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Digital marketing implementation using python programming for ad campaign optimization and data analysis

Abstract
The use of technology in digital marketing has grown rapidly, especially in terms of data processing and analysis of advertising campaigns. Python, as a powerful programming language, offers an effective solution for optimizing digital marketing campaigns through in-depth data analysis. This research aims to explore the application of Python in digital marketing, especially in advertising campaign optimization and data analysis. Using libraries such as Pandas, Matplotlib, and NumPy, Python enables efficient processing of large data, calculating important metrics such as Cost Per Click (CPC), Cost Per Conversion (CPCo), and Return on Investment (ROI), and generating campaign performance visualizations. The results of this analysis provide deeper insights for advertisers to design more targeted and efficient strategies. Through the application of Python, advertisers can automate the data analysis process, improve calculation accuracy, and make better data-driven decisions in ad budget allocation. This research is expected to contribute to the development of more optimal data-based digital marketing strategies and analysis.
Keywords: Data analysis, Cost Per Click (CPC), Cost Per Conversion (CPCo), Digital marketing, Ad campaigns, Python, Visualization.

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Abstrak
Penggunaan teknologi dalam pemasaran digital telah berkembang pesat, terutama dalam hal pemrosesan dan analisis data kampanye iklan. Python, sebagai bahasa pemrograman yang kuat, menawarkan solusi efektif untuk mengoptimalkan kampanye pemasaran digital melalui analisis data yang mendalam. Penelitian ini bertujuan untuk mengeksplorasi penerapan Python dalam pemasaran digital, khususnya dalam optimasi kampanye iklan dan analisis data. Dengan menggunakan perpustakaan seperti Pandas, Matplotlib, dan NumPy, Python memungkinkan pemrosesan data besar secara efisien, perhitungan metrik penting seperti Cost Per Click (CPC), Cost Per Conversion (CPCo), dan Return on Investment (ROI), serta pembangkitan visualisasi kinerja kampanye. Hasil analisis ini memberikan wawasan yang lebih mendalam bagi pengiklan untuk merancang strategi yang lebih tertarget dan efisien. Melalui penerapan Python, pengiklan dapat mengotomatisasi proses analisis data, meningkatkan akurasi perhitungan, dan membuat keputusan yang lebih baik berdasarkan data dalam alokasi anggaran iklan. Penelitian ini diharapkan dapat berkontribusi pada pengembangan strategi dan analisis pemasaran digital berbasis data yang lebih optimal.
Kata Kunci: Analisis data, Biaya Per Klik (CPC), Biaya Per Konversi (CPCo), Pemasaran digital, Kampanye iklan, Python, Visualisasi.

1. Introduction

The development of information and communication technology has brought about major changes in the world of marketing. Digital marketing is now one of the main strategies in reaching a wider and segmented audience, by leveraging various digital platforms, such as social media, search engines, and email (Nargis et al., 2024). However, while digital marketing provides a lot of convenience, a major challenge arises in the management and

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analysis of advertising campaign data that continues to grow rapidly. The large and diverse data generated from digital advertising campaigns is often difficult to process effectively, which can hinder the ability to measure success and optimize marketing strategies (Krasniqi et al., 2024). This is where Python programming offers the right solution. With data analysis libraries such as Pandas, Matplotlib, and NumPy, Python enables more efficient and accurate processing and analysis of ad campaign data (Fursov et al., 2022). Python can be used to calculate important metrics, such as ad spend, number of clicks, conversions, as well as Cost Per Click (CPC) and Cost Per Conversion (CPCo) calculations, which are critical in assessing the effectiveness of ad campaigns. Through Python programming, ad campaign data can be analyzed in more depth, providing valuable insights for marketers to make more informed decisions in allocating ad budgets. With more effective data processing, companies can design campaigns that are more targeted and tailored to the needs of their audience. Python, with data analysis libraries such as Pandas, NumPy, and Matplotlib, offers an efficient solution for managing and analyzing ad campaign data.

Python programming allows advertisers to automate data processing, calculate important metrics, and generate in-depth visualizations to more accurately evaluate campaign performance. The implementation of Python in digital advertising campaigns starts with the collection and processing of data from various advertising platforms (Kabir & Ahmed, 2024). This data can include information about ad spend, the number of clicks received, conversions that occur, and cost-per-click (CPC) or cost-per-conversion (CPCo). Using Python, advertisers can automatically calculate these key metrics, which can provide a clear picture of the effectiveness of ad campaigns. A significant example of implementation is the calculation of Cost Per Click (CPC) and Cost Per Conversion (CPCo) metrics (Sampath, 2024). Python makes it possible to calculate the cost incurred for each click or conversion in an ad campaign. With this information, advertisers can assess the extent to which ad spend delivers results that match their desired goals. Further, this analysis can be used to decide on a more efficient allocation of ad budgets, focusing on the platform or ad format that delivers the best results(Almestarihi et al., 2024).

