TWO-STAGE FRAMEWORK FOR DIGITAL CONTENT OPTIMIZATION AND SCHEDULING

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Abstract: *Rapid changes in technology and consumer preferences continue to change the way things are done. As a result, all communication flows should include strategies to adapt to the way things are done in a digital environment. There is a lot of data in the digital space that describes the behavior of people in the market and influences the best strategies to follow for success. Current research determines how linear programming can be applied for solving problems in digital marketing to find optimal solutions for the best marketing results. Platforms like Facebook, Instagram, LinkedIn and TikTok significantly shape the way people relate to the content created by the marketing team. By analyzing some of the trends established by using such platforms, it is possible to arrive at a more effective content planning that is in line with the market trend. Our research highlights the importance of customized content and optimal placement in maximizing marketing effectiveness in the digital domain.*

Keywords*: digital marketing, social media, linear programming, portfolio, scheduling*

1. INTRODUCTION

In recent decades, the marketing field has embraced the idea that comprehending consumer behavior entails considering social influences alongside individual actions, rather than studying individuals in isolation (Haenlein, 2013). Billions of people worldwide now integrate internet, social media, mobile apps, and other digital communication technologies into their daily routines. (Dwivedi et al., 2020).

Developing social media strategies for organizations poses significant challenges within a changing landscape where consumers wield more power and cultural norms are increasingly recognized (Kietzmann et al., 2011). In response to shifting consumer behavior, organizations have integrated digital and social media as crucial elements of their marketing strategies. (Stephen, 2016). By utilizing digital tools and social media, organizations can achieve deeper engagement with their target markets.

The digital landscape generates a wide range of data, including clickstream data, customer reviews, blogs, tags, social interaction data, responses to marketing efforts, and insights on collaborators and competitors (Kannan & Li, 2017). Digital marketing plays a pivotal role in the digital business transformation journey, integrating novel marketing approaches rooted in information and communication technologies (Veleva & Tsvetanova, 2020). Digital marketing initiates crucial shifts in both business and consumer behavior. It provides companies with a unique platform to understand customer requirements and create timely, location-specific opportunities. (Minculete & Olar, 2018).

Research in the field of digital marketing, besides deepening theoretical understanding of this dynamic field, also provides valuable guidelines for effective utilization of digital platforms for marketing purposes. While reviewing the literature in this field, various approaches to solving optimization problems in marketing activities were explored. The first approach focused on statistical inference (Alamsyah et al., 2021), while the other two delved into linear programming techniques, with one employing binary linear programming (Bigler et al., 2019) and the other investigating AHP (Analytic Hierarchy Process) - based goal linear programming (Robielos & Awit, 2020).

This study seeks to introduce a two-phase framework designed to boost the advertising success of startup companies using digital marketing tools. The framework comprises two integer linear models. The first model determines the optimal number of posts within specific categories for advertising across various social media platforms, aiming to maximize advertising-generated profit. The second model focuses on maximizing user recognition by strategically scheduling previously acquired posts within a designated timeframe, typically spanning a week.

The paper is structured as follows: in chapter two, stage one presents the proposed model for selecting the optimal advertising portfolio intended for specific social media platforms, followed by stage two, which introduces the model for scheduling posts within the observed interval. Chapter three illustrates both models through a case study example, while chapter four offers a discussion of the results. Conclusions and potential future research directions are presented in the final chapter.

2. FRAMEWORK

In this study, the approach of linear integer programming was selected for addressing optimization and decision-making issues around digital media selection and post scheduling. Linear programming is a mathematical modeling technique used to solve real-world problems and generate optimal solutions. In both theory and practice, numerous problems can be transformed into linear programs to leverage their solution using efficient algorithms (Cohen et al., 2021). Linear programming (LP) stands out as a distinctive technique utilized in operations research to adjust linear characteristics through equalities and inequalities, aiming to reach optimal outcomes like revenue maximization or cost minimization within a specified mathematical framework defined by linear equations (Akpan & Iwok, 2016; Kalwar et al., 2022). Considering the values derived from the proposed framework, particularly the number of posts in various categories and the daily post frequency on a specific platform, the choice has been made to utilize integer linear programming (ILP). ILP represents a specialized branch of linear programming tailored to address problems featuring integer constraints on decision variables (Ammar & Emsimir, 2020).

