
Collection Life Cycle Analysis: Enhancing Market Strategies through Advanced Data Analytics

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Abstract:

Purpose: This study introduces an analytical application designed to deeply analyze the product life cycle and optimize a business's marketing and operational strategies. The primary objective of this application is to help companies effectively identify and navigate the various phases of a product's life, from launch to growth, maturity, and decline.

Design/Methodology/Approach: The application features interactive tools, such as sales value maps and animations illustrating changes in selected indicators, to enable real-time sales data analysis and forecast future trends using the Prophet model. The article elaborates on the application's capabilities, including statistical analysis of selected collections like average sales value, number of orders, storage costs, and the effects of seasonality and special promotional periods on sales outcomes.

Findings: The study highlights how this application aids businesses in adapting their strategies to dynamically changing market conditions, enabling efficient resource management and maximizing profitability.

Practical Implications: The article presents the application's functionalities and emphasizes its value in adjusting business strategies to rapidly changing market conditions. It underlines the significance of using advanced analytical tools for informed decision-making, which can contribute to the company's enduring success.

Originality/Value: This work presents an innovative analytical tool that provides businesses with crucial insights for adapting their marketing and operational strategies. It adds value by demonstrating the importance of leveraging advanced analytics in decision-making to ensure long-term business success in fluctuating market environments.

Keywords: Product life cycle, sales analysis, marketing strategy, forecasting data.

JEL codes: C45, C61, C88, L11, L86, M31, O32, D83.

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1. Introduction

Product life cycle is a critical concept in marketing management, referring to the entire period a product is present on the market. As in the case of living organisms, a product goes through several stages, birth, growth, maturity, and end of life. This analogy to the human life cycle allows us to better understand the dynamics of changes in demand and adjustments to marketing strategies (Kotler and Keller, 2016; Armstrong and Cunningham, 2019; Baker, 2016; Urban and Hauser, 1993).

The length of a product's life cycle can vary significantly - some products remain on the market for many years, while others, responding to short-term trends, disappear after a few weeks. Products with a short life cycle are often characterized by rapid growth and rapid decline in interest (Meade and Islam, 2018; Król, Rymarczyk, Niderla, and Kozłowski, 2023; Norena-Chavez and Thalassinou, 2023).

Understanding the product life cycle is the foundation for a company's development strategy. These strategies can be effectively developed using the product life cycle model, which distinguishes four main phases: introduction, growth, maturity, and decline. Each of these phases involves different levels of revenue and profit. For example, the introduction phase often has lower revenues due to promotion and distribution costs, while the maturity phase typically brings the highest returns.

Knowing the stage at which a product is located allows enterprises to plan appropriate activities, such as investments in product development, modification of marketing strategies, or inventory management. Therefore, the product life cycle model is a key tool for optimizing operational and strategic decisions in the company (Król, Rymarczyk, and Wyrwisz, 2023; Tyagi *et al.*, 2023).

2. Product Life Cycle Phases

The product life cycle is an integral element of strategic analysis in product management and marketing. Understanding and identifying individual product life cycle phases allows companies to plan market activities more effectively.

The go-to-market phase is highly critical and challenging for any company. It is characterized by low sales, which grow very slowly, and marginal profits at the beginning. The product, which is new on the market, is not yet widely recognized, and its distribution encounters numerous obstacles. Significant investments in promotion and logistics are necessary to achieve success in this phase, and these are expected to bring returns in the long run.

The product then enters a sales growth phase, during which sales and profits increase rapidly. This is the result of the product's growing acceptance on the market and the increasing number of consumers. In response to growing competition and demand, companies are forced to increase production and expand the distribution network.

During this period, continuous product improvement is also needed to maintain consumer interest. The market maturity phase is the stage in which product sales reach their peak and then begin to decline gradually. This state of affairs is market saturation or the emergence of new, more attractive alternatives. Customers familiar with the product and have tried it before become less sensitive to marketing activities.