Python can also be used to perform predictive analysis in digital marketing. With statistical and machine learning techniques, Python allows predictions about the results of ad campaigns based on historical data (El-Hajj & Pavlova, 2024; Singhal, 2024). This allows advertisers to plan a more optimal advertising strategy based on predictions of results obtained from previous analysis. In addition, Python makes it easy to visualize the results of the analysis. Through the Matplotlib or Seaborn libraries, data can be visualized in the form of graphs and diagrams, which makes it easy to understand campaign performance trends and patterns. For example, graphs can show ad spend, clicks, and conversions over time, helping in evaluating whether a campaign needs a change or adjustment to the strategy (Miraz et al., 2025; Waskom, 2021). Overall, the implementation of Python in digital advertising campaigns provides advantages in terms of efficiency and effectiveness of data analysis. With the ability to automate data processing, real-time calculation of metrics, and easy-to-understand visualizations, Python helps advertisers make more data-driven decisions and improve the results of every ad campaign they run (Apaza-Caceres et al., 2026; Lissy et al., 2024).

While previous studies have emphasized the critical role of big data in digital marketing (Krasniqi et al., 2024) and the general utility of Python for data automation Bhardwaj et al. (2023), the majority of existing literature tends to focus on high-level theoretical frameworks or isolated predictive models rather than practical, end-to-end

operational implementations. For instance, recent studies often highlight the potential of machine learning in ad targeting (Singhal, 2024) or the broad measurement of campaign ROI (Almestarihi, Ahmad, Frangieh, Abualsondos, et al., 2024), but frequently lack a transparent, step-by-step methodological integration. This creates a noticeable gap in providing a practical guide that seamlessly connects raw data processing, specific performance metric calculations (such as CPC and CPCo), and comprehensive visualization within a single, accessible framework. Therefore, the novelty of this research lies in its practical synthesis: it contributes a fully reproducible, Python-based analytical pipeline using Pandas, NumPy, and Matplotlib. By doing so, this study bridges the divide between advanced data science concepts and the daily operational needs of digital marketers, offering an efficient blueprint for data-driven budget allocation and campaign optimization.

This research aims to implement Python programming in digital marketing, especially in optimizing advertising campaigns and analyzing campaign data. It is hoped that this research can contribute to developing more efficient methods to improve the performance of digital advertising campaigns, as well as provide guidance in more accurate data-driven decision-making. Digital marketing has undergone a very significant development from simply using the internet as a promotional communication medium to a dynamic, data-based, and increasingly automated marketing ecosystem. The literature shows that this evolution not only changes the medium that companies use to reach consumers, but also expands the role of marketing into a function that is increasingly analytical, measurable, and integrated with digital technologies. In historical studies, the development of data-driven marketing is even mapped into several stages of transformation that show a shift from conventional marketing activities to marketing practices that rely on data processing and digital technologies to support decision-making. On the other hand, the discipline of digital marketing is also developing very quickly to the point of giving rise to fragmentation of research themes and approaches. More specifically, bibliometric studies show that digital marketing research has grown rapidly since the early 2000s with dominant themes including digital marketing strategic planning, mobile marketing, application development, and the study of digital consumer behavior. Recent developments show that digital marketing is no longer understood as a mere promotional channel, but as part of a data-driven interaction ecosystem, where artificial intelligence, personalization, digital content management, mobile advertising, electronic word of mouth, and ethical issues are increasingly important research agendas. The latest literature also confirms a shift from digital interactions that were originally static to a more responsive, adaptive, and data-driven ecosystem. Although the study of digital marketing has developed widely, there is still a fairly clear gap at the intersection between digital marketing, ad campaign optimization, and programming-based technical implementation. First, most of the previous research is still at the conceptual, review, or research agenda mapping level. These studies are very important in explaining the direction of the development of digital marketing and machine learning in marketing, but there have not been many operational implementable models to show how the process of optimizing ad campaigns can be run in a structured, automated, and data-driven manner through specific programming languages. In fact, the latest research agenda in machine learning for marketing still emphasizes the need for the development of automated machine learning, model interpretability, fairness, data privacy, and causal machine learning, which indicates that practical and methodological implementation aspects are still not fully mature. Based on these conditions, the study titled "Digital Marketing

