

EXTENDING THE INFECTION MODEL IN MEME COMMUNICATION

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ABSTRACT

This paper extends the infection model in meme communication by integrating a word-of-mouth inflection model with an advertising memory effect model to depict meme virality and assess the impact of meme-style advertising. In the developed Internet era, meme-based advertising presents an economical and efficient strategy to enhance advertising effectiveness and foster immediate customer engagement due to its user-generated content nature.

Two distinct models are proposed, differing in their consideration of the meme spread rate: a one-step model assuming an exponentially distributed spread rate, and a two-step model incorporating a 'change point' for varying spread speeds across dissemination stages. Empirical data from a Taiwanese meme database and survey responses from 1248 subjects. Model validation showed a good fit between predictions and real-world data. This research successfully quantifies the memetic phenomenon, providing a predictive model for meme spread rates and advertising effects, offering marketing managers a valuable tool for strategic decision-making and contributing to future quantification studies of memes.

Keywords: *Meme, Advertising Memory Effect, Spread Rate, Infection Model, Meme Marketing.*

ENFEKSİYON MODELİNİN GENİŞLETİLMESİ

ÖZ

Bu çalışma, memetik virallliği tasvir etmek ve meme tarzı reklamların etkisini değerlendirmek amacıyla, bir ağızdan ağıza iletişim (WOM) kırılma modelini bir reklam hafıza etkisi modeliyle entegre ederek meme iletişimindeki enfeksiyon modelini genişletmektedir. Gelişmiş internet çağında, meme tabanlı reklamcılık, kullanıcı tarafından oluşturulan içerik yapısı gereği reklam etkinliğini artırmak ve anında müşteri katılımını teşvik etmek için ekonomik ve verimli bir strateji sunmaktadır.

Meme yayılma oranını ele alma biçimlerine göre farklılaşan iki ayrı model önerilmektedir: Üstel olarak dağılmış bir yayılma oranı varsayan tek aşamalı bir model ve yayılım aşamaları boyunca değişen yayılma hızları için bir "değişim noktası" (change point) içeren iki aşamalı bir model. Araştırmada, Tayvanlı bir meme veri tabanından elde edilen ampirik veriler ve 1248 katılımcının anket yanıtları kullanılmıştır. Model doğrulaması, tahminler ile gerçek dünya verileri arasında iyi bir uyum olduğunu göstermiştir. Bu araştırma, memetik fenomeni başarılı bir şekilde nicelleştirerek meme yayılma oranları ve reklam etkileri için öngörücü bir model sağlamakta, pazarlama yöneticilerine stratejik karar alma süreçlerinde değerli bir araç sunmakta ve gelecekteki meme nicelleştirme çalışmalarına katkıda bulunmaktadır.

Anahtar Kelimeler: Meme, Reklam Hafıza Etkisi, Yayılma Oranı, Enfeksiyon Modeli, Meme Pazarlaması.

INTRODUCTION

The rapid development of digital and social media has fundamentally changed the way advertising messages are created, distributed, and consumed. In contemporary online environments, consumers are exposed to a large volume of commercial messages and can easily avoid, ignore, or selectively attend to advertisements (Baek et al., 2026; Henrie and Gilde, 2026; Vardeman, 2024). Consequently, obtaining consumer attention and maintaining advertising effectiveness have become increasingly challenging for marketers. The development of electronic and social media has therefore encouraged advertisers to seek communication formats that are not only capable of attracting attention but also facilitate voluntary sharing and interpersonal dissemination (Kiljańczyk, and Kacprzak, 2026; Henrie and Gilde, 2026).

Internet memes have emerged as an important form of digital communication within this environment (Kamath and Alur, 2025; Ward, 2026). Internet memes generally refer to rapidly circulating forms of digital content that may take the form of images, text, animation, GIFs, tags, or videos and that can communicate ideas through humor, sarcasm, exaggeration, and other forms of culturally recognizable expression (Brubaker et al., 2018; Malodia et al., 2022; Shifman, 2013). Unlike conventional advertising messages, meme content is frequently reproduced, modified, and redistributed by users. Its communication process therefore involves not only exposure to an original message but also subsequent acts of imitation, adaptation, and sharing.

The communicative characteristics of memes have attracted increasing attention from marketers (Kolar et al., 2026; Ward, 2026; Wang et al., 2026). Because memes can be reproduced and circulated by users, companies can adapt existing popular meme formats to create advertising content. Meme-based advertising may consequently provide an economical approach to generating engagement and facilitating the circulation of commercial messages (Malodia et al., 2022). The user-generated nature of meme communication also distinguishes meme marketing from conventional advertising because consumers may become participants in the dissemination process rather than merely passive recipients of advertising messages (Wang et al., 2026).