Therefore, to maintain interest, companies emphasize promotions, such as price reductions, intended to encourage subsequent purchases. The final phase, decline, is characterized by a marked decrease in sales and profits. The main reasons include the emergence of substitutes, increased competition, technological progress, and changes in consumer trends. In this phase, mainly new-averse consumers, known as "laggards", buy.

Advertisements and existing promotions lose their effectiveness. In response, companies limit production, distribution, and other sales activities, which often leads to the gradual withdrawal of the product from the market. Understanding and properly managing each phase of the product life cycle allows companies to maximize profits and maintain a competitive position in the market.

3. Description of the Application Providing Analysis and the Possibility of Integration with the User

Product life cycle analysis is a key tool for companies that strive to effectively manage their resources and maintain and develop their market position. A specialized application was developed to facilitate the understanding and interpretation of sales data, which are the foundation for identifying individual product life cycle phases. This application allows deep data analysis while offering interactive tools like charts and tables.

The tools presented in the application enable users to observe data passively and actively manage the way they are given by using various filters and criteria. Thanks to this, users can better adapt the analysis to specific needs and market variables, allowing for more precise forecasting of future trends and more effective marketing and product activities planning.

Each chart or table in the application has been designed to ensure maximum usability and intuitive operation. The user can select data from different periods, track changes in the product life cycle, and identify patterns and anomalies that may influence the company's strategic decisions.

The application's interactivity also facilitates a better understanding of the relationships between different market segments and the impact of external factors on sales results. Consequently, this tool supports the decision-making process at the

operational and strategic levels, providing valuable information that can contribute to the company's long-term success.

Figure 1. Data from the database regarding sales of collections over time

Poniższa tabela przedstawia dane sprzedażowe dotyczące poszczególnych kolekcji w czasie. Istnieje tutaj wiele istotnych zmiennych z punktu widzenia monitorowania cyklu życia kolekcji. Poszczególne kolumny tabeli można filtrować za pomocą widocznego szarego paska znajdującego się pod nazwami kolumn.

Miesiąc	Kolekcja	Sprzedaż Wartość	Zam Klienta Ilość	Zam Klienta Liczba docelowych	Sp.ekspozycyjna	Sp.handlowa	Wydajność z m2	Mag Stany Ilość księgową	Mag Stany Wartość księgową	Mag Rotacja dniach
Filter data...										
Styczeń, 2015	PRASS	218613.28	1392	123	9094	209519.28	272.81	7653	222899.06	43.92
Luży, 2015	PRASS	243609.99	1279	96		243609.99	395.47	7366	176703.27	22.93
Marzec, 2015	PRASS	305926.38	1179	114	6625.67	299300.71	340.11	1301	209630.35	21
Kwiecień, 2015	PRASS	183893.51	1138	92	10386.45	173507.06	233.21	1688	252813.36	38.55
Maj, 2015	PRASS	291869.54	1177	109	2073.16	289796.38	365.9	2177	340993.7	32.25
Czerwiec, 2015	PRASS	205504.71	990	90	2064.97	203439.74	299.18	2188	341572.51	47.61
Lipiec, 2015	PRASS	337786.02	1865	120	6967.35	33088.67	405.42	2408	385187.87	34.88
Sierpień, 2015	PRASS	283714.57	1618	106	7768.77	275945.8	359.3	2367	359649.26	45.47
Wrzesień, 2015	PRASS	396060.1	1445	105	5721.74	390338.36	508.25	2890	465284.2	33.35
Październik, 2015	PRASS	330510.25	1575	98	10206.27	320303.98	435.2	3091	531855.8	49.56

Source: Own creation.

The developed application supports enterprises that want to maintain their market position, dynamically respond to changing conditions, and use sales data to optimize their product offer and market strategy.

The first element of the application is a Table of data available for analysis. The data is loaded from the SQL Server database, so we have access to current values if the database is updated. The Figure above shows the input table (Figure 1). We can also filter the columns of the presented data to obtain the information we are interested in - in the figure below, the PORTO collection and the lines where the number of customer orders exceeds 5,000 pieces have been selected (Figure 2).