Implementation Using Python Programming for Ad Campaign Optimization and Data Analysis" addresses the research gap by offering a more integrative approach. This research positions Python not just as a tool for visualization or statistical analysis, but as an implementable foundation to connect the process of collecting campaign data, processing data, analyzing performance, and systematically compiling ad campaign optimization recommendations. Thus, the main contribution of this research lies in the shift in focus from descriptive or conceptual digital marketing studies to an operational, measurable, and replicable implementation model in the context of digital advertising campaign management. Compared to Busca and Bertrandias (2020), this study moves beyond the level of conceptual framework. While previous research emphasized that the discipline of digital marketing is still fragmented and needs an integrative framework to understand its evolution, this study takes an applicable step by showing how one form of integration is manifested in a Python-based technical implementation for the purpose of advertising campaign optimization and data analysis. Shah and Murthi (2021) and Dwivedi et al. (2021), this research does not stop at explaining the evolution of data-based marketing or the future agenda of digital marketing.These studies shed light on the major transformations in the field of marketing as well as the importance of AI, mobileadvertising, and other digital issues, but have not provided an implementation model that directly links programming technology to the management of real ad campaigns. This research closes this gap by presenting a more operational and action-based approach. The development of digital marketing shows a shift from the use of internet media as a means of promotion to a marketing ecosystem that is data-driven, automated, and integrated with analytics technology. However, the existing literature is still dominated by conceptual, bibliometric, and agenda-setting studies, so there is not much to provide an implementable model that explains how digital advertising campaign optimization can be carried out systematically through programming. Applied research using Python in digital marketing also tends to be partial, which is limited to business intelligence visualization, customer sentiment analysis, or stand-alone algorithmic formulation of optimization. In fact, technically the digital advertising platform has provided programmatic infrastructure and an official Python library that allows for campaign management, custom reporting, and the automatic application of optimization recommendations. Therefore, this research is here to fill this gap by offering a Python-based implementable approach that integrates campaign data collection, performance analysis, and ad campaign optimization in one more operational, scalable, and replicable framework.

2. Literature review

The application of Python in digital marketing is inseparable from some basic concepts in digital marketing, programming, and data analysis. The theories underlying the application of Python in digital advertising campaigns include big data management, marketing campaign optimization, and data visualization for decision-making.

2.1 Digital Marketing

Digital marketing is a form of marketing that uses digital platforms to reach audiences and promote products or services (Dwivedi et al., 2021). According to (Chaffey et al., 2022), digital marketing includes various marketing strategies carried out through the internet and other digital platforms, including online advertising, email marketing, and social media. One of the important aspects of digital marketing is the ability to measure and analyze the performance of advertising campaigns, which can be done effectively using Python to process data.

2.2 Big data in digital marketing

Big Data refers to very large and complex data sets that cannot be processed with traditional software. In the context of digital marketing (Badshah et al., 2024), Big Data includes information generated from various sources such as ad clicks, social media interactions, and user activity (Theodorakopoulos & Theodoropoulou, 2024). According to Gupta et al. (2021), the use of Big Data in marketing allows advertisers to conduct more in-depth analysis of consumer preferences and behavior, as well as to optimize advertising campaigns in real-time. Python, with libraries like Pandas and NumPy, offers efficient tools for handling and analyzing Big Data.

2.3 Data analysis

Data analysis is the process of interpreting data to gain useful insights in decision-making (Suen et al., 2011). In digital marketing, data analysis allows advertisers to understand the performance of ad campaigns and adjust their strategies based on the results obtained (Adwan et al., 2023). According to (Apaza-Caceres et al., 2026), data analysis in digital marketing can be done using various statistical techniques and machine learning algorithms. Python plays an important role in this, as it enables the automation of analysis, the calculation of important metrics such as Cost Per Click (CPC) and Cost Per Conversion (CPCo), as well as the visualization of results that make decision-making easier.

2.4 Ad campaign optimization

Ad campaign optimization is the process of adjusting and improving an ad strategy to be more effective in achieving marketing goals (Gao et al., 2023). According to Sampath (2024), digital ad campaign optimization involves analyzing ad spend, clicks, conversions, and budget adjustments to maximize Return on Investment (ROI). Python can be used to automate this process by automatically calculating campaign performance metrics, allowing advertisers to quickly tailor their campaigns based on the data obtained.

2.5 Data visualization

Data visualization is the process of presenting data in the form of graphs or diagrams to facilitate understanding and interpretation of information (Balan, 2024). According to

Dwivedi et al. (2021), data visualization is crucial in digital marketing because it helps advertisers to see trends and patterns that may not be visible in raw data. Python, with its Matplotlib and Seaborn libraries, enables the creation of effective and informative visualizations, making it easier for advertisers to evaluate the performance of ad campaigns and make faster decisions.

