including DOE, to aid structured decision making for a retail bank, enabling hypothetical analysis and portability to other markets and portfolios.

PERCEPTION OF DOE APPLICATION IN THE FINANCIAL MARKET

One notices, through the analysis of the themes addressed in the publications that are the object of this study, that the Planning of Experiments techniques have been widely used in the most diverse segments of the economy. In the financial market, however, a gap in content is identified whose analysis and planning of experiments is the main methodology used. To quantify this gap in publications, it is noteworthy that from the universe of approximately 10.8 thousand publications analyzed, a little over twenty publications, among articles and technical

Web of Science categories	Record Counting	% from 10.827
Multidisciplinary Materials Science	1451	13%
Mechanical Engineering	1262	12%
Chemical Engineering	1013	9%
Engineering Manufacturing	898	8%
Electrical Engineering Electronics	864	8%
Multidisciplinary Engineering	662	6%
Pharmacy Pharmacology	634	6%
Energy Fuels	620	6%
Analytical Chemistry	506	5%
Applied Physics	494	5%
Automation Control Systems	463	4%
Multidisciplinary Chemistry	460	4%
Interdisciplinary Computer Science Applications	407	4%
Microbiology Applied to Biotechnology	405	4%
Industrial Engineering	385	4%
Mechanics	373	3%
Operations Research Management Science	362	3%
Physical Chemistry	357	3%
Metallurgy Metallurgical Engineering	333	3%
Probability Statistics	328	3%
Environmental Sciences	324	3%
Research Methods Biochemistry	319	3%
Polymer Science	288	3%

Table 2: Areas with applicability of Design of Experiments.

Source: The authors (2021).

Area	Title	Keywords	Authors	Citations
Management; Operations Research & Management Science	Financial Literacy, Financial Education, and Downstream Financial Behaviors	behavioral economics; household finance; consumer behavior; education systems; public policy; government programs; statistics; causal effects; design of experiments; meta-analysis; financial education; financial literacy	Daniel Fernandes; John G. Lynch; Richard G. Netemeyer	1558
Computer Science, Artificial Intelligence; Computer Science, Information Systems	An insight into the experimental design for credit risk and corporate bankruptcy prediction systems	Credit risk; Corporate bankruptcy; Experimental design; Data splitting; Performance metric; Statistical test	Vicente García; Ana I. Marqués &; J. Salvador Sánchez	81
Economics; Management; Mathematics, Interdisciplinary Applications	Efficient Sampling and Meta-Modeling for Computational Economic Models	Computational economics; Exploration of agent-based models; Design of experiments; Meta-modeling	Isabelle Salle &MuratYıldızoğlu	70

Statistics & Probability	On using the hypervolume indicator to compare Pareto fronts: Applications to multi-criteria optimal experimental design	Pareto front; Multi-objective optimization; Design of experiments; Point exchange	Yongtao Cao; ByranJ. Smucker; Timothy J. Robinson	57
Economics; Engineering, Civil; Operations Research & Management Science; Transportation; Transportation Science & Technology	The value of lead time reduction and stabilization: A comparison between traditional and collaborative supply chains	Agent-based modelling and simulation; Lead time; Supply chain collaboration; Supply chain management; Taguchi design of experiments; Throughput accounting	Borja Ponte; José Costas; JulioPuche; Raúl Pino; David de la Fuente	45
Business, Finance	Kriging metamodels and experimental design for Bermudan option pricing	regression Monte Carlo (RMC); Gaussian process regression; sequential design; Bermudan option valuation; stochastic simulation	Michael Ludkovski	36
Computer Science, Artificial Intelligence	Design Of Experiments On Neural Network's Parameters Optimization For Time Series Forecasting In Stock Markets	Stock price prediction; back propagation neural network; design of experiment; financial ratios	Mu-Yen Chen; Min-HsuanFan; Young-Long Chen; Hui-Mei Wei	29
Economics	Portfolio optimization using Mixture Design of Experiments: Scheduling trades within electricity markets	Mixture Design of Experiments; Portfolio optimization; CVaR and electricity markets	Francisco Alexandrede Oliveira; Anderson Paulode Paiva; José Wanderley Marangon Lima; Pedro Paulo Balestrassi; RonãRinston Amaury Mendes	28
Business, Finance	Recent developments in the experimental elicitation of time preference	Time preference; Discounted utility; Instantaneous utility; Choice list	Stephen L. Cheung	20
Business; Management	Integrating corporate social responsibility and financial performance	Design of Experiments; Corporate social responsibility; Financial performance; TOPSIS; Prospect Theory	Amelia Bilbao-Terol; Mar Arenas-Parra; Susana Alvarez-Otero; Verónica Cañal-Fernández	19
Economics	Financial riskinformationavoidance	Criteria for decision-making under risk and uncertainty; behavioural finance; behavioural microeconomics; design of experiments; information; uncertainty	Anna Blajer-Gołębiewska; DagmaraWach; Maciej Kos	18
Management; Operations Research & Management Science	Marketing Optimization in Retail Banking	marketing optimization; retail banking; customer relationship management; mathematical programming; genetic algorithm; Markov chains; fuzzy mathematical programming	Ramasubramanian Sundararajan, Tarun Bhaskar, Abhinanda Sarkar, Sridhar Dasaratha, Debasis Bal, Jayanth K. Marasanapalle, Beata Zmudzka, Karolina Bak	16

