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| Research Article

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Modeling and Forecasting of Business Processes through Time Series

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Abstract: This article analyzes the methodology for modeling and forecasting business processes based on time series. The study is carried out on the example of Apple's quarterly revenues for 2020-2024, and a forecast of future revenues is formed using trend and seasonal components, moving averages, and regression models. Time series analysis is important for planning business processes, optimizing resources, and making evidence-based strategic decisions.

Key words: business processes, time series, forecasting, trend, seasonal component, regression model, Transformer, Reinforcement Learning, quarterly earnings, strategic planning.

Introduction

Business process modeling and forecasting is an important factor in improving the efficiency of an enterprise and ensuring its competitiveness. In recent years, digital transformation and the growth of big data have forced enterprises to analyze their processes based on real-time data and predict future situations. Therefore, business process modeling is a relevant and practically important topic.

From a scientific perspective, time series forecasting not only allows for identifying trends and seasonality, but also provides a scientific basis for optimal resource utilization, risk management, and strategic decision-making processes. Methods such as predictive process monitoring, deep learning, and reinforcement learning increase forecast accuracy by taking into account uncertainties and problems in business processes.

The relevance of this study is that it combines the practical and scientific aspects of modeling and forecasting business processes through time series. The analysis was carried out on the example of

Apple's quarterly earnings for 2020-2024 using open data. It demonstrates the effectiveness of time series analysis in predicting future corporate earnings and strategic planning. At the same time, the results of the study can serve as a methodological basis for analyzing and forecasting business processes for enterprises and the scientific community.

Literature review

Many scientists have conducted research on business process modeling and forecasting.

In particular, research in the field of time series modeling and forecasting of business processes covers three main scientific areas: predictive process monitoring, forecasting based on deep time series analysis, and statistical dynamic analysis of economic processes. One of the most important surveys on predictive process monitoring is presented by Márquez-Chamorro et al., which systematically analyzes the use of event logs, machine learning, statistical modeling, and sequence-based approaches to predict process outcomes [1]. This work provides a methodological framework for business process monitoring and forecasting by interpreting process dynamics as time-dependent sequences.

In recent years, the use of Reinforcement Learning in process forecasting has expanded significantly. Bousdekis et al. compare RL-based approaches with traditional time series models, demonstrating their potential for improving the efficiency of forecasting process outcomes under uncertainty [2]. This methodology serves to determine the future state of the process and to formulate optimal decision strategies.

One of the most comprehensive works on deep learning time series modeling is the survey proposed by Lim and Zohren, which covers the advantages and disadvantages of architectures such as Transformer, Temporal Fusion Transformer, multi-horizon forecasting, and multivariate modeling issues [3]. At the same time, in recent years, comprehensive time-series forecasting surveys have highlighted the emergence of foundation models, long-context transformers, and diffusion architectures [4]. This trend is expanding the possibilities of forecasting multi-variable sequences in business processes with high accuracy.

In Uzbekistan, scientific research on modeling the dynamics of economic processes uses more traditional time series, regression approaches, and statistical scenario forecasts. In particular, Klychev analyzes the time series of real sector enterprises based on econometrics to forecast production volumes and formulates various scenario forecasting models [5]. Nutfulloyev, on the other hand, highlights the mechanisms of practical application of AI, big data, and time series analytics technologies for the business sector in the context of digital transformation [6].

In general, the existing scientific literature indicates that the main trend in the development of deep learning, Transformer architecture, RL approaches, and traditional economic and statistical models in time series modeling of business processes is the integration of these models.

Research methodology

This study used a methodology for modeling and forecasting business processes based on time series. Apple's quarterly revenue for 2020-2024 was taken as a data source. In the analysis, moving average, centered moving average, as well as trend and error components were distinguished. This methodology allows us to determine the future state of business processes through time series analysis, optimize strategic decisions and resource management.

Analysis and results

Time series forecasting is one of the most important analytical tools for ensuring the stability of business processes, increasing operational efficiency, and determining the optimal use of resources. Factors such as sharp fluctuations in market conditions, seasonal fluctuations in supply and demand, and uncertainty in cost dynamics force enterprises to rely on accurate numerical

forecasts. Therefore, using time series to determine future conditions based on past data allows for planned management of business operations, minimizing risks, and making evidence-based strategic decisions[7].

The relevance of forecasting in modern business practices is primarily due to the acceleration of digital transformation processes. Enterprises now have access to large volumes of transactional data, customer flow, production indicators and real-time information about logistics processes, and by modeling them, they are able to assess future dynamics with much greater accuracy than traditional reporting approaches. In particular, the use of time series in processes such as sales forecasting, inventory management, consumer behavior, and production capacity allocation has become a factor that directly affects the profitability and competitiveness of the enterprise[8].

For the analysis, we perform a time series econometric analysis using Apple's quarterly public data for 2020-2024.