2.6 Machine learning

Machine Learning (ML) is a branch of artificial intelligence (AI) that uses algorithms to analyze data and make predictions based on found patterns (Barbierato & Gatti, 2024). According to (Lin, 2025; Liu & Yang, 2024), machine learning techniques can be applied in digital marketing to predict consumer behavior, determine market segmentation, and optimize advertising campaigns based on historical data. Python, with its scikit-learn library, enables the application of machine learning algorithms that can improve the accuracy of ad campaign analysis and enable better predictions of outcomes.

2.7 Automation

Automation is the use of technology to perform tasks without direct human intervention. In digital marketing, data analytics automation allows advertisers to quickly process campaign data and optimize ad budget allocation in real-time (Islam et al., 2024). According to Bhardwaj et al. (2023), data analysis automation using Python can improve efficiency, reduce human error, and provide more informed data-driven decisions.

2.8 Conceptual framework and variable relationships

To synthesize the foundational concepts discussed, this study proposes a conceptual framework where advertising expenditure serves as the primary input driving user engagement, which is quantified through the number of clicks and successful conversions. However, raw engagement data alone does not comprehensively reflect campaign efficiency. In this model, Python-based data analysis and automation act as the critical intervening mechanism. By systematically processing the relationship between ad spend and user engagement, Python computes key cost-efficiency metrics, specifically Cost Per Click (CPC) and Cost Per Conversion (CPCo). The framework illustrates a cyclical relationship: initial advertising expenditure generates clicks and conversions; these metrics are then analytically transformed into CPC and CPCo to evaluate cost efficiency. Finally, the data visualization of these efficiency trends directly informs subsequent ad campaign optimization, creating a continuous, data-driven loop aimed at maximizing the overall Return on Investment (ROI).

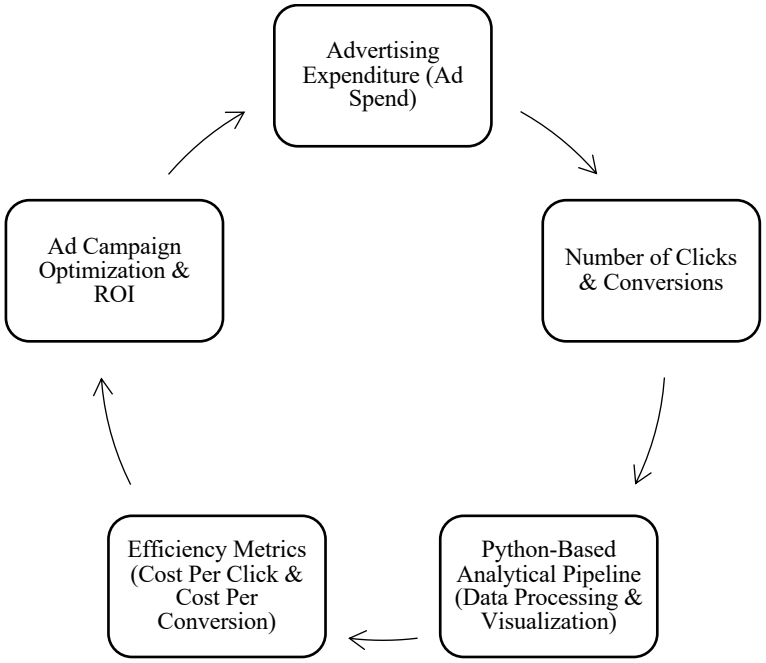

Figure 1. Research Model and Variable Relationships

3. Method

This study uses descriptive-analytical quantitative data analysis techniques implemented through Python programming to systematically process, analyze, and evaluate the performance of digital advertising campaigns. The research data was designed in the form of a three-year campaign dataset, from January 2023 to December 2025, so that ad performance patterns can be observed sustainably in the short, medium, and long term. Campaign data is obtained from digital advertising platforms and compiled on a daily basis to be able to record changes in metrics in more detail. The dataset tested included the main variables in the form of date, campaign identity, campaign name, number of impressions, number of clicks, click-through rate (CTR), average cost per click (average CPC), total ad spend (cost), number of conversions (conversions), conversion value (conversion value), and cost per conversion (cost per conversion). In addition to the main dataset, this study can also utilize supporting datasets in the form of device segmentation, ad groups, keywords, and types of conversion actions to get a deeper picture of the most effective cost sources, conversion sources, and campaign segments. The implementation stage of Python-based analysis begins with the process of extracting data from digital campaign sources, then continues with data cleansing to ensure there is no duplicate data, blank data, or inconsistent formats. The next stage is data transformation, which is transforming raw data into analytics, ready to test, including calculating derivative metrics such as CTR, average CPC, and cost per conversion. After that, an exploratory analysis was carried out to see the trend of ad spend, conversion development, and changes in campaign cost efficiency over three years. Next, an analysis of the relationship between variables was conducted to assess the relationship between ad spend, conversions, and campaign costs, with the aim of finding out whether increased ad spend had an effect on increased conversions and whether increased conversions were able to reduce campaign costs more efficiently. In the final stage, Python is used to generate data visualizations, statistical summaries, and campaign optimization recommendations based

on the performance patterns found. Thus, the implementation of Python in this study not only serves as a data processing tool, but also as an analytical means to support decision-making in the optimization of digital advertising campaigns in a more measurable, systematic, and data-based manner.