The effectiveness of meme communication, however, cannot be understood solely in terms of whether a meme is viewed or shared (Vardeman, 2026; Zheng et al., 2025). The communication process also involves the probability that the content will continue to spread among individuals and whether an advertising message embedded within the meme can subsequently be recalled (Baek et al., 2026; De Keyzer et al., 2022). Thus, two related processes need to be considered

which are the dissemination process of the meme itself and the memory process associated with the advertising message. Examining these processes separately may provide only a partial representation of the overall effectiveness of meme-based advertising.

The concept of infection provides a useful conceptual perspective for understanding this dissemination process. Memes have been described as possessing contagious characteristics because they can be copied, adapted, and transmitted through social interaction. Wang et al.(2011) emphasized the contagious properties of memes, while Brodie (2009) used the analogy of infectious disease to explain how memes can spread from one individual to another. From this perspective, meme communication can be conceptualized as a process in which exposure to meme content indicates the possibility of subsequent transmission, analogous to the transmission of an infection.

Although the infection perspective provides a useful conceptual explanation of meme diffusion, a quantitative framework is required to describe the probability and rate of such dissemination. In particular, meme communication may not necessarily proceed at a constant rate. The speed of dissemination may differ across stages of communication, suggesting that a model based on a single spread-rate process may not adequately represent all meme communication patterns (Kamath and Alur, 2025; Rathi and Jain, 2024). Huang (2016) demonstrated the use of an infection perspective to examine word-of-mouth effects and proposed that different stages of communication can involve different spread-rate characteristics. This provides a basis for extending the infection approach to the study of meme communication.

In addition to dissemination, advertising effectiveness involves the extent to which consumers successfully retain and recall advertising information (Fan et al., 2026). Moreover, this study incorporates an advertising memory effect into the infection framework. Based on associative network theory, memory activation can be understood as a process in which information is activated when the relevant stimulus reaches an activation threshold (Collins & Loftus, 1975). In the context of meme-based advertising, this perspective suggests that the circulation of a meme and the recall of the advertising message embedded within that meme represent related but distinct components of communication effectiveness (González-Aguilar et al., 2023; Kolar et al., 2026).

Accordingly, this study extends the infection model in meme communication by integrating a word-of-mouth infection framework with an advertising memory effect model. Two alternative meme spread-rate specifications are developed. The first is a one-step model that assumes a single stochastic spread-rate process,

while the second is a two-step model that incorporates a change point to represent different spread-rate characteristics across stages of meme dissemination. These models are combined with the advertising memory component to establish an integrated framework for examining meme communication and advertising effects.

The empirical analysis uses meme data collected from a Taiwanese meme database together with survey responses concerning advertising memory. Through maximum likelihood estimation, the parameters of the advertising memory model and the two alternative meme spread-rate models are estimated and subsequently incorporated into the proposed infection framework. Model calibration is then conducted to examine the correspondence between model predictions and empirical observations.

The study makes two principal contributions. First, it extends the infection perspective of meme communication by providing a quantitative model that represents meme dissemination through alternative spread-rate assumptions. Second, it connects meme dissemination with advertising memory, thereby providing a framework for examining not only how meme content spreads but also how advertising information embedded in meme content may be recalled. Through this integration, the study contributes to the quantitative examination of meme communication and provides a potential analytical tool for evaluating meme-based advertising effectiveness.

The remainder of this article is organized as follows. The next section reviews the development and characteristics of memes, their contagious and communicative properties, and their application to marketing and advertising. The model section then develops the advertising memory effect and the alternative meme spread-rate models. The research method describes the empirical data, parameter estimation procedure, and model validation process. Finally, the results and conclusion discuss the empirical findings, theoretical and managerial implications, limitations, and directions for future research.

LITERATURE REVIEW

Meme Definitions and Its History

The concept of the meme originated with Dawkins (1976), who proposed the term to describe the transmission of cultural elements through processes analogous to biological reproduction. In this conceptualization, cultural information can be reproduced, retained, and transmitted among individuals

through imitation (González-Aguilar et al., 2023; Kamath and Alur, 2025;. Dawkins (1976) therefore emphasized the reproductive and transmissible characteristics of memes and suggested that cultural elements possess characteristics of both similarity and variation as they are transmitted between individuals.

The emergence of digital communication has substantially transformed the way memes are reproduced and disseminated (Agrawal et al., 2025; Razzaq et al., 2023). When the process of cultural transmission occurs within Internet environments, it can be described as Internet meme communication (Malodia et al., 2022; Meikle, 2016; Miltner, 2018; Shifman, 2013; Ward, 2026). Digital technologies facilitate the rapid copying, modification, and redistribution of cultural content. Unlike traditional cultural transmission, Internet memes can therefore be reproduced at a high frequency and distributed across geographically dispersed social networks (Agrawal et al., 2024; Henrie and Gilde, 2026; Kim et al., 2026; Wang et al., 2026).

