



EMERALD STUDIES IN FINANCE,
INSURANCE, AND RISK MANAGEMENT

VOLUME 11

FINANCE ANALYTICS IN BUSINESS

PERSPECTIVES ON ENHANCING
EFFICIENCY AND ACCURACY

EDITED BY

SANJAY TANEJA • PAWAN KUMAR • KIRAN SOOD
ERCAN ÖZEN • SIMON GRIMA

Finance Analytics in Business

EMERALD STUDIES IN FINANCE, INSURANCE, AND RISK MANAGEMENT

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Finance Analytics in Business: Perspectives on Enhancing Efficiency and Accuracy

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INVESTOR IN PEOPLE

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Foreword

Insurance is one of the most important economic and the world's most dynamically developing market. It is a very important segment of the financial market because insurance and the related protection against all risks play a fundamental role in managing financial resources. Decision-making in the insurance market is very complicated due to the various types of insurance, including life insurance, health insurance, property, accident insurance, car insurance and others. Each of them addresses different risks and needs. Insurance companies pay the insured losses incurred in case of any accident in these areas. For this purpose, many advanced techniques for modelling and analysing financial data are created yearly to monitor and improve the decision-making process in the financial sector. This ensures financial stability and risk minimisation for households, enterprises, organisations and the state. This allows companies and organisations to make conscious decisions, optimise their financial strategies and increase efficiency and accuracy in various financial processes. Many tools are available for risk analysis, some simple and others more complex, such as SWOT Analysis, Monte Carlo Risk Assessment Method, Value at Risk (VaR) Assessment Method, Risk Factor Analysis (RFA), Risk Matrix and many other classic tools. Recently, due to the rapid development of IT systems and, consequently, the method of collecting and storing data, including financial data, has resulted in the creation of modern tools for data analysis and collection. Traditional data types were structured and could be easily stored in a relational database. With the emergence of Big Data technology, new, unstructured data of unknown value are being collected, originating from various social media (Twitter, Facebook, LinkedIn, etc.), web tracking technologies or mobile applications or data from equipment with sensors. For some enterprises, this may be millions of terabytes of data. Such a huge amount of data contributed to the creation of innovative analyses, enabling the study of interdependencies between people, institutions, entities and processes and using the obtained conclusions with much greater precision than before. This allows for making effective decisions. Currently, the main innovation lies in having technologies and methods that allow the analysis of huge amounts of data and the analysis and formulation of conclusions based on unstructured data such as text data. This phenomenon allowed for a continuation of Turing's assumption from the 1950s, in which he suggested that machines, like humans, can draw logical conclusions to solve problems or decision-making. These assumptions have become a reality because we can teach machines instead of programming them. This is made possible by the availability of big datasets that can be used to train

machine learning models. For this purpose, the giant's market has created and used various artificial intelligence algorithms such as Google, Amazon, Microsoft and others. In the era of artificial intelligence, data are of great importance. Data help artificial intelligence systems learn, improve and increase accuracy. For example, AI systems use data to generate insights, predict outcomes and decision-making. For an AI system to succeed, it is necessary to have the highest quality data available, as these data are used to train, validate and test the AI model. A machine learning system that is not powered by data would be limited in its capabilities and unable to use its full potential. Scientists have recently collected motion, temperature and other physical sensor data. One type of data from sensors is data from human physiological measurements. Examples of physiological measurements include brain electrical activity, electrodermal activity (skin-galvanic reaction), muscle electrical activity, eye movement and facial expression. Based on this type of measurement, it is possible to analyse human reactions to external stimuli during various cognitive and emotional tasks. This approach allows obtaining information at its source (in the brain) before presenting it as an opinion, assessment or decision. In this way, data collection can contribute to the creation of innovative approaches to financial analyses in business and, at the same time, increase the efficiency and accuracy of conclusions from these analyses, which can constitute the basis for making rational business decisions. The main objective of this book is to provide good knowledge about financial analytics in business perspectives on increasing efficiency and accuracy, especially in the field of finance and insurance. The primary goal of this book is to provide good knowledge of Finance Analytics in Business Perspectives on Enhancing Efficiency and Accuracy, particularly in the insurance field. The company's performance on the Stock Exchange was analysed in the context of the war and COVID-19. Innovative solutions for the financial sector were discussed regarding financial instruments and related services using fintech technology and AI to improve the efficiency and availability of services offered on the market. Moreover, the book discusses issues related to blockchain technology, meta-analysis covering the studies of developed and emerging economies and business intelligence (BI) in banking in perspectives on enhancing efficiency and accuracy. The book covers selected aspects of Finance Analytics in Business and presents the importance of innovative methods and technologies for theoreticians and economic practice. I wish the readers great learning and finding of research gaps for future research.