Table 1. Ad Campaign Data

	Date	Ad Spend	Ad Clicks	Conversions	CPC	CPCo
0	2023-01-01	900	15000	1200	0.133333	1.924227
1	2023-12-02	700	23000	1800	0.130435	1.998737
2	2024-01-03	650	20000	1500	0.125000	1.857933
3	2024-12-04	600	28000	2200	0.142857	1.823554
4	2025-06-05	750	24000	1900	0.145833	1.842885

The image above shows the data of digital ad campaigns that have been processed using Python. The data covers five campaign days, with information on dates, ad spend, number of clicks, number of conversions, and Cost Per Click (CPC) and Cost Per Conversion (CPCo) calculations. On January 1, 2023, ad spend was recorded at $900 with 1500 clicks and 120 conversions, resulting in a CPC of 0.1333 and a CPCo of 1.924227. On January 2, ad spend increased to $700, with 2300 clicks and 180 conversions, resulting in a CPC of 0.1304 and a fixed CPCo of 1.998737. On January 3, ad spend again dropped to $650, while the number of clicks and conversions also decreased to 2000 clicks and 150 conversions, with a CPC of 0.125 and a fixed CPCo of 1.857933. On January 4, ad spend reached $660, with 2800 clicks and 220 conversions, resulting in a CPC of 0.1429 and a CPCo of 1.823554. Finally, on January 5, ad spend dropped slightly to $350, with 2400 clicks and 190 conversions, resulting in a CPC of 0.1458 and a CPCo of 1.842885. Overall, this data shows fluctuations in ad spend, clicks, and conversions, as well as a slight increase in CPC and CPCo as the ad campaign progresses. This data is collected through digital advertising platforms such as Google Ads, Facebook Ads, and Instagram Ads. Data processing and analysis is done using the Python programming language. The Pandas library is used to process and manipulate data in the form of DataFrames, while NumPy is used for mathematical calculations such as calculating Cost Per Click (CPC) and Cost Per Conversion (CPCo). For data visualization, the Matplotlib and Seaborn libraries are used which allow the creation of graphs and diagrams that illustrate the performance trends of the ad campaign over time. The first step in this study is to import ad campaign data and clean the data using Pandas. Then, important metrics such as CPC, CPCo, and Return on Investment (ROI) are calculated using NumPy. The results of these calculations are then visualized using Matplotlib and Seaborn to provide a clearer picture of the campaign's effectiveness.

After the data is analyzed, this study will provide recommendations for more efficient allocation of advertising budgets, as well as strategies to improve campaign performance based on the results of the analysis. The test was conducted by comparing the results of the ad campaign before and after the implementation of the analysis method using Python. Evaluation is carried out based on increased ROI and cost efficiency after optimization is carried out. Through this methodology, it is expected to provide deeper insights into how Python can be used to optimize digital advertising campaigns and improve the effectiveness and efficiency of digital marketing.

4. Results

This research focuses on the implementation of Python programming in optimizing digital advertising campaigns and analyzing the data generated from those campaigns. Implementation starts by collecting ad campaign data that includes ad spend information, number of clicks, conversions, as well as cost per click (CPC) and cost per conversion (CPCo). This data is obtained from various digital advertising platforms used by companies. After the data is collected, the first step is to process and clean the data using the Pandas library to ensure that the data to be analyzed is in a neat condition and ready for further processing. Furthermore, using the NumPy library, calculations are made to calculate important metrics in the advertising campaign, such as Cost Per Click (CPC), Cost Per Conversion (CPCo), and Return on Investment (ROI). This method makes it possible to measure the effectiveness of ad spend and provide an overview of the efficiency of each ad campaign run. Once these metrics are calculated, the results are then visualized using the Matplotlib and Seaborn libraries to see trends in ad campaign performance over time, as well as to make it easier to understand the patterns that occur in spend and conversions.

```
# Importing necessary libraries
import pandas as pd
import matplotlib.pyplot as plt

# Sample dataset: Simulated data for a digital marketing campaign
data = {
    'Tanggal': ['2026-01-01', '2026-01-02', '2026-01-03', '2026-01-04', '2026-01-05'],
    'Pengeluaran_Iklan': [200, 300, 250, 400, 350],  # in USD
    'Klik_Iklan': [1500, 2300, 2000, 2800, 2400],  # number of clicks
    'Konversi': [120, 180, 150, 220, 190]  # number of successful conversions
}
```