Shifman (2013) conceptualized Internet memes as a form of digital communication characterized by replication and variation. The same basic meme format can be reproduced by different users while being modified according to individual interpretations and communication contexts. Meikle (2016) similarly emphasized that memes constitute visible and shareable forms of Internet expression that can be adopted and adapted by users. These characteristics indicate that meme communication is not simply a process of reproducing identical content; rather, it involves continuous modification during dissemination (Kim and Baek, 2026).

The variability of meme content is also important for understanding its communication effectiveness (Kim and Kim, 2025). As memes are copied and modified, the original message can acquire new meanings while retaining recognizable characteristics of the original format (Lee and Kwon, 2025). Chua and Soriano (2020) noted that Internet memes consist of digital elements that can be consciously imitated, copied, and shared by Internet users. Their combination of visual and textual elements facilitates the integration of ideas and expressions into easily recognizable communication formats.

The characteristics of replication, adaptation, and sharing distinguish Internet memes from conventional forms of advertising communication (Kiljańczyk and Kacprzak, 2026; Kamath and Alur, 2025). A conventional advertisement is generally produced and distributed by an identifiable advertiser (Fan et al., 2026), whereas meme content may be reproduced and transformed by users themselves (Baek et al., 2026). This user participation creates the possibility that the audience

becomes part of the communication process (Kim and Baek, 2025; Vardeman, 2026). For this reason, the meme should be considered not only as a content format but also as a mechanism through which communication can continue to expand across users and social networks.

Meme Communication and Contagiousness

The dissemination characteristics of Internet memes have frequently been described through the concept of contagion (De Keyzer et al., 2022; Ward, 2026; Vardeman, 2024). The analogy between memes and infectious processes arises from their ability to move from one individual to another through social interaction (Fan et al., 2026). Wang et al. (2011) emphasized the contagious properties of memes and argued that successful dissemination depends on both the publicity characteristics of the content and the social interactions through which it is transmitted. From this perspective, the existence of a meme does not guarantee successful diffusion; its dissemination depends on the interaction between the characteristics of the content and the communication process (Henrie, and Gilde, 2026).

Brodie (2009) similarly used infectious disease as an analogy for explaining the dissemination of memes. The infection perspective suggests that exposure to a meme may increase the possibility that an individual will subsequently reproduce or transmit that meme to others. Such a process provides a conceptual basis for examining meme dissemination in terms of transmission probability and spread rate (Kim and Kim, 2025; Kim et al., 2026).

The infection perspective is particularly relevant to the study of Internet memes because digital communication enables repeated exposure and rapid interpersonal transmission (Agrawal et al., 2025; Kim et al., 2026). When users encounter a meme, they may ignore it, consume it without further action, or reproduce and share it with other users (González-Aguilar and Feijoo, 2023). Consequently, meme communication involves a dynamic transition between exposure and subsequent transmission (Kiljańczyk and Kacprzak, 2026). The resulting dissemination process can potentially be represented using stochastic models that estimate the probability and rate of transmission.

The existing conceptual discussion also suggests that meme dissemination may not necessarily occur at a uniform rate (Kim and Baek, 2025; Razzaq et al., 2023). As communication develops, a meme may experience different levels of exposure, sharing, and reproduction. Huang (2016), in examining the infection effect of word-of-mouth communication, proposed an approach that considers different spread-rate characteristics across stages of communication. This

perspective is relevant to meme communication because the diffusion of a meme can similarly involve changes in communication speed (Vardeman, 2026).

Based on this literature (Agrawal et al., 2025; Brodie, 2009; Fan et al., 2026; González-Aguilar and Feijoo, 2023; Kiljańczyk and Kacprzak, 2026; Kim and Baek, 2025; Kim et al., 2026; Razzaq et al., 2023) the present study conceptualizes meme dissemination as an infection-like communication process. However, rather than treating infection merely as a metaphor, the study develops probability-based spread-rate models to quantify the dissemination process. A one-step model is used to represent a single spread-rate process, while a two-step model introduces a change point to account for the possibility that dissemination dynamics differ across stages. This modeling approach provides the foundation for extending the infection perspective into a quantitative framework.

Meme Marketing and Advertising Effectiveness

The communicative characteristics of memes have also created opportunities for their application in marketing and advertising (Rathi and Jain, 2024; Vardeman, 2026). The rapid circulation and user-generated nature of memes provide organizations with an alternative means of communicating commercial messages (Wang et al., 2026; Ward, 2026). Malodia et al. (2022) specifically examined meme marketing and highlighted the potential of viral memes to generate consumer engagement. In this context, advertisers may adapt popular meme formats to create advertising content that is more compatible with the communication practices of social media users (Vardeman, 2024; Zhenget al., 2025).

The economic and communication advantages of meme-based advertising arise partly from the possibility that users themselves contribute to the dissemination process (Agrawal et al., 2025). When users share or reproduce meme-based advertising content, the advertiser may benefit from additional exposure beyond the initial distribution of the advertising message (Baek et al., 2025; Henrie and Gilde, 2026). Thus, meme marketing can potentially combine advertising communication with electronic word-of-mouth processes (Fan et al., 2026).