Economics; Psychology, Multidisciplinary	Money illusion, financial literacy and numeracy: Experimental evidence	Behavioral sciences; Money illusion; Design of experiments; Behavioral finance; Financial literacy; Numeracy	Elisa Darriet; Marianne Guille; Jean-Christophe Vergnaud; Mariko Shimizu	12
Management	The X-bar control chart with restriction of the capability indices	Statistical process control; Capability analysis; Estimated parameters; Simulation methods	Pedro Carlos Oprime; Glauco Henrique de Sousa Mendes	07
Statistics&Probability	Optimal statistical, economic and economic statistical designs of attribute np control charts using a full adaptive approach	Adaptive control charts; FA np control chart; Markov chain; statistical design; economic design; economic statistical design	MehdiKatebi; M. BameniMoghadam	06
Statistics&Probability	Estimating sensitivity indices based on Gaussian process metamodels with compactly supported correlation functions	Bayesian estimation; Computer experiments; Global sensitivity indices; Main-effect sensitivity indices; Process-based estimator; Quadrature-based estimator; Total sensitivity indices	Joshua Svenson; Thomas Santner; Angela Dean; Hyejung Moon	04
Engineering, Industrial; Engineering, Manufacturing	Integrating Financial Metrics with Production Simulation Models	P&Q; Discrete Event Simulation; Design of Experiments	Clive Acheson, David Mackle, Adrian Murphy, Joseph Butterfield, Peter Higgins, Rory Collins, Colm Higgins, J. Darlington, R. Tame	03
Mathematics; Statistics&Probability	Regular Fractions and Indicator Polynomials	Algebraic statistics; design of experiments; indicator polynomial; regular fractions; complex coding; Galois field coding	Giovanni Pistoneand Maria PieraRogantin	03
Computer Science, Information Systems; Computer Science, Theory & Methods	An Exploration of the Cultivation Mode of Innovation and Entrepreneurship Education with Modern Information Technology for Statistics Students	statistics; entrepreneurship education; cultivation mode	YongLiHe; HuangXuexin; Zhou	02
Engineering, Multidisciplinary	Economic-statistical Design of NP Control Chart with Variable Sample Size and Sampling Interval	The Np Control Chart; Economic-statistical Design; Markov Chain; Design of Experiments; Variable Sampling Schemes	M. S Fallahnezhad M Shojaie-Navokh Y Zare-Mehrjerdi	02
Economics	Inducing risk preferences in economics experiments	experiments; risk; choice; learning	Ian M. Dobbs; Anthony D. Miller	01
Engineering, Industrial; Operations Research & Management Science	The Optimal Re-sampling Strategy for a Risk Assessment Model	Risk assessment; Re-sampling strategy; Imbalanced data; Design of Experiments; Dual Response Surface Methodology	L. I. Tong; W. Y. Wei; P. Y. Wu	00

Chart 3: Selection of articles by area, title, keywords, authors and citations.

Source: The authors (2021).