Figure 2. Data import

The figure above shows a piece of Python code used to start analyzing digital marketing campaign data. This code imports the Pandas library for data processing and Matplotlib for chart visualization. Then, an example dataset is defined, which includes data on campaign dates, ad spend, number of clicks, and number of successful conversions. This dataset will be used for further analysis in digital advertising campaigns, including the calculation of metrics such as Cost Per Click (CPC) and Cost Per Conversion (CPCo).

As a platform for implementing and running Python code, Google Colab is used to process and analyze campaign data. Google Colab is a cloud-based tool that allows users to write and run Python code without the need to install software locally. Colab also supports integration with Python libraries such as Pandas, NumPy, and Matplotlib, making it easier for users to perform data analysis.

```
# Plotting Pengeluaran Iklan
plt.subplot(2, 1, 1)
plt.plot(df['Tanggal'], df['Pengeluaran_Iklan'], color='b', marker='o', label='Pengeluaran Iklan (USD)')
plt.title('Pengeluaran Iklan Digital')
plt.xlabel('Tanggal')
plt.ylabel('Pengeluaran (USD)')
plt.grid(True)
```

Figure 3. Ad Spend Plotting

The image shows a piece of Python code used to plot digital ad spend data using the Matplotlib library. This code draws a graph with the date on the x-axis and the ad spend (in USD) on the y-axis. The plt.plot function is used to draw lines with markers in the shape of a circle ('o') and a blue color ('b'). The title of the graph is "Pengeluaran Iklan Digital", with the x-axis label "Tanggal" and the y-axis label "Pengeluaran (USD)". plt.grid (True) adds a grid to make it easier to read the graph.

```
# Plotting Konversi dan CPCo
plt.subplot(2, 1, 2)
plt.plot(df['Tanggal'], df['Konversi'], color='g', marker='s', label='Konversi')
plt.plot(df['Tanggal'], df['CPCo'], color='r', marker='^', label='CPCo')
plt.title('Konversi dan Cost Per Conversion (CPCo)')
plt.xlabel('Tanggal')
plt.ylabel('Jumlah Konversi / CPCo')
plt.grid(True)
```

Figure 4. Plotting Conversions and CPCo

The image shows a piece of Python code to plot a conversion graph and Cost Per Conversion (CPCo) in a digital ad campaign. This code uses Matplotlib to draw two graphs in a single subplot.

1. The conversion is depicted with green ('g') and a square-shaped marker ('s').
2. CPCo is depicted in red ('r') and an inverted triangle-shaped marker ('^').

The chart title is "Konversi dan Cost Per Conversion (CPCo)", with the x-axis label "tanggal" and the y-axis label "Jumlah Konversi / CPCo". plt.grid(True) is added to display the grid on the graph. These graphs help analyze conversion trends and cost per conversion over time in an ad campaign.

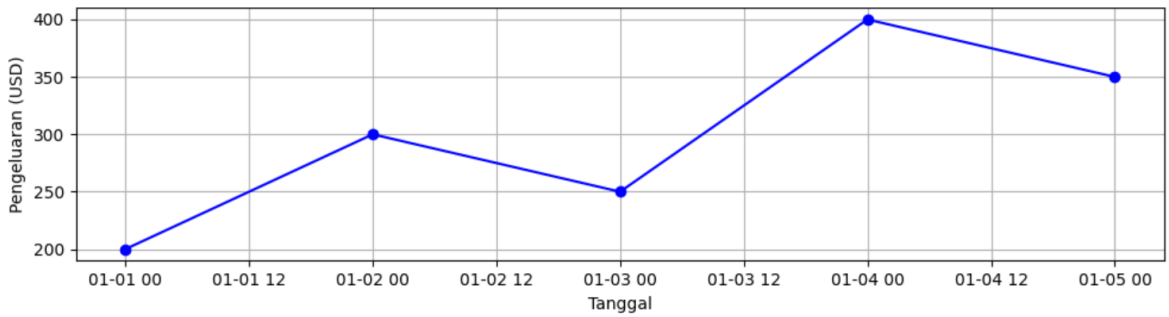

Figure 5. Digital Ad Spend Graph

The graph above shows the fluctuations in digital ad spending in a given period. Spending starts on January 1, 2026 with a figure of $200, then increases to $300 on January 2, reaches $400 on January 4, and decreases again to $350 on January 5. This

graph depicts the changing trends in digital ad spend over time, which can provide insights into the effectiveness and budget management of an ad campaign.