However, the spread of a meme does not necessarily indicate that the embedded advertising message has been successfully communicated (Vardeman, 2024). A meme may become widely circulated because of its humor, recognizability, or entertainment value, while the advertising component receives relatively limited attention or memory activation (De Keyzer et al., 2022; González-Aguilar et al., 2023). Therefore, evaluating meme marketing effectiveness requires

consideration of both the dissemination of the meme and the consumer's ability to recall the advertising message (Kiljańczyk and Kacprzak, 2026).

The present study consequently distinguishes between meme dissemination and advertising memory while integrating the two components into a single analytical framework. Meme dissemination represents the communication process through which the content is transmitted (Kolar et al., 2026; Henrie and Gilde, 2026), whereas advertising memory represents the outcome in which advertising information is successfully recalled by consumers (Collins and Loftus, 1975; Si et al., 2025). This distinction allows the proposed model to examine the relationship between the communication dynamics of meme content and the effectiveness of advertising embedded within that content.

This approach is particularly relevant because advertising memory provides an observable indicator of whether advertising information has been retained by consumers. The present study therefore incorporates an advertising memory probability model into the infection framework. By doing so, the study extends the analysis of meme marketing from the question of whether a meme spreads to the broader question of whether the advertising information associated with that meme is successfully retained and recalled.

Advertising Memory and the Infection Model

The advertising memory component of the present study is based on the principle of activation within associative memory (Collins and Loftus, 1975; Si et al., 2025). Collins and Loftus (1975) proposed that information in memory can be represented through interconnected nodes and that activation can spread through these associative connections. The activation of a particular memory node depends on whether the relevant stimulus reaches an activation threshold. This perspective provides a theoretical basis for treating advertising recall as a probabilistic process rather than as a deterministic outcome (Fanet al, 2026).

In the context of meme-based advertising, the activation threshold is particularly relevant because meme communication can expose consumers to advertising information through a format that is simultaneously social, visual, textual, and highly variable (Baek et al., 2026; De Keyzer et al., 2022). The same meme format may be encountered repeatedly or in modified forms, potentially affecting the likelihood that associated advertising information is activated in memory (Fanet al, 2026; González-Aguilar et al., 2023). Accordingly, the probability of successful advertising recall can be incorporated into a model that also describes the dissemination of the meme.

The literature (Baek et al., 2026; De Keyzer et al., 2022; Fanet al, 2026; González-Aguilar et al., 2023) reviewed above suggests that meme communication involves at least two interconnected processes. The first is the transmission process, through which meme content is copied, adapted, and shared among users. The second is the memory process, through which advertising information associated with the meme may be activated and subsequently recalled. Existing discussions of memes provide the conceptual basis for understanding replication and contagion, while the advertising memory perspective provides a mechanism for representing the consumer-level advertising outcome (Kiljańczyk and Kacprzak., 2026)

The present study therefore integrates these two processes into an extended infection model. The infection component represents the dissemination of meme content and allows alternative assumptions concerning the spread rate. The advertising memory component represents the probability of successful advertising recall. The combination of these components enables the model to capture both the communication process and an advertising-effect outcome.

The resulting research framework addresses a limitation of treating meme communication exclusively as a phenomenon of viral diffusion. High dissemination does not necessarily imply high advertising effectiveness. By incorporating advertising memory into the infection framework, the present study attempts to establish a quantitative relationship between meme spread and advertising recall.

THE MODEL

Accordingly, the literature provides the conceptual foundation for the proposed model through three related perspectives. First, the evolutionary concept of memes explains their capacity for replication and variation (Dawkins, 1976). Second, research on Internet memes and contagious communication explains their adoption, adaptation, sharing, and infection-like dissemination (Agrawal et al., 2025; Brodie, 2009; Fan et al., 2026; González-Aguilar and Feijoo, 2023; Kiljańczyk and Kacprzak, 2026; Kim and Baek, 2025; Kim et al., 2026; Razzaq et al., 2023; Si et al., 2025). Third, research on meme marketing and associative memory provides the basis for considering the advertising implications of meme communication and the role of advertising memory (Baek et al., 2026; De Keyzer et al., 2022; Malodia et al., 2022; Collins & Loftus, 1975). These perspectives suggest that meme-based advertising involves two related but distinguishable processes: the dissemination of meme content and the activation of advertising

information in consumers' memory. Building on these theoretical foundations, the present study develops an integrated infection model that combines the spread rate of meme communication with the advertising memory effect. To construct this integrated framework systematically, the model is developed in three sequential components: first, an advertising memory model is established to represent the probability of successful advertising recall; second, alternative one-step and two-step models are developed to represent different assumptions concerning the spread rate of memes; and third, these components are integrated into an overall infection model to represent the combined effect of meme dissemination and advertising memory.