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Preface

This book ‘Finance Analytics in Business: Perspectives on Enhancing Efficiency and Accuracy’ brings together experts from diverse backgrounds, blending theoretical depth with practical insights at the intersection of finance and analytics. Aimed at both students and professionals, this book serves as an invaluable educational resource and a toolkit for continuous professional development. Each chapter provides actionable insights, showcasing the transformative impact of analytics on financial efficiency and accuracy. The contributors, a mix of seasoned professionals and academics, offer a comprehensive understanding of the subject, ensuring a rich and well-rounded exploration. Whether you’re a student entering the world of finance or a seasoned professional navigating the complexities of the industry, this book provides a guide to leveraging analytics for strategic decision-making. With a focus on emerging trends like machine learning, blockchain integration, and ethical considerations, the book doesn’t just capture the current state of finance analytics; it propels readers towards the future, where the convergence of finance and analytics opens new horizons for innovation and excellence. Welcome to a journey where theory meets practice, and analytics becomes a catalyst for efficiency and accuracy in the ever-evolving landscape of finance.

This book:

- **Blends Theory and Application:** Bridging theory and real-world application for practical insights.
- **Expert-Led Content:** Features seasoned professionals, ensuring real-world relevance.
- **For Students:** Offers a structured foundation and prepares the next-gen for industry demands.
- **For Professionals:** Facilitates continuous learning and skill enhancement for finance practitioners.
- **Efficiency and Accuracy:** Showcases how analytics optimises workflows and improves decision precision.

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Chapter 1

Path Stock Structural Changes and Forecasts in the Context of the Ukrainian War

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Abstract

Purpose: The objective of this chapter is to analyse the performance of the UiPath (PATH) company on the New York Stock Exchange, in the context of the war between Russia and Ukraine, and to predict the closing price of the PATH stock using autoregressive integrated moving average with (ARIMAX) and without (ARIMA) exogenous variable methods and autoregressive neural networks (NNAR, NNARX).

Need for Study: UiPath has gained a significant reputation in the IT market and has become a point of interest in recent years. However, the current context is marked by an event of international impact, the war between Russia and Ukraine. In this context, this analysis will consider performance from two perspectives: forecasts of the closing price and forecasts of the closing price with an exogenous variable, namely the war between Russia and Ukraine.

Methodology: In the analysis that follows, we will address a forecast of the stock closing price using ARIMA, ARIMAX, NNAR and NNARX, as well as analysis of changing points and structural breaks of the series.

Findings: The changing points in the mean and variance but also the breaks in the structure justify the course of the closing price. From the information extracted in the analysis, it can be concluded that market sentiment is

currently pessimistic due to the downward trend in the price. Both the public and the shareholders are disappointed with the performance of PATH stock and are waiting for the next change point that will change the trend of the series.

Keywords: UiPath; RPA forecast; NNAR; ARIMA; time series; stock; Ukrainian war

JEL Codes: C53; C22; F17

Introduction

One of the most important events that led to the formation of today's society is the Industrial Revolution, which changed technology and, implicitly, the way people work. This process began in Britain in the 18th century and spread throughout the world. The main planes of reference for the changes induced by industrial revolutions are technological, socio-economic and cultural.

Although at the beginning, the technology and information age got off to a rough start, growth has become exponential in the 21st century, bringing with it the Fourth Industrial Revolution or Industry 4.0. The concept that defines it is of rapid change in technology, industry and social patterns due to interconnectivity and automation facilitated by artificial intelligence (AI). The term was introduced by Klaus Schwab, the founder and executive director of the World Economic Forum. According to Schwab, it is assumed that the Fourth Industrial Revolution will be driven by the merging of digital innovations with those in biology and physics. Technologies such as AI, genome editing, augmented reality and robotics are already changing much of the way people create and distribute value (Schwab, 2016).

On a business level, the UiPath company has achieved impressive growth over time. Following rebranding and launches in 2015, the company secured its first substantial funding from Accel Partners and enjoyed international expansion with offices in London, New York, Bangalore, Paris, Singapore, Washington and Tokyo.