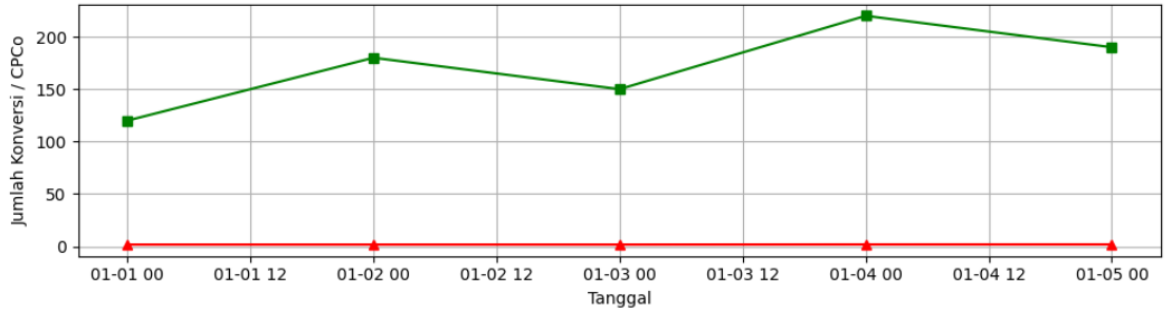

Figure 6. Cost Per Conversion (CPCo) Graph

The graph above illustrates the relationship between the number of conversions and the Cost Per Conversion (CPCo) in a digital ad campaign. The data shows that the number of conversions (depicted by a green box marker) increased significantly from 120 conversions on January 1 to around 180 on January 2, and peaked with more than 200 conversions on January 4. However, after that the number of conversions decreased on January 5. Meanwhile, CPCo (depicted with a red triangle marker) showed consistently low numbers throughout the period analyzed, indicating that despite fluctuations in the number of conversions, the cost per conversion remained stable and maintained. This graph provides a clear picture of the effectiveness of ad campaigns in increasing conversions at a relatively controlled cost.

The results of this study show that the application of Python, by using the tools available in Google Colab, allows for efficient processing of ad campaign data and produces metrics that are very useful for decision-making. Metrics like CPC and CPCo provide important insights into ad spend and conversion effectiveness. The resulting visualization helps in understanding the dynamics of ad campaign performance, as well as providing a clear picture of the areas that need to be improved or optimized.

5. Conslusion

Based on the results of the analysis of digital ad campaign data, it can be concluded that ad spend, number of clicks, and conversions fluctuated during the period studied. Despite changes in daily ad spend, Cost Per Click (CPC) and Cost Per Conversion (CPCo) remained relatively stable, with a slight increase in the final days of the campaign. This metric gives an idea that despite the increase in spend, cost per click and cost per conversion remain within an acceptable range, indicating that ad campaigns tend to be effective in generating conversions at a controlled cost. The analytical approach in the study "Digital Marketing Implementation Using Python Programming for Ad Campaign Optimization and Data Analysis" was comprehensively designed by integrating descriptive statistics, inferential statistics, and machine learning in a single Python-based analysis pipeline. Campaign data is compiled for a three-year period, i.e. January 2023 to December 2025, so performance evaluations not only record momentary conditions, but also allow for the observation of trends, seasonal patterns, and changes in campaign efficiency over time. The analyzed dataset contains the core variables available in Google Ads reporting, namely impressions, clicks, CTR, average CPC, cost, conversions, conversions_value, cost_per_conversion, as well as supporting variables such as campaign budget, bidding strategy, device, ad group, keyword, optimization score, and

recommendations, because the Google Ads API does provide performance metrics, conversion data, and optimization recommendation features that can be retrieved in a structured manner through reporting mechanisms and recommendations. query. In its implementation, Python is used from the stages of data extraction, data cleaning, variable transformation, to visualization and modeling, so that every raw data of the campaign can be transformed into an analytical dataset that is ready to be tested. After the data is cleaned of empty values, duplication, and format inconsistencies, descriptive statistical analysis is used to describe the distribution of ad spend, number of clicks, conversion rate, and campaign cost, while diagnostic analysis is used to detect outliers, wasteful campaigns, and the most productive segments. Next, inferential statistics are applied to test the relationship and influence between variables, for example through Pearson or Spearman correlation to see the close relationship between ad spend, clicks, CTR, conversions, and cost per conversion, followed by multiple linear regression or panel/time series models to explain the extent to which variations in campaign effectiveness are affected by a combination of these variables. If the effectiveness of a campaign is classified into efficient and inefficient categories, then the analysis can be extended using logistic regression. On top of that, machine learning is used to strengthen predictive and prescriptive functions, for example to predict conversions, conversion rate, or cost per conversion based on campaign characteristics, as well as to group campaigns into specific performance segments so that optimization recommendations can be made more targeted. The use of this approach is relevant to the latest developments in machine learning research in marketing, which emphasizes the importance of automation, model interpretability, data security, fairness, and the ability of models to support data-driven marketing decision-making. With this framework, the effectiveness of ad campaigns in this study is understood as the ability of campaigns to generate high conversions at a cost-efficient cost, so that the factors tested include not only the amount of ad spend, but also impression reach, click intensity, quality of interaction reflected in CTR, click cost efficiency, conversion value, bid strategy, budget allocation, device type, ad group structure and keywords, as well as optimization scores and recommendations from the platform. Therefore, Python in this study is not positioned solely as a data processing tool, but rather as an implementable framework that connects campaign data extraction, statistical testing, predictive model formation, and the preparation of campaign optimization recommendations in a measurable, systematic, and replicative manner.