The AD Effect

We consider that x is a random variable which is the number of successfully recalling ad content. X follows binomial distribution as

$$f(x|p) = p^x(1 - P)^{n-x} (1)$$

In this equation, n is the total numbers that ad appears, p is the probability that the consumers successfully recall the ad content, $(1-p)$ is the probability that the consumers unsuccessfully recall the ad content.

According to the principles of associative network theory (Collins and Loftus, 1975), the likelihood of activation spreading through memory via the stimulus node suggests the presence of a threshold for node activation. Thus we consider p , the probability that the consumers successfully recall the ad content, has a prior distribution which is an uniform as

$$p \sim U(1, \pi)$$

$$f_p(p) \begin{cases} = \frac{1}{1 - \pi} & \text{for } \pi < p < 1 \\ = 0 & \text{otherwise} \end{cases}$$

π is the value of threshold which demonstrates the memory of customer evoking only exists in the threshold for node activation more than π .

Then we can calculate the full model as

$$f(x) = \sum_{p=\pi}^1 p^x(1 - P)^{n-x} \frac{1}{1 - \pi}$$

(3)

And the boundary is dependent on the context and is typically considered to vary among individuals (Collins and Loftus, 1975). Therefore, π is

$$\pi = c_0 + c_1\mu^v + c_2\sigma^u + \tau$$

(4)

c_0, c_1, c_2 are constants and μ, σ are the factors which influence the activation threshold and different from individuals. For example, μ, σ can be considered as the demographic variables or the experience of ad exposure. v and u indicates the power. If $v=1$ and $u=1$, then it is the linear relationship of μ, σ and π .

The Spread Rate of Meme

The One Step Model

The different between the one step model and two step models is the different consideration of spread rate of meme.

In one step model it is considered the spread rate is random variable y which is followed exponential distribution as $g(y) = \frac{a}{b}e^{(-\frac{a}{b})y}$. And its joint density is

$$f(x, y) = \sum_{p=\pi}^1 p^x (1-p)^{n-x} \frac{1}{1-\pi} e^{(-\frac{a}{b})y}$$

The Two Step Model

It suggests the spread rate of meme is two stages. There is a “change point” to portray that the different trend of spread speed when meme is disseminated in the internet.

Thus, according to Huang(2016), there are various spread rate in different stages.

It is considered the **spread rate** is a random variable S_k which is follows geometric density as

$$g_k(z) = I_{(k<\delta)}d(z|t, k) + I_{(k\geq\delta)}j(z|w, k, \delta)$$

$I(\cdot)$ is the indicator function. k is the k -th stage of spreading process and δ is the change point in the spreading process. $d(z|t, k)$ is the pdf of spread rate process which is before change point(δ) as

$$d(z|t, k) = t^k \theta e^{-(t^k \theta)z}.$$

$j(z|w, k, \delta)$ is the pdf of spread rate process which is after the change point(δ) as

$$j(z|w, k, \delta) = w^{k-\delta} \theta e^{-(w^{k-\delta} \theta)z}$$

The probability if change point follows Bernoulli distribution with parameters q . And the probability of not change is $(1-q)$. Thus, the density before change is

$$l_d = d(z|t, k)(1 - q)^k$$

The density after change is

$$l_j = j(z|w, k, \delta)(1 - q)^{\delta-1} q$$

Before Change

It considers parameter α is followed uniform distribution between 0 and 1.

$$t \sim U(0,1)$$

$$g_t(t) \begin{cases} = 1 & \text{for } 0 < t < 1 \\ = 0 & \text{otherwise} \end{cases}$$

Then,

$$d(z|k) = \int_0^1 t^k \theta e^{-(t^k \theta)z} g_t(t) dt = z^{-(k^{-1}+1)} \gamma(k^{-1} + 1, \theta z)$$

In which $\gamma(k^{-1} + 1, \theta z) = \theta z^{k^{-1}+1} \Gamma(k^{-1} + 1) e^{-\theta z} \cdot \sum_{i=0}^{\infty} \Gamma(k^{-1} + 2 + i)^{-1} \theta z^i$

After Change

In the stage of $k \geq \delta$, it is considered

$$j(z|w, k, \delta) = w^{k-\delta} \theta e^{-(w^{k-\delta} \theta)z}$$

In which the parameter w of $j(z|w, k, \delta)$ is followed uniform distribution between 1 and ε .

$$w \sim U(1, \varepsilon)$$

$$g_w(w) \begin{cases} = \frac{1}{\varepsilon - 1} & \text{for } 1 < \varepsilon \\ = 0 & \text{otherwise} \end{cases}$$

Then,

$$\begin{aligned} j(z|k - \delta) &= \int_1^\varepsilon w^{k-\delta} \theta e^{-(w^{k-\delta} \theta)z} g_w(w) dw \\ &= \frac{1}{\varepsilon - 1} z^{-[(k-\delta)^{-1}+1]} \cdot [\gamma((k - \delta)^{-1} + 1, \varepsilon^{k-\delta} \theta z)] \end{aligned}$$