In this context, it becomes even more important to be able to provide future predictions of PATH stock, and in order to do that, two univariate forecasting models autoregressive intergrated moving average with exogenous variable (ARIMAX) and neural network autoregression with exogenous variable (NNARX) have been applied in order to identify the most appropriate model and to forecast the future values of PATH. This research is investigating the daily PATH closing price covering the period between 21 April 2021 (the listing date of the UiPath stock) and 31 May 2022, thus containing 281 daily observations with a decreasing trend and high fluctuations in volatility. Data was provided by Yahoo Finance and the forecast of PATH is based on the next 30 days, until the 30th of June.

Analysing the patterns of PATH stock, the research aims to respond to the following questions: Does the PATH exhibit a non-stationary non-linear pattern?

Do the more sophisticated methods such as ARIMAX, NNARX perform better than simple methods (ARIMA and NNAR)? What is the univariate forecasting method that performs best within the data in the sample? Which method best captures the shock of the war? What is the combination of methods that could offer reliable future values for the PATH stock?

On the basis of these questions, the following three main hypotheses can be formulated:

H1. The PATH stock exhibits a non-stationary non-linear pattern over the period from 21 April 2021 to 30 May 2022.

H2. The NNARX and ARIMAX models registered the best forecast performance of all four methods applied.

H3. The combination of the NNARX and ARIMAX models offers the best approach to forecasting the PATH stock for June 2022.

This chapter is organised as follows. The review of the literature presents an overview of the most important studies on this topic of forecasting Robot Processing Automation (RPA) companies, while “[Data and Methodology](#)” section is dedicated to the presentation of different forecasting models. Section “[Empirical Results](#)” incorporates information related to the data used in the analysis and the main empirical results of all forecasting methods. The last part of this section ends with a comparison of models that forecast performance for the sample dataset. The final section of this chapter presents the main conclusions on the relevance of this research.

Literature Review

In recent years, the field of robotisation of automatic processes has drawn attention in the scientific environment; thus, numerous studies have been carried out on the impact of automation in companies, on the benefits and processes of RPA and the multitude of application areas of these types of products.

RPA is a revolutionary form of automation, seen as a simplified form of AI. This technology is considered revolutionary due to its ease of use, low cost and rapid deployment. RPA is defined as a solution consisting of software that automates repetitive processes based on a set of rules, using structured and pre-determined data. The difference between traditional automation and robotic process automation is that in the former, machines can be programmed to perform any task within an operational process, while robotic process automation is a form of automation that is operated from the front-end level of the system and requires no back-end action. RPA, according to the IoT Agenda, can handle very large amounts of tasks that require human intervention by using existing applications to communicate and trade data. RPA bots act at the interface level and interact with a system as a person would ([Grima et al., 2021](#); [Hicham et al., 2023](#)).

Among them is the study ‘Introduction to Robotic Process Automation a Primer’ (Dilla & Jaynes, 2015), which presents a comparative study between

traditional automation and robotic process automation using new technologies on the market. This article argues that robotic process automation has high performance in any domain with definable, repetitive and rule-based processes, highlighting the variety of domains and processes that can be simplified using RPA technology.

In *Delineated Analysis of Robotic Process Automation Tools* (Issac et al., 2018), Issac, Muni and Desai provide a comparative analysis of the top three RPA companies leading the market. In this paper, they compare the tools offered by the three companies considering what kinds of processes can be automated with them, the ways in which they can be automated, the accessibility of the interface and the level of security of the data used. The conclusion of this study was that UiPath is the company that offers the best product by comparison and presents the best development opportunities thanks to the adaptive algorithms they work with (Sood et al., 2022).

Authors Moffit and Rozario in *Robotic Process Automation for Auditing* (Moffitt et al., 2018) have explained how the use of RPA technology is much more efficient in all aspects than the alternatives to automating processes with Python or R. Auditing involves long and complex processes, where even a small error can lead to very complex adjustment steps. RPA technology offers accessibility without the need for expert users and enhanced data protection.

In the work entitled *Robotic Process Automation: Future of Business Organisations: In A Review* (Gami et al., 2019), the authors Gemi, Mehta, Jetly and Patil highlight the importance of RPA technology, its benefits and the evolution perspectives of this technology. Using this type of automation reduces costs by reducing human resource requirements, reducing errors and ensuring data security.

As for the analysis and forecasting methods, specific to time series, they are constantly used in numerous studies, for both microeconomic and macroeconomic analyses; in [Table 1.1](#), a summary of the most relevant studies in this field is presented. The tools offered by this field of study are numerous and can be compared to analyse their performance and level of accuracy. Thus, in the following work, several methods of making a time series forecast are discussed.