Figure 2. Example data filtering

Poniższa tabela przedstawia dane sprzedażowe dotyczące poszczególnych kolekcji w czasie. Istnieje tutaj wiele istotnych zmiennych z punktu widzenia monitorowania cyklu życia kolekcji. Poszczególne kolumny tabeli można filtrować za pomocą widocznego szarego paska znajdującego się pod nazwami kolumn.

Miesiąc	Kolekcja	Sprzedaż Wartość	Zam Klienta Ilość	Zam Klienta Liczba docelowych	Sp.ekspozycyjna	Sp.handlowa	Wydajność z m2	Mag Stany Ilość księgową	Mag Stany Wartość księgową	Mag Rotacja dniach
Filter data... PORTO >=5000										
Lipiec, 2017	PORTO	659630.02	5056	144	10435.5	649194.52	665.16	3464	342015.21	17.35
Lipiec, 2018	PORTO	852275.81	5480	176	5364.17	846911.64	653.48	3957	417403.57	12.66
Sierpień, 2018	PORTO	951057.46	6289	197	26913.68	924143.78	695.89	4777	511579.23	18.31
Wrzesień, 2018	PORTO	1076370.32	5683	205	8371.55	1067998.77	794.64	3740	414202.98	11.5
Październik, 2018	PORTO	933214.14	5132	189	7940.91	925273.23	625.18	3904	360333.58	11.39
Listopad, 2018	PORTO	762422.54	5617	182	8491.92	753930.62	620.01	4947	518557.99	13.94
Lipiec, 2019	PORTO	1045247.95	6842	200	7218.66	1038029.29	750.02	5664	658433.22	21.34
Sierpień, 2019	PORTO	1217314.32	7518	201	6196.31	1211118.01	880.5	5053	594323.96	14.92
Wrzesień, 2019	PORTO	1161634.78	5931	206	10445.15	1151189.63	782.06	5542	673662.78	16.11
Październik, 2019	PORTO	1156417.52	5705	206	14516.11	1141901.41	731.99	5512	711389.29	20.19

Source: Own creation.

Users can interactively analyze data using application tools to discover essential patterns and relationships for effective product management and strategic planning. By using the ability to filter data, for example, in the PORTO collection analysis, we can obtain valuable information regarding the seasonality of demand.

Based on the filters used in the application illustration, it can be observed that orders for the PORTO collection reach their peak in the summer and autumn months, where the number of pieces sold exceeds 5,000. This is an essential tip for the marketing and logistics departments, suggesting that during these periods, they should focus on increased production, inventories, and intensification of promotional activities to exploit the product's market potential fully.

Such analyses allow the ongoing optimization of activities and long-term planning. Understanding seasonal sales trends enables a company to prepare in advance for increased demand, minimizing the risk of insufficient inventory or overloaded distribution channels. Moreover, viewing historical data allows you to forecast trends and adjust your product strategy appropriately.

The interactivity of the application significantly facilitates the analysis process, enabling users to quickly and effectively adjust analysis parameters to their individual research needs. This, in turn, translates into a better understanding of the market and more informed decision-making, which are crucial for the success of products in a competitive market.

3.1 Sales Value Map

The sales value map is an essential analytical tool in the application. It provides a detailed picture of sales dynamics for individual product collections over time. Such visualization enables intuitive and quick identification of sales trends, which is crucial for effective product portfolio management.