The proposed framework consists of two stages. In the initial stage, Model 1 is applied to generate an optimal social media content portfolio. This optimal solution, from stage one, serves as the input parameter for the second stage, where Model 2 is utilized to devise and schedule an optimal arrangement of portfolio content within the specified time interval.

2.1. STAGE ONE

An integer linear programming (ILP) model is proposed to select the optimal number of posts from various categories for publication on a specific social media platform. The objective of the Model 1 (1-5) is to maximize the profit attained through a well-suited portfolio of posts made for social media advertising.

$$\max\left(\sum_{j=1}^{n}\sum_{i=1}^{m}(d_{ij}-c_{ij})x_{ij}\right) \tag{1}$$

$$s.t.$$

$$\sum_{j=1}^{n}\sum_{i=1}^{m}c_{ij}x_{ij} \le C \tag{2}$$

$$q_j\left(\sum_{i=1}^{m}x_{ij}\right) \ge r_j \quad j = 1,2,\dots n \tag{3}$$

$$\sum_{j=1}^{n}\sum_{i=1}^{m}a_{ijs}x_{ij} \le m_s \quad s = 1,2,\dots,t \tag{4}$$

$$u_{ij} \le x_{ij} \le v_{ij} \quad j = 1,2,\dots n,\ i = 1,2,\dots,m \tag{5}$$

$$x_{ij} \ge 0 \quad j = 1,2,\dots n,\ i = 1,2,\dots,m$$

where:
n: number of social media platforms used for advertising, m: number of categories of posts, t: number of specialist profiles. The task is to optimise x_{ij}: number of posts of category i intended for social media platform j, taking into account the following parameters: d_{ij}: revenue per post of category i intended for social media platform j, c_{ij}: cost of creating one post of category i created for social media platform j, C: advertising budget, q_j: average user engagement per post on social media platform j, r_j: minimal average user engagement on social media platform j, u_{ij}: minimum number of posts of category i intended for social media platform j, v_{ij}: maximum number of posts of category i intended for social media platform j, a_{ijs}: required time for a specialist of profile s to create one post of category i intended for social media platform j and m_s: available capacity of specialist profile s.

In the objective function, profit is expressed as the difference between the revenue and the creation costs per post of the corresponding category intended for the selected platform (1). The first constraint provides that entire social media advertising costs must be kept below the predetermined budget (2).

In the context of this model, user engagement includes activities such as liking, sharing, commenting, downloading, and other interactions that signify active participation and interest from users. The quantified user engagement must meet or exceed the designated platform minimum (3). The last two constraints (4,5) involve the upper limit of availability of individual specialist profiles engaged in content creation, as well as the threshold values that determine advertising frequency. Advertising frequency represents a range of values that dictate the number of posts of category created for the chosen platform.

Obtained optimal content structure for social media publication serves as input parameters for Model 2. This ensures that Model 2 schedules posts in alignment with the acquired values.

2.2. STAGE TWO

Model 2 (6-9), an integer linear programming model, is employed to schedule the posts within the portfolio throughout a designated time interval. The objective of the model is to maximize the total reach of the content published on social media platforms.

$$\max\left(\sum_{j=1}^{n}\sum_{i=1}^{m}\sum_{k=1}^{d} e_{ijk}\, y_{ijk}\right) \tag{6}$$

$$s.t.$$

$$\sum_{k=1}^{d} y_{ijk} = x_{ij} \quad j = 1,2,\dots n,\ i = 1,2,\dots,m \tag{7}$$

$$\sum_{i=1}^{m} y_{ijk} \le b_{jk} \quad j = 1,2,\dots n,\ k = 1,2,\dots,d \tag{8}$$

$$u_{ijk} \le y_{ijk} \le v_{ijk} \quad j = 1,2,\dots n,\ i = 1,2,\dots,m,\ k = 1,2,\dots,d \tag{9}$$

$$y_{ijk} \ge 0 \quad j = 1,2,\dots n,\ i = 1,2,\dots,m,\ k = 1,2,\dots,d$$

where:
d: number of time units in the observed interval. The task is to optimise y_{ijk}: number of posts of category i posted on social media platform j during time unit k, taking into account the following parameters: e_{ijk}: reach per post of category i within social media platform j over time unit k, x_{ij}: obtained from Model 1 output; optimal number of posts of category i intended for social media platform j, b_{jk}: maximum number of posts posten on social media platform j during time unit k, u_{ijk}: minimum number of posts of category i posted on social media platform j during time unit k, v_{ijk}: maximum number of posts of category i posted on social media platform j during time unit k.