Marginal Density

The marginal density of pro-change is as

$$l_d(z) = d(z|k)(1 - q)^k = z^{-(k^{-1}+1)} \gamma(k^{-1} + 1, \theta z) (1 - q)^k$$

The marginal density of **post-change** is as

$$\begin{aligned} l_j(z) &= j(z|k, \delta)(1 - q)^{\delta-1} q \\ &= \frac{1}{\varepsilon - 1} z^{-[(k-\delta)^{-1}+1]} \cdot [\gamma((k - \delta)^{-1} + 1, \varepsilon^{k-\delta} \theta z)] \\ &\quad \cdot (1 - q)^{\delta-1} q \end{aligned}$$

The Joint Density of Pro-change

In the situation of pro-change,

$$f_{l_a}(x, z) = l_a(z) \cdot f(x) \\ = z^{-(k^{-1}+1)} \gamma(k^{-1} + 1, \theta z) (1 - q)^k \sum_{p=\pi}^1 p^x (1 - P)^{n-x} \frac{1}{1 - \pi}$$

The Joint Density of Post-change

In the situation of post change

$$f_{l_j}(x, z) \\ = l_j(z) \cdot f(x) \\ = \frac{1}{\varepsilon - 1} z^{-[(k-\delta)^{-1}+1]} \cdot [\gamma((k - \delta)^{-1} + 1, \varepsilon^{k-\delta} \theta z)] \\ \cdot (1 - q)^{\delta-1} q \sum_{p=\pi}^1 p^x (1 - P)^{n-x} \frac{1}{1 - \pi}$$

The RESEARCH METHOD

Research Design

This study adopts a quantitative research design to develop and empirically evaluate an extended infection model for meme communication. The research integrates two complementary sources of empirical evidence which are meme database data and survey data. The meme database is used to characterize meme content and estimate the parameters associated with meme dissemination, whereas the survey data are used to estimate the parameters of the advertising memory effect model. The integration of these two data sources enables the proposed framework to represent both the diffusion process of meme communication and the advertising effect generated through consumers' memory of advertising content.

The research procedure consists of four major stages. First, empirical meme data were collected from a Taiwanese meme database and classified according to content-related characteristics and meme styles. Second, survey data were collected to assess the advertising memory effect associated with meme-based

advertising. Third, maximum likelihood estimation (MLE) was employed to estimate the parameters of the advertising memory model and the alternative meme spread-rate models. Finally, the estimated parameters were incorporated into the proposed infection model, and model calibration was conducted to evaluate the correspondence between model predictions and empirical observations.

The Empirical Data

1. Empirical Meme Data

The empirical data is collected to estimate the parameters of the infection model. The data is from meme database in Taiwan during September 1 2020 to April 1 2024. There are 3480 meme but 113 are similar with the original meme which means 3480 meme are small change such as conversation change, text commentary content from the original meme composition. There are four kinds of meme content related factors: relevance, iconicity, humor and spreadability (Malodia et al., 2022). Based on these content related factors four (Malodia et al., 2022), it can use content analysis to categorize meme style into humor, sarcasm, exaggerate and daily life repetition.

2. Survey Data and Measurement of Advertising Effect

The advertising effect component of the proposed model was estimated using survey data derived from the meme database. The purpose of the survey was to identify popular meme content and examine its potential application as advertising-related meme content. Meme styles identified from the empirical database were therefore used as the basis for constructing the advertising-related stimuli examined in the survey.

A total of 1,248 respondents completed the questionnaire. The sample consisted of 637 females and 611 males, and respondents ranged in age from 18 to 32 years. The survey data were used to estimate the probability of successful advertising recall. In the proposed model, advertising memory is operationalized as whether an individual successfully recalls the advertising content. Thus, the observed advertising-memory outcome provides the empirical basis for estimating the parameters of the advertising effect model.

Parameter Estimation

Maximum likelihood estimation (MLE) was employed to estimate the parameters of the proposed models. MLE was selected because the study specifies probability distributions for both advertising recall and meme dissemination,

allowing the unknown model parameters to be estimated by maximizing the likelihood of observing the empirical data under the proposed probability models.

The Model Validation

Following parameter estimation, the estimated parameters were used to construct the proposed infection model and evaluate its empirical performance. To conduct model calibration, two-thirds of the available empirical observations were randomly selected for calibration. A total of 894 observations were used for this calibration procedure.

The predictive performance of the proposed model was evaluated using the root-mean-square deviation (RMSD). RMSD was selected as the model validation measure to quantify the deviation between the values predicted by the proposed infection model and the corresponding observed empirical values. A lower RMSD indicates a smaller discrepancy between predicted and observed values.