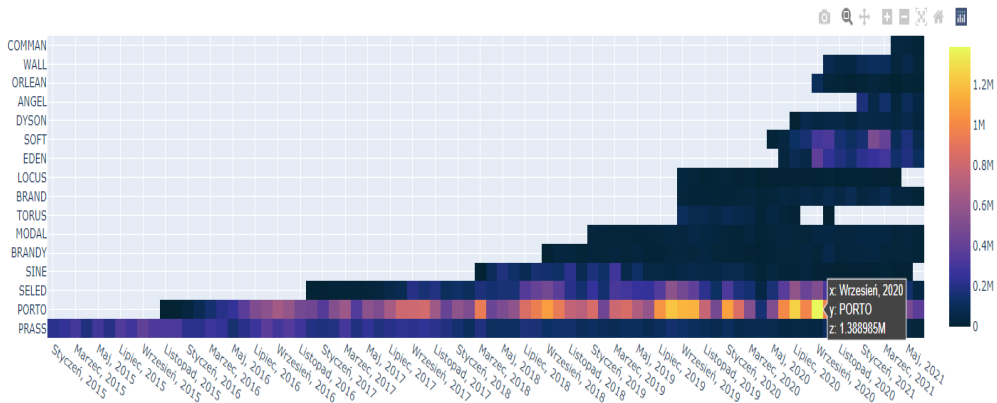
Using the sales value map, application users can quickly identify which collections maintain a stable, good sales level and observe the periods in which individual collections reached their sales peaks. This makes it possible to determine when the products were introduced to the market and when they were withdrawn from the market.

This type of information is invaluable for strategic planning and marketing departments because it allows them to optimize strategies related to introducing new products, life cycle management of existing collections, and effective management of resources and capital.

Analyzing sales patterns also helps identify potential causes of sales declines, such as increased competition, changes in consumer preferences, or other external factors.

A sales value map generated based on available data is, therefore, a valuable visual tool that significantly facilitates making solid business decisions. This tool enables current market analysis and allows forecasting and planning of future activities, which is necessary in a dynamically changing business environment.

Figure 3. Sales value heat map



Source: Own creation.

The Figure above shows that the PORTO collection dominates in terms of sales value in individual months of the life cycle, and its highest sales were achieved in September 2020. We can also notice that, for example, the PRASS collection, which is the first collection introduced, maintains an equal level despite the decline in sales value, while collections such as SOFT or EDEN, despite their relatively short history of existence, stand out from others with a similar or even longer lifespan.

3.2 Distribution of Statistics Over Time

Another advanced visualization tool available in the application is an animation of changes in selected features of individual collections over time. This allows for a deep analysis of market changes and consumer behavior. By selecting different variables from the database, users can tailor the analysis to their specific research needs and business interests.

Using animation to observe changes over time offers a unique perspective on market dynamics. Users can track changes in sales values and analyze other critical operational aspects, such as order volume, discount values, storage costs, and even the effectiveness of promotional campaigns. This allows for a more complex interpretation of the data, revealing apparent patterns and less visible relationships that can impact sales results.

A fascinating insight that can be gained from such an analysis is the correlation between sales results and applied discounts. Many companies may find that their

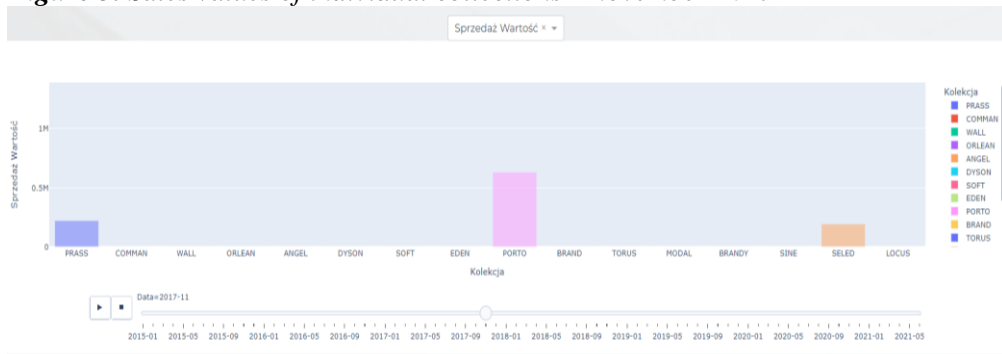
best-selling products are rarely subject to price promotions. This suggests that there may be value in maintaining a higher price for high-demand products, which in turn may increase margin and profitability. Using charts presenting sales data at selected moments in time, you can observe how the market situation has changed for individual collections. Such visualizations help assess the market condition and plan future marketing activities and pricing strategies adapted to current conditions and trends (Figures 4-6).