The objective function aggregates the reach of posts for each category-platform combination in the portfolio for the observed time interval (6). In the observed time interval, the total number of posts must equal the optimal number defined within the portfolio (7).

Number of posts on a specific platform must remain below the designated maximum for the observed time unit. (8). Constraint (9) establishes the bounds for the number of posts that can be published within a particular unit of time during the observed time interval.

3. CASE STUDY

"WheelDeel" is a startup that enables car owners to rent out their vehicles to other users. The core idea is to utilize existing owner cars and provide users with affordable mobility options without the need for purchasing or long-term vehicle rentals. While "WheelDeel" offers a practical and economical alternative to traditional car rental, the challenge lies in attracting car owners to join the platform and promote their vehicles while simultaneously attracting users to utilize the platform's services. Therefore, it is necessary to employ specific promotion channels.

Promoting the platform can be done through various social media networks, including Instagram, Facebook, LinkedIn, and TikTok, utilizing creative content such as photos, videos, and user stories. To maximize profit from promotion, "WheelDeel" faces several constraints. The primary constraint is the budget available, which significantly impacts the realization of set goals. In addition to the budget, it's crucial to monitor user

engagement, advertising frequency, and the availability of specialist profiles. Average user engagement on a specific platform incorporates interactions users have with "WheelDeal's" social media content, primarily through actions like liking, sharing, and commenting.

For this study, data were acquired through discussions with the founders of the mentioned startup and utilizing materials they provided. These materials offered insight into the available resources for engaging content creators and the research budget. As the startup's social media platforms are still in their early stages, data on user engagement were gathered from secondary sources. The mentioned sources include user engagement on the social media platforms of other well-established marketing startups. The optimal portfolio for WheelDeal's publications, along with the scheduling of posts on a weekly basis, were determined by using Excel Solver for solving Model 1 and Model 2. The results are displayed in tabular format alongside a concise overview.

Table 1: Optimal portfolio of different category posts on social media platforms

Category / Platform	Text posts	Image post	Video post	Carousel post	Story post	Giveaway	Survey
Facebook	4	3	1	1	2	0	2
Instagram	2	4	2	2	6	1	1
LinkedIn	5	2	1	0	0	0	0
TikTok	0	0	5	2	0	0	0

Obtained portfolio emphasizes that most of the advertising should focus on Instagram and Facebook platforms, around 67%, while LinkedIn and TikTok have lower engagement rates. Concerning Instagram, the emphasis should be on story posts, whereas the best results for Facebook would be achieved through textual posts. Giveaway posts are best executed through Instagram, whereas advertising surveys demonstrate optimal performance on Facebook.

It has been decided that the obtained portfolio will be distributed on specific days of the week, considering the reach that would be achieved with such scheduling. Below are the results of the scheduling optimization.

Table 2: Posts scheduling by weekdays

Day / Category-platform	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Cumulative number of posts
Text post on Facebook	1	0	1	0	1	1	0	4
Image post on Facebook	0	0	1	0	1	1	0	3
Video post on Facebook	0	0	1	0	0	0	0	1
Carousel post on Facebook	0	0	1	0	0	0	0	1
Story post on Facebook	1	0	0	0	1	0	0	2
Survey on Facebook	1	1	0	0	0	0	0	2
Text post on Instagram	0	0	2	0	0	0	0	2
Image post on Instagram	2	0	1	0	1	0	0	4
Video post on Instagram	0	1	0	0	1	0	0	2
Carousel post on Instagram	0	1	0	0	1	0	0	2
Story post on Instagram	0	2	0	0	1	1	0	6
Giveaway on Instagram	0	0	1	0	0	0	0	1
Survey on Instagram	1	0	0	0	0	0	0	1
Text post on LinkedIn	0	2	2	1	0	0	0	5
Image post on LinkedIn	0	1	1	0	0	0	0	2
Video post on LinkedIn	0	1	0	0	0	0	0	1
Video post on TikTok	0	2	0	1	1	1	0	5
Carousel post on TikTok	0	0	0	1	1	0	0	2