Data and Methodology

To determine the best model to forecast the PATH stock, we investigated the daily PATH closing price covering the period between 21 April 2021 (the listing date of the UiPath stock) and 31 May 2022, thus containing 281 daily observations with a decreasing trend and high fluctuations in volatility. Data were provided by Yahoo Finance.

The main objective of the paper is to compare the forecasting potential of four models: autoregressive integrated moving average (ARIMA), autoregressive integrated moving average with exogenous variable (ARIMAX), autoregressive neural networks (NNAR) and autoregressive neural networks with exogenous

Table 1.1. An Overview of the Most Relevant Studies in the Field.

Authors	Year	Title of Paper	Methods	Conclusions
Demir, I., Kirisci, M.	2022	Forecasting COVID-19 Disease Cases Using the SARIMA-NNAR Hybrid Model	SARIMA, NNAR, SARIMA-NNAR	NNAR has provided better results by comparison.
Siame-Namini, S., Tavakoli, N., Namin, A. S.	2019	A Comparison of ARIMA and LSTM in Forecasting Time Series	ARIMA, LSTM, BiLSTM	The recommendation is to use the BiLSTM model.
Adebiyi, A. A., Adewumi, A. O., Ayo, C. K.	2014	Comparison of ARIMA and Artificial Neural Network Models for Stock Price Prediction	ARIMA, ANN	ANN offers an increased level of accuracy.
Perone, G.	2021	Comparison of ARIMA, ETS, NNAR, TBATS, and Hybrid Models to Forecast the Second Wave of COVID-19 Hospitalisations in Italy	ARIMA, ETS, NNAR, TBATS and hybrid models	The best models are ARIMA and NNAR.
Ahangar, R. G., Yahyazadehfar, M., Pournaghshband, H.	2010	The Comparison of Artificial Neural Network With Linear Regression Using Specific Variables for Prediction Stock Price in Tehran Stock Exchange	GRNN, Linear regression	The GRNN model showed faster performance and a higher accuracy of the estimation rate than the linear regression model.

(Continued)

Table 1.1. (*Continued*)

Authors	Year	Title of Paper	Methods	Conclusions
Islam, M. R., Nguyen, N.	2020	Comparison of Financial Models for Stock Price Prediction	ARIMA, ANN, GBM	ARIMA and GBM provide a better prediction for future prices than ANN.
Ma, Q.	2020	Comparison of ARIMA, ANN and LSTM for Stock Price Prediction.	ARIMA, ANN, LSTM	The ANN model performs better than ARIMA.
Wijaya, Y. B., Kom, S., Napitupulu	2010	Stock Price Prediction: Comparison of ARIMA and Artificial Neural Network Methods: An Indonesian Stock Case	ARIMA, ANN	The results of the study showed that the artificial neural network method has higher precision than the ARIMA method.
Li, M., Ji, S., Liu, G.	2018	Forecasting of Chinese E-Commerce Sales: An Empirical Comparison of ARIMA, Nonlinear Autoregressive Neural Network, and a Combined ARIMA-NARNN Model	ARIMA, NARNN, ARIMA-NARNN	The study shows that the ARIMA-NARNN model is more effective than the ARIMA and NARNN models in forecasting sales.
Urrutia, J. D., Abdul, A. M., Atenza, J. E.	2019	Forecasting Philippines Imports and Exports Using a Bayesian Artificial Neural Network and an Integrated Moving Average	ARIMA, BANN	Researchers concluded that Bayesian artificial neural networks are the most suitable for forecasting Philippine imports and exports.

Source: Author's own creation.

variable (NNARX), and to predict future values of PATH stock beyond the period under consideration.

Change Points

In time-series analysis, to make predictions with a high level of accuracy, the data sample used must represent the entire series as well as possible. Many time series can be influenced over time by exogenous variables, events that cannot be predicted and over which we have no control. These events can influence the time in certain periods, and thus, we can end up with sequences in the data that are not representative of the entire series. There is always the possibility that the models or parameters that best describe the series may undergo changes over unknown time periods, and if these changes are not accounted for in the analysis, then the analysis loses its validity.