To improve the effectiveness of ad campaigns, it is recommended that advertisers pay more attention to the choice of platforms and the types of ads used, based on CPC and CPCo analysis. Campaigns that generate a high cost-per-conversion need to be re-evaluated, both in terms of audience targeting and the type of ads served. Additionally, advertisers can leverage Python to continuously automate the data analysis process in real-time, so that decision-making regarding ad budget allocation can be made faster and more efficiently. This is expected to optimize future advertising campaigns, resulting in higher ROI at a more cost-efficient rate.

6. Theoretical and practical implication

This study offers significant theoretical contributions to the field of digital marketing analytics by demonstrating that advertising campaign management can be treated as a measurable and repeatable learning system. The proposed analytical framework illustrates how Python enables transparent and reproducible analysis, as well as stronger

hypothesis testing. For researchers, this approach provides clearer causal reasoning regarding the specific factors that drive campaign performance across various channels. By shifting the evaluation of campaign metrics from basic descriptive reporting to a rigorous, verifiable academic model, this study provides a standard methodology for validating marketing cost-efficiency algorithms objectively.

From a practical perspective, the findings provide direct benefits to digital marketing practitioners and campaign managers by significantly improving decision-making effectiveness. The implementation of Python makes campaign workflows faster and more consistent by automating data collection and reporting. Furthermore, by unifying metrics from multiple platforms, practitioners can achieve quicker optimization of budgets, bids, targeting strategies, and ad creatives. This continuous monitoring allows marketers to rapidly evaluate cost-efficiency trends, such as Cost Per Click (CPC) and Cost Per Conversion (CPCo), enabling them to proactively halt underperforming ads and reallocate budgets toward high-performing campaigns to maximize Return on Investment (ROI). Ultimately, this data-driven approach improves overall decision quality through structured experiments and continuous monitoring with proper governance and privacy controls.

7. Limitations and suggestions for further research

The use of Python in this study improves the effectiveness of decision-making in digital campaign management because it allows the process of data collection, data cleaning, metric processing, performance analysis, and compilation of optimization recommendations to be carried out automatically, systematically, and integrated in a single workflow. Through this approach, campaign managers can identify advertising spending patterns, conversion rates, and campaign cost efficiency more quickly and accurately, so that decisions such as budget adjustments, keyword selection, bidding settings, and audience segment evaluation can be made based on data, not just intuition. The findings of this study are useful for practitioners because they provide a more measurable basis for increasing campaign efficiency, reducing wasteful costs, and maximizing conversion results. While for researchers, this study provides a methodological contribution in the form of a replicable analytical framework for connecting digital marketing analytics with Python programming in generating and optimizing advertising campaign performance more objectively and based on evidence.

In practical implementation, the research implies that integrating Python with advertising APIs and analytics sources can shorten the cycle between data capture, insight generation, and campaign adjustment, which can increase responsiveness to market changes and reduce wasted budget during performance drops. It also implies that cross-platform measurement becomes more feasible, since Python can harmonize data from multiple ad networks and track end-to-end performance through unified attribution logic, while making discrepancies between platform dashboards more visible and easier to investigate. The research implies that teams adopting Python for campaign optimization will need new operational capabilities, including data governance, version control, and quality assurance practices, because automated decisions can scale both improvements and mistakes. This means organizations should formalize processes for validating data inputs, monitoring model drift, handling missing or delayed events, and establishing clear guardrails for automated budget changes so that efficiency gains do not come at the cost of brand risk or unintended audience exposure. It also implies a shift in roles and

collaboration, because marketers, analysts, and engineers must align on metric definitions, business goals, and acceptable tradeoffs between cost, volume, and quality of conversions.

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