Table 1. Apple's quarterly earnings for 2020-2024

Year	Quarter	Period	Revenue (in billion US dollars)
2020	Q1	December 2019	91.82
2020	Q2	March 2020	58.31
2020	Q3	June 2020	59.69
2020	Q4	September 2020	64.7
2020	Total		274.52
2021	Q1	December 2020	111.44
2021	Q2	March 2021	89.58
2021	Q3	June 2021	81.43
2021	Q4	September 2021	83.36
2021	Total		365.82
2022	Q1	December 2021	123.95
2022	Q2	March 2022	97.28
2022	Q3	June 2022	82.96
2022	Q4	September 2022	90.15
2022	Total		394.33
2023	Q1	December 2022	117.15
2023	Q2	April 2023	94.84
2023	Q3	July 2023	81.8
2023	Q4	September 2023	89.5
2023	Total		383.29
2024	Q1	December 2023	119.58
2024	Q2	March 2024	90.75
2024	Q3	June 2024	85.78
2024	Q4	September 2024	94.93
2024	Total		391.04

Source: Apple Investor Relations, SEC Filings

This chart shows Apple's revenue The volume is quarterly data for 2020-2024, and using this data, we generate Table 2.

Table 2. Indicators for calculation

No.	Y (%)	Four-quarter slider	Four-quarter moving average	Center-weighted moving average	Seasonal component price	S	T+E=YS	73.7+1.6t
1	91.82	-	-	-	-	24.82969	67.0	75.2
2	58.31	274.52	68.6	-	-	-1.84781	60.2	76.8
3	59.69	294.14	73.5	71.1	-11.4	-13.02	72.7	78.4
4	64.7	325.41	81.4	77.4	-12.7	-9.44375	74.1	80.0
5	111.44	347.15	86.8	84.1	27.4	24.82969	86.6	81.6
6	89.58	365.81	91.5	89.1	0.5	-1.84781	91.4	83.2
7	81.43	378.32	94.6	93.0	-11.6	-13.02	94.5	84.8
8	83.36	386.02	96.5	95.5	-12.2	-9.44375	92.8	86.4
9	123.95	387.55	96.9	96.7	27.3	24.82969	99.1	87.9
10	97.28	394.34	98.6	97.7	-0.5	-1.84781	99.1	89.5
11	82.96	387.54	96.9	97.7	-14.8	-13.02	96.0	91.1
12	90.15	385.1	96.3	96.6	-6.4	-9.44375	99.6	92.7
13	117.15	383.94	96.0	96.1	21.0	24.82969	92.3	94.3
14	94.84	383.29	95.8	95.9	-1.1	-1.84781	96.7	95.9
15	81.8	385.72	96.4	96.1	-14.3	-13.02	94.8	97.5
16	89.5	381.63	95.4	95.9	-6.4	-9.44375	98.9	99.1
17	119.58	385.61	96.4	95.9	23.7	24.82969	94.8	100.6
18	90.75	391.04	97.8	97.1	-6.3	-1.84781	92.6	102.2
19	85.78	-	-	-	-	-13.02	98.8	103.8
20	94.93	-	-	-	-	-9.44375	104.4	105.4
21	131.8					24.82969		107.0
22	106.7					-1.84781		108.6
23	97.1					-13.02		110.2
24	102.3					-9.44375		111.7
25	138.2					24.82969		113.3
26	113.1					-1.84781		114.9
27	103.5					-13.02		116.5
28	108.7					-9.44375		118.1
29	144.5					24.82969		119.7
30	119.4					-1.84781		121.3
31	109.8					-13.02		122.9
32	115.0					-9.44375		124.4

Source: The data in this table are based on the data provided in Table 1.

Here, **S (** the average value of the S-quartile component) is found by finding the moving average and the centered moving average over the four quarters.

T- trend

E - error

T= a+b*t

To construct a trend equation, we analyze the main outcome **a and the factor b** that affects the outcome through regression[9].

Table 3. Regression statistics

Indicator	Value
Multiple R	0.7777
R-squared	0.6048
Normalized R-squared	0.5828
Standard error	7.7995
Number of observations	20

Source	df	SS	MS	F	Significance of F (p)
Regression	1	1675.5031	1675.5031	27.5427	0.0000544
Remainder	18	1094.9917	60.8329		
Total	19	2770.4948			
Coefficient	**Standard error**	**t-statistic**	**P-value**	**Lower 95%**	**High 95%**
Y-intercept	73.6537	3.6231	20.3287	0.000000000	66.0418
Variable X1	1.5873	0.3025	5.2481	0.0000544	0.9519

Source: The data in this table was calculated in Excel.

From the table above, the Y-intercept is 73.6537 and the X1 variable is 1.5873. These are equal to the coefficient **a** and coefficient **b , respectively.**

T= 73.6537 + 1.5873 *t

We will calculate the average value of the S-quartile component in Excel.

$$\mathbf{K} = \frac{S_1 + S_2 + S_3 + S_4}{4}$$

In this:

K- correction coefficient

S1 – I quarter

S2 – II quarter

S3 – III quarter

S4 – IV quarter

We get the result K = 0.518125000000008.