In the time series, we identify change points and introduce them into the analysis as follows: a change point occurs at time $1, \dots, T-1$, with the mention that the statistical properties of the series $\{y_1, \dots, y_{\tau}\}$ and $\{y_{\tau+1}, \dots, y_T\}$ are different. Therefore, we can serially identify up to m change points that will be associated with the positions $\tau_{1:m} = \{\tau_1, \dots, \tau_m\}$. The change points will be ordered such as $\tau_i > \tau_j$ if and only if $i > j$. Depending on the m change points, we will divide the data into $m+1$ segments where the time i can be summarised by a set of parameters. The parameters at time i will have the form of $\{\theta_i, \phi_i\}$ where ϕ_i is a possible set of nuisance parameters, and θ_i represent parameters that can describe the change. Ideally, we want to find out through tests how many $m+1$ segments are needed to provide the best representation of the underlying data.

Using the maximum likelihood method proposed by Hinkley (1970), we can decide through a statistical test whether changes have been recorded or not, following the calculation of the maximum likelihood of occurrence in the lags for each hypothesis. For the null hypothesis, the formula for calculating the likelihood of occurrence is as follows:

$\log_p(y_{1:T} | \hat{\theta})$, where $p(\cdot)$ is the probability density function associated with the data, and $\hat{\theta}$ is the maximum estimated likelihood of occurrence of the parameters.

Taking into account the discrete nature of the location of change points, the maximum likelihood of occurrence in lags of the alternative hypothesis will be $\max_{\tau_1} \text{ML}(\tau_1)$, i.e. the maximum value among all locations in time where change points are being identified. For the minimisation of the general equation, we can consider the binary segmentation algorithm, the neighbour segmentation algorithm and the pruned exact linear time (PELT).

The neighbour segmentation algorithm popularised by Bai and Perron (1998, 2002) minimises the expression by a dynamic programming technique that optimises the segmentation for $m+1$ turning points by reusing information that has been computed for m turning points.

The PELT method, proposed by Killick, Fearnhead and Eckley (2002), assumes an exact solution which is computationally more efficient compared to the previously presented methods.

Structural Breaks

Breaks in the structure of the series are in many ways similar to change points but refer to specific change points in the regression coefficients. Therefore, a structural break is done with a regression model specification. Thus, for the linear regression model, we will have the following formula: $y_t = x_t^T \beta_j + \varepsilon_t, j = \{1, \dots, m + 1\}$ and the hypothesis of the regression coefficients is constant $H_0: \beta_j = \beta_0$, compared to the alternative hypothesis which assumes that at least one coefficient varies over time. If x_t becomes constant, then the test takes the form of the test for change points in the mean.

The Zivot-Andrews test (Zivot & Andrews, 1992) is the most commonly used test for identifying the unit root in a series with structural breaks. This test uses an optimisation procedure that tests the points that are most likely to represent structural breaks because those are the ones that are most likely to validate the null hypothesis of the test.

The statistical test is formulated as follows.

$$\Delta y_t = \mu + \pi y_{t-1} + \alpha t + \beta_2 D_L \hat{\lambda} + \sum_{i=1}^k \gamma_i \Delta y_{t-1} + \varepsilon_t$$

The Quandt test (QLR) is an extension of the Chow test, in which the F statistic is calculated for all potential structural breaks in a potential range. The range depends mainly on the number of degrees of freedom that are needed to estimate the regression model. The most extensive statistical test with potential structural breakpoints is the QLR test.

ARIMAX Model

ARIMAX is an extension of the ARIMA model that includes the exogenous variable X_t in the analysis. The purpose of including the exogenous variable in the estimation of a forecast is to investigate the relationship between the analysed time series and the time variable implicitly to find out how the variable influences the prediction of the series.

The form of the ARIMAX model is as follows:

$$\phi(L)\Delta y_t = \phi(L)X_t + \theta(L)\varepsilon_t \text{ where } \phi(L) = (1 - \phi_1 L^1 - \phi_2 L^2 - \dots - \phi_r L^r)$$

For the estimation of the fitted model, the coefficient of determination R^2 or the average sum of the squares of the residual values can be analysed. The most widely used method to determine the best model is information criteria analysis. The Akaike criterion (AIC) and the Bayesian criterion (BIC) can be compared between models, the goal being minimisation in the identification of the best model. To calculate the AIC and the BIC, we first need the sum of the squares of the residual values and the variance of the estimators, $\hat{\sigma}_k^2 = \frac{SSR_k}{T}$.

In the last step of the Box-Jenkins methodology, the goal is to confirm that the best possible model has been estimated by analysing the residuals, ideally