Figure 4. Sales values of individual collections - January 2015



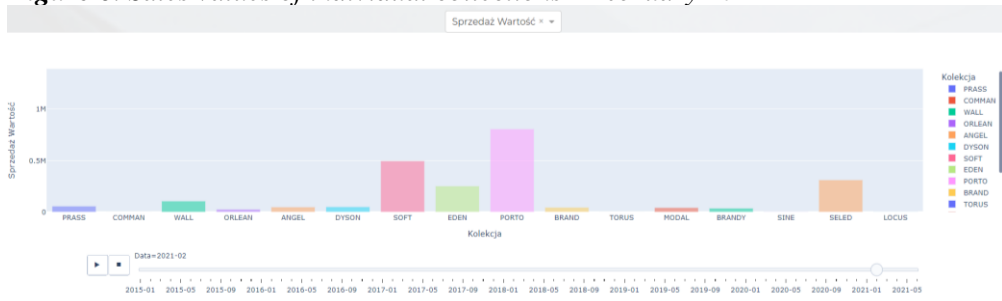
Source: Own creation.

Figure 5. Sales values of individual collections - November 2017



Source: Own creation.

Figure 6. Sales values of individual collections - February 2021



Source: Own creation.

We can, therefore, observe the change of individual values over time and the appearance of new collections that begin to lead in sales.

3.3 Sales Leader and Basic Collection Statistics

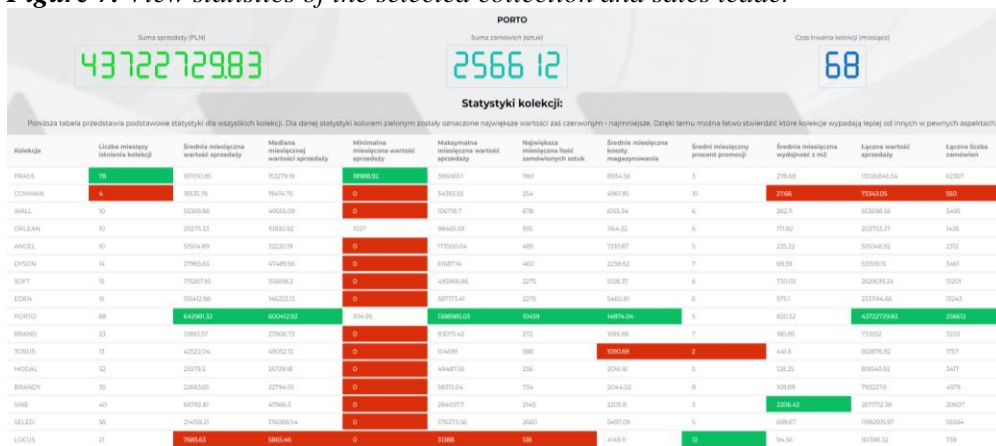
One function in the analytical application allows you to isolate collections that generate the highest total revenues. This functionality is crucial because it allows the company to focus resources and marketing activities on the products that generate the most revenue. The definition of "sales leader" depends on the adopted criteria, and in this application, leadership is measured based on sales value, which is an objective indicator of market success.

Additionally, the application provides users with comprehensive statistics for the selected collection. This allows you to understand how long products stay on the market, observe sales fluctuations, and assess the effectiveness of promotions and storage costs. These statistics include average monthly sales values and data on the most significant orders. Information on average storage costs and promotion percentages gives insight into the relationship between costs and prices, and the efficiency per square meter allows you to assess the efficiency of space use.