Overall, the methodological design establishes a sequential empirical process in which meme content data are used to characterize dissemination patterns, survey data are used to estimate advertising memory effects, MLE is employed to estimate the model parameters, and model calibration is used to assess predictive correspondence. This integrated procedure provides the empirical foundation for extending the infection model from a general analogy of meme contagion to a quantitative framework for examining meme dissemination and advertising effects.

RESULTS

The Results of Parameters Estimation

The empirical analysis provides evidence supporting the applicability of the extended infection model to meme communication and meme-based advertising. The proposed framework integrates two components which are an advertising memory effect model and a meme communication spread-rate model. The advertising memory component represents the probability that an individual successfully recalls advertising content, whereas the infection component represents the dissemination process of memes through communication networks. By integrating these two components, the proposed framework provides a quantitative approach to examining both the diffusion of meme content and its potential advertising effect.

The empirical dataset consisted of meme content collected from a Taiwanese meme database. After excluding 113 memes that were identified as similar to the original memes due to minor modifications, such as changes in dialogue or textual commentary, a total of 3,251 memes remained for analysis. Following the four meme-related factors proposed by Malodia et al. (2022)—relevance, iconicity, humor, and spreadability—the remaining memes were classified according to these four dimensions. The distribution of the memes across the four content-related factors and the corresponding meme styles is presented in Table 1.

Table 1.

The numbers of meme distributions in content related factors and styles

Meme style	Content related factors			
	Relevance	Iconicity	Humor	Spreadability
Humor	225	223	234	275
Sarcasm	112	185	121	156
Exaggerate	183	175	332	245
Daily Life Repetition	234	103	221	227

A total of 1,340 memes were randomly selected from the four meme categories and used to estimate the parameters of the meme spread-rate model. Accordingly, the value of (n) in Table 3 was set to 1,340.

The advertising memory effect was estimated using survey data collected from 1,248 respondents. It is use maximum likelihood estimation (MLE) method to estimate parameters of π , c_0 , c_1 , c_2 , v , u , μ , σ in AD effect model a , b in one step model and k , θ , q , ε in two step model.

The estimated parameters of the advertising memory effect model were $\pi = 1.540$, $c_0 = 1.256$, $c_1 = 0.388$, $c_2 = 2.475$, $v = 0.121$, $u = 1.356$, $\mu = 3.550$, and $\sigma = 1.212$. The results are shown respectively in table 2 to table 4.

Table 2.

The results of parameters estimation in AD effect model

n	π	c_0	c_1	c_2	v	u	μ ,	σ
1248	1.540	1.256	0.388	2.475	0.121	1.356	3.550	1.212

In table 2, these estimates indicate that the proposed model can represent advertising recall as a probabilistic outcome associated with the activation threshold of advertising information in memory. In particular, the inclusion of individual-level factors through the threshold formulation allows the model to account for heterogeneity in advertising memory rather than treating recall probability as identical across all consumers.

Table 3.

The results of parameters estimation in One step model

n	π	a	b
1340	1.545	2.545	2.315

In table3, the one-step infection model estimated the parameters a and b as 2.545 and 2.315, respectively, with the reported estimation based on 1,340 meme content. The one-step model assumes that the meme spread rate can be represented by a single stochastic process with an exponential distribution. This specification provides a relatively parsimonious representation of meme dissemination and is useful when the communication process is assumed to follow a relatively consistent spread pattern.

Table 4.

The results of parameters estimation in Two step model

Before		After	
k	θ	q	ε
1.212	0.334	0.714	0.227

In table 4, the two-step model explicitly incorporates a change point to represent different dissemination dynamics across stages of meme communication. The estimated parameters were $k = 1.212$, $\theta = 0.334$, $q = 0.714$, and $\varepsilon = 0.227$. The incorporation of a change point is theoretically important because meme diffusion may not remain constant throughout its communication process. A meme may initially experience one dissemination pattern and subsequently move into a different stage characterized by another spread dynamic. The two-step specification therefore provides a more flexible representation of temporal variation in meme diffusion.

The Results of Model Validation

Model validation was subsequently conducted using the estimated parameters. According to the research design, two-thirds of the available data were randomly selected for model calibration, resulting in 894 observations being used for the calculation of the root-mean-square deviation (RMSD). The resulting RMSD was 0.817, which was interpreted in the study as indicating a good fit between the predicted values generated by the proposed model and the observed empirical data.

The validation result provides empirical support for the predictive capability of the extended infection model. More importantly, the model demonstrates that meme communication can be examined as a measurable process rather than solely as a qualitative cultural or communication phenomenon. The combination of observed meme dissemination data and advertising memory data makes it possible to connect the diffusion of meme content with a specific advertising-effect indicator. Thus, the proposed framework provides a basis for investigating how the communication dynamics of memes may contribute to advertising effectiveness.