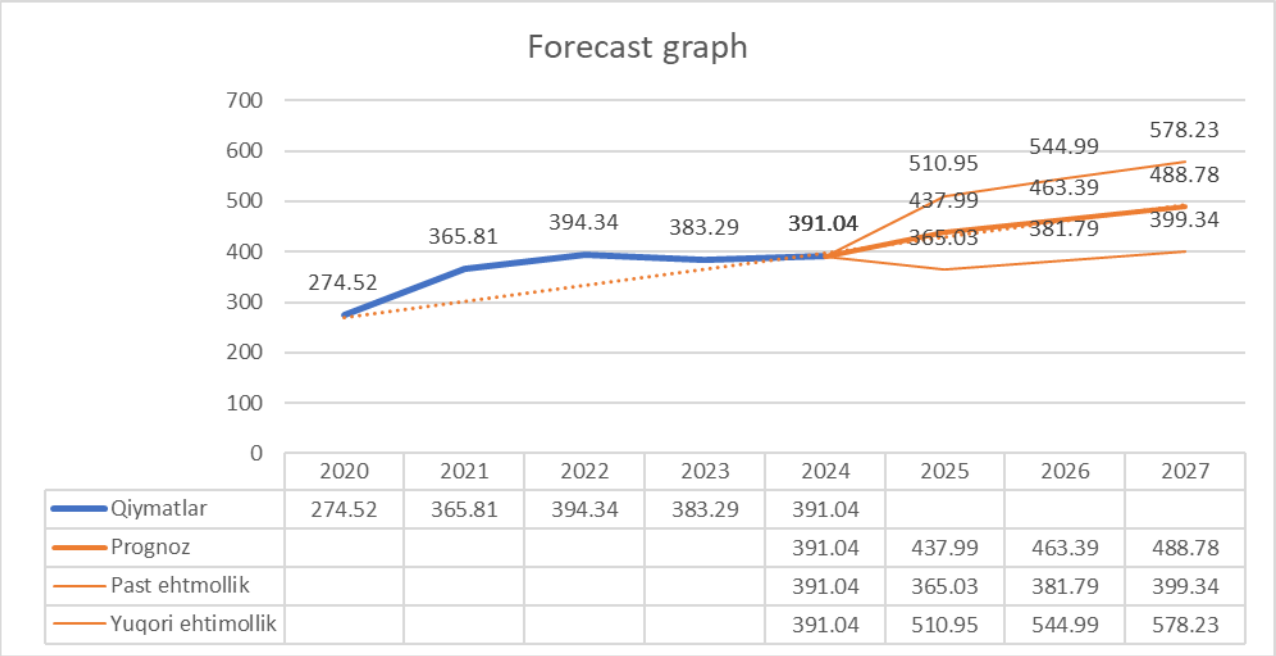
As a result of the calculation of the indicators, we obtain the following annual values of the average monthly salary (Table 4).

Table 4. Apple's revenue for 2020-2024 and forecast

Years	Quantities
2020	274.52
2021	365.81
2022	394.34
2023	383.29
2024	391.04
2025	437.9909
2026	463.3878
2027	488.7848

Source: The data in this table are annual sums of the Quantities (Y) given in Table 2.

Apple's revenue in monetary terms will be $488.7848 billion by 2027. This figure is expected to increase by 1.3 times compared to 2024.



	2020	2021	2022	2023	2024	2025	2026	2027
Qiymatlar	274.52	365.81	394.34	383.29	391.04			
Prognoz					391.04	437.99	463.39	488.78
Past ehtmollik					391.04	365.03	381.79	399.34
Yuqori ehtimollik					391.04	510.95	544.99	578.23

Figure 1. Graphical representation of forecast results

is expected to be approximately $437.99 billion, $463.39 billion, and $488.78 billion in 2025-2027, respectively . According to the general forecast, it can be said that many factors affect the trend of Apple's revenue[10] .

Conclusion and suggestions

Modeling and forecasting business processes based on time series is an important tool for effective management of economic activity. In this study, a time series analysis was performed based on Apple's quarterly earnings for 2020-2024. The analysis results showed that separating the trend and seasonal components using historical data provides high accuracy in determining the future values of the company's earnings.

Using a time series regression model and quarterly components, Apple's revenue forecast for 2025-2027 was determined. The results showed that revenue is expected to reach $488.78 billion by 2027, a significant increase compared to 2024. At the same time, taking into account trend and seasonal components helps to increase the reliability of the forecast.

The study shows that time series analysis can help plan business processes, minimize risks, and make strategic decisions based on evidence. In addition, when advanced techniques such as deep learning and reinforcement learning are integrated with traditional statistical approaches, the accuracy and efficiency of forecasts are further increased.

As a result of the research conducted, the following proposals were developed:

First, businesses need to regularly update their time series data and continuously recalibrate their forecasting models, allowing them to more accurately identify future trends.

Secondly, advanced techniques, including Transformer architecture and Reinforcement Learning approaches, should be applied to business processes, as they increase the accuracy of forecasts in uncertain and changing conditions.

Third, it is recommended to optimize resource allocation and improve operational efficiency by integrating forecast results into the decision-making process.

Fourth, in the future, it is advisable to develop complex models that take into account the influence of economic and external factors, as well as introduce analytical systems that combine internal and external data of the enterprise.

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