This segment of the application, illustrated in sample drawings, allows users to compare this data visually, which is especially useful in a dynamic business environment. Thanks to this, companies can not only monitor the current performance of their collections but also effectively plan future activities, taking into account the sales and operational achievements of individual products.

This application functionality promotes a better market understanding and supports strategic business decisions. An example view of this part of the application is presented in Figure 7 below.

Figure 7. View statistics of the selected collection and sales leader



Source: Own creation.

3.4 Sales Value and Quantity Charts and Forecasting

The last functionality lets the user view sales data from a line chart. Here, you can choose from a chart of the sales value or the number of individual collections. The sales value chart is presented below in Figure 8.

Figure 8. Line chart of the sales value of individual collections



Source: Own creation.

The analytical application also includes a function allowing you to forecast a selected collection's sales value or volume. This process uses the advanced Prophet forecasting model developed by the Facebook team. The Prophet model is based on an additive regression method that is excellent at predicting time series data with vital seasonal components and trends.

A key element of the Prophet model is its ability to model growth trends that can be linear or logistic flexibly. The model automatically detects changes in trends, which allows for effective adjustment of forecasts to dynamically changing market conditions. This functionality is precious in environments where sales data shows irregularities due to external or internal factors.

The Prophet model integrates annual and weekly seasonal components that are extremely important in retail. Annual seasonality is modeled using a Fourier series, allowing the model to adapt to different yearly patterns flexibly. Dummy variables represent weekly changes to reflect typical weekly shopping patterns.

The last but equally important element of the model is the ability for the user to include a list of essential holidays that may significantly impact sales results. This allows for more precise sales forecasts during periods when shopping is intensified, for example, before Christmas.

Using the Prophet model in the application enables an accurate forecast of sales for the coming periods and a better understanding of the factors influencing sales

dynamics. This, in turn, will allow companies to manage inventories, plan promotions, and optimize pricing strategies more consciously. This tool will enable companies to respond more effectively to changing market conditions and maximize revenues. In general, the model is described by equation:

$$y(t) = g(t) + s(t) + h(t) + \epsilon_t, \quad (1)$$

where $g(t)$ is a trend function modeling non-periodic changes in the value of the time series, $s(t)$ represents changes occurring periodically (e.g. weekly and annual seasonality) and $h(t)$ is responsible for the so-called holiday effects. For obvious reasons, a random component ϵ_t has been added here, representing the error that we usually assume is typically distributed.

This procedure (as mentioned earlier) works best in analyzing series with strong seasonal effects and several seasons of data to train the model. It is robust in handling missing data and deals well with outliers. The model used here is described in more detail elsewhere in the documentation. Below is an example chart that considers historical data for the PRASS collection and prediction using the Prophet model every month.

Figure 10. Chart including historical data for the PRASS collection and monthly predictions using the Prophet model.



Source: Own creation.

4. Conclusions

Product life cycle analysis is indispensable for every company that strives to manage its resources and marketing strategies effectively. Advanced analytical tools, such as the application described, allow for deep understanding and interpretation of sales data, which is crucial for optimizing business decisions and adapting to dynamically changing market conditions.

The app allows users to analyze different phases of a product's lifecycle, from launch through growth and maturity to sales decline. Features such as interactive sales value maps and animations of critical indicators changing over time provide insight into seasonal changes in demand and the effectiveness of pricing and promotional strategies.

Additionally, the ability to conduct detailed statistical analyses for selected collections allows you to identify sales leaders and understand the factors influencing individual product sales results.

A vital function of the application is also the ability to forecast future sales trends using the Prophet model. Thanks to its advanced methodology, this model allows for precise forecasts, considering both regular seasonal cycles and irregular events, such as holidays. This tool will enable companies to better prepare for future changes, manage inventories, and optimize their marketing activities.

Therefore, this application provides valuable support for enterprises that want to respond to current market changes and anticipate future events that may significantly affect their competitiveness and profitability. Introducing such a tool into everyday business practice may be a vital element of the strategy, leading to sustainable growth and maintaining a leading position in the market.

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