DISCUSSION AND CONCLUSION

This study extends the infection model of meme communication by integrating meme dissemination with advertising memory effects. Previous conceptualizations of memes have emphasized their capacity for imitation, adaptation, replication, and rapid circulation in digital environments. The present study advances this perspective by developing a quantitative framework through which the spread of memes and the advertising effects associated with meme-

based communication can be modeled simultaneously. The study therefore contributes to the emerging effort to quantify meme communication and its implications for marketing practice.

A major contribution of the study is the integration of the advertising memory effect into the infection model. The advertising component is based on the assumption that successful advertising recall depends on the activation of information in memory and that an activation threshold may vary across individuals. This approach enables the advertising effect to be represented probabilistically rather than simply measured as a descriptive frequency of recall. The resulting framework is particularly relevant to meme marketing because meme-based advertising does not depend exclusively on exposure; its effectiveness may also depend on whether the advertising message becomes sufficiently salient to be encoded and subsequently recalled by consumers.

A second contribution concerns the modeling of heterogeneous meme diffusion. The study compares a one-step model, which assumes a single spread-rate process, with a two-step model that introduces a change point. The latter specification recognizes that the diffusion process may change as a meme moves through different stages of communication. This distinction is important because the dissemination of digital content is unlikely to be completely uniform over time. The two-step structure consequently provides a methodological mechanism for representing changes in meme communication dynamics.

The empirical validation further strengthens the contribution of the proposed framework. The RMSD value of 0.817 obtained from 894 observations indicates a good correspondence between the model predictions and the empirical observations according to the validation criterion employed in this study. This result suggests that the proposed infection model has potential as a predictive tool for examining meme dissemination and its associated advertising effects. Nevertheless, the result should be interpreted as evidence of model applicability rather than as evidence that a single mathematical specification can fully explain the complexity of meme communication.

From a managerial perspective, the findings have several implications. First, marketing managers can use the proposed framework as a quantitative reference when evaluating meme-based advertising strategies. Instead of evaluating a meme only through immediate engagement indicators, managers may consider both its potential dissemination rate and its ability to generate advertising memory. Second, the distinction between one-step and two-step dissemination processes suggests that marketers should consider the temporal development of a meme campaign. A communication strategy that is effective during the initial

dissemination stage may not necessarily remain equally effective after the meme enters a subsequent stage. Third, the proposed framework may assist managers in evaluating meme-based advertising according to specific communication objectives, particularly when the objective involves increasing message exposure and advertising recall.

Based on these findings, several recommendations can be proposed for marketing practice. First, organizations should monitor meme dissemination over an extended period rather than evaluating campaign performance solely from short-term engagement. Meme communication is a dynamic process, and changes in dissemination speed may provide meaningful information concerning the development of a campaign. Second, marketers should select or design meme content according to characteristics that facilitate relevance, iconicity, humor, and spreadability, because these dimensions were used in the present study to characterize meme content. Third, meme-based advertising should be designed to maintain a meaningful connection between the original meme format and the advertising message. High dissemination alone may not guarantee advertising effectiveness if consumers remember the meme but fail to associate it with the advertised content. Finally, organizations should consider combining communication-performance indicators with advertising-memory indicators when assessing meme marketing effectiveness.

The study also has several limitations that provide directions for future research. First, the empirical meme data were obtained from a Taiwanese meme database. Therefore, the estimated parameters may reflect characteristics of the Taiwanese digital communication environment and should not automatically be generalized to other cultural or media contexts. Future research could collect comparable meme datasets from multiple countries or regions and examine whether the parameters of the infection model vary across cultural environments.

Second, the advertising effect in the present study is operationalized through advertising memory, particularly whether advertising content is successfully recalled. Although memory is an important indicator of advertising effectiveness, advertising effectiveness is multidimensional and may also include attention, attitude, engagement, intention, behavioral response, and sharing behavior. Future studies could incorporate multiple indicators rather than relying on a single memory-based measure. Such an extension could provide a more comprehensive assessment of the relationship between meme diffusion and advertising effectiveness.

Third, future research could incorporate qualitative data, including interviews, to investigate consumers' subjective responses to meme content. Interview data may

help identify the psychological and contextual mechanisms underlying meme recognition, interpretation, sharing, and advertising recall. Combining qualitative evidence with the quantitative infection model could therefore improve the interpretation of model parameters and provide a richer explanation of why particular memes achieve different levels of dissemination.

Finally, future research should examine meme communication using longer observation periods and more complex dissemination structures. The present two-step model provides an initial mechanism for representing changes in spread rate, but meme communication may involve multiple stages, repeated exposure, network effects, and interactions among different communication channels. Extending the model to accommodate multiple change points or more complex diffusion processes may therefore improve its predictive capability. The framework may also be extended beyond meme marketing to electronic word-of-mouth communication and other forms of digitally mediated consumer communication.

In conclusion, this study demonstrates the feasibility of extending the infection model to quantify meme communication by integrating meme spread rates with advertising memory effects. The empirical results, including the