After analyzing the obtained values (Table 2), the recommendation is to distribute most of the content during the workdays. Major advertising efforts are focused on Wednesday and Friday, accounting for approximately 43.5% of the overall content distribution, followed by Monday, Tuesday and Thursday. The weekend sees reduced engagement, particularly on Sundays, which is advised for a complete absence of social media

activity. On Saturday, it's recommended to keep activities minimal, with just a few scheduled posts for publication, making up approximately 8.7% of the total portfolio.

4. RESULT DISCUSION

Social media allows regular internet users to share their experiences and opinions online, giving them a platform to have their voices heard by a wide audience (Li & Xie, 2019). Upon analyzing the findings of the presented case study, it becomes evident that over 53% of the total posts distributed on Facebook fall into the category of textual posts (4 of them) and image posts (3 of them). This observation aligns with some studies (e.g. Peruta & Shields, 2018) indicating that Facebook users generally lean towards simple and familiar messages accompanied by photos and text, as opposed to content requiring them to click on links or watch videos.

As noted by Rejeb et al. (2022), Instagram's user base surpasses 1 billion monthly and 500 million daily active users, solidifying its position as a primary platform for information exchange and communication. Roughly 38% of the content created for advertising purposes by the mentioned startup should be crafted for Instagram, emphasizing the platform's widespread presence and its impact on the brand's success. Recognizing the widespread popularity of Instagram story posts, we can conclude that their substantial presence in the acquired portfolio is justified. Belanche et al. (2019) study supports this by implying that unique characteristics of inventive advertising formats, such as Instagram stories, have the potential to enhance the efficacy of a social media advertising campaign.

Examining the study findings reveals that the model has effectively promoted a category of posts on the LinkedIn platform that doesn't demand significant user interaction. Moreover, the length of these textual posts can be tailored to suit user preferences. This observation is consistent with Robson & Banerjee (2023) insight on LinkedIn, particularly concerning start-ups, where likes seem attainable through concise posts without any unnecessary interactivity, such as clicking a link. The revelations from this research, as outlined in Guarda et al. (2021), provide further confirmation of TikTok's dominance as the social network of the moment. Its focus on short-format videos, diverse sound options, and creative tools align perfectly with the platform's skyrocketing popularity.

The findings suggest that Facebook content is best posted primarily on Wednesday, followed by Mondays and Fridays. Regarding Instagram, Monday, Wednesday, and Friday are equally favored for sharing created content, with each of these days having four posts distributed. In contrast, based on the Singh et al. (2023) study conducted for Great Deal Tires, a regional company in Pennsylvania (USA), the Facebook page experiences higher engagement on Tuesdays and Wednesdays, while Instagram sees increased activity on Fridays. Observing the results obtained for Facebook, we notice that it's preferable to share content on weekdays rather than weekends, as suggested by the research performed by Drossos et al. (2023). This contrasts with the results of Villamediana et al. (2019) study, which highlight Thursday and Saturday as the optimal days for content publication, despite the suggestion to post zero times on Thursday and only twice on Facebook on Saturday in this study.

5. CONCLUSION

This paper addresses the issue of choosing an adequate structure and frequency of content to present the optimization of advertising for startups in a more credible manner, aiming at maximizing profit. By applying the mentioned method, an optimal promotion portfolio has been obtained across various social media platforms. Utilizing content creators, social media advertising specialists, and social media SEO specialists, WheelDeel will build awareness of its platform, stimulate user engagement, thereby increasing the number of registered car owners and vehicle bookings.

In future research directions, a deeper exploration of content personalization could be a focal point. This would entail studying how individual user characteristics, including interests, preferences, and demographic data, can be integrated into the decision-making process regarding content structure and frequency. By analyzing user behavior data and employing machine learning algorithms, it's possible to create personalized advertising strategies for individual users. Future studies could explore the incorporation of multiple aspects of time within the observed interval. For instance, beyond considering only the weekday as proposed in this example, researchers could also examine the specific time of day on that day.

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