01	**Design Of Experiments On Neural Network's Parameters Optimization For Time Series Forecasting In**	The artificial neural network (ANN) model has been used for years to conduct research in stock price prediction for three reasons. First, it has a higher prediction accuracy rate in empirical research. Second, it is not subject to the assumption of having samples from a normal distribution. Third, it can handle non-linear problems. However, the prediction accuracy depends on the neural network parameter settings, as well as the complexity of the problems and the neural network architecture; the analysis results can be even more significant with the selection of optimal parameters and network architecture. Currently, as a way of setting parameters, most researchers have employed the trial and error method. However, this method is very time consuming and labor intensive and may not result in the optimal parameters. Therefore, this research leveraged a back-propagation neural network (BPNN) for the purpose of parameter optimization by building a stock price forecasting model, applying design of experiment (DOE) to systematize the scheduling of experiments, and methods of main effects analysis and interaction analysis. The research used two datasets of financial indices of 50 top-tier companies in the Taiwan stock market and 40 U.S. banks listed on the New York Stock Exchange as the experimental samples. The research results showed that the correlation prediction, root mean square error (RMSE) and computation time, which can effectively increase the accuracy of stock price prediction, are better than traditional statistical methods and conventional neural network model.
02	**An insight into the experimental design for credit risk and corporate bankruptcy prediction systems**	In recent years, a growing interest has been observed in the financial and business communities for any application tool related to credit risk and bankruptcy prediction, probably due to the need for more robust decision-making systems capable of managing and analyzing complex data. As a result, many techniques have been developed with the aim of producing accurate forecasting models that are able to deal with these problems. However, the design of experiments to evaluate and compare these models has attracted little attention so far, although it plays an important role in validating and supporting theoretical evidence of performance. Experimental design must be done carefully if the results are to be meaningful; otherwise, it can be a potential source of misleading and contradictory conclusions about the benefits of using a particular prediction system. In this paper, we review over 140 articles published in peer-reviewed journals over the period 2000-2013, emphasizing the basics of experimental design in credit scoring and bankruptcy prediction applications. We provide some caveats and guidelines for the use of databases, data partitioning methods, performance evaluation metrics, and hypothesis testing procedures in order to converge on a consistent and systematic validation standard.
03	**The Optimal Re-sampling Strategy for a Risk Assessment Model**	The global economic environment is changing rapidly. Consequently, the financial risks of banks or financial institutions are also increased. Banks or financial institutions often use various rating methods to build risk assessment models to determine whether to lend to a company or an individual. Often, it turns out that the data used to build a risk assessment model is unbalanced. That is, the number of defaulters is significantly smaller than the number of delinquents. In this case, most rating methods are unable to build a risk assessment model. accurate risk, since classification methods are subject to unbalanced data. The trial and error method is often used to balance sample sizes for standard and non-standard classes. However, the trial and error method is expensive and the sampling strategy determined by the trial and error method may not effectively classify the unbalanced data. Therefore, this study aims to develop an optimal resampling strategy using design of experiments (DOE) and dual response surface (DRS) methodology. The proposed method can be employed for any classification method to develop a risk assessment model. The effectiveness of the proposed procedure is verified using a real case of a Taiwanese financial institution.
04	**Marketing Optimization in Retail Banking**	In this paper, we address the problem of making optimal product offers to customers of a retail bank using techniques including Markov chains, genetic algorithms, mathematical programming, and design of experiments. Our challenges were the large size of the problem, uncertainty about estimates of customer responses to product offers, and practical training and implementation issues. The solution had an estimated financial impact of about $20 million; it also provided other intangible benefits including structured decision making, the ability to perform what-if analysis, and portability to other markets and portfolios.

Table 4: Most relevant selected articles about DOE and Financial Market.

Source: The authors (2021).

procedures, had as their object of study the DOE associated with the financial market, totaling 0.2% of all publications. In this set of publications related to the financial market, the Netherlands presents a prominent position as the country with the most publications (8), ahead of countries like the USA and England, with 5 and 6 publications, respectively. Another point to be highlighted is how the application of DOE is complemented with other techniques and processes such as Monte Carlo Simulations, Gaussian processes, TOPSIS, Markovian chains, stochastic simulation, and Bayesian estimation.

FINAL CONSIDERATIONS

Through this research one can get a glimpse of the use of the Design of Experiments tool in the financial market, which despite the increased interest by the financial and business community, unfortunately is still little used.

With the execution of this research it was possible to identify a total of 192 areas that are applying the tool, and that the countries that publish the most are located in the group of developed countries, where financial education is more rooted in society, with a well-developed financial and capital market. It was also identified that the predominant language of the published articles is English, followed by Spanish.

The authors who stood out the most were Daniel Fernandes; John G. Lynch; Richard G. Netemeyer; Vicente García; Ana I. Marqués&; J. Salvador Sánchez; Isabelle Salle; ByranJ. Smucker; Timothy J. Robinson;Borja Ponte; José Costas; JulioPuche; Raúl Pino; David de la Fuente.

As a future work, the challenge is to conduct a search using the same criteria in other databases, in addition to an interview with a DOE specialist with a focus on the numerous possibilities that this tool can bring benefits to the financial market.

Finally, it is hoped that this work can help to engage professionals in the financial market to increasingly use DOE in the identification of probabilities, in problem solving, in risk analysis and in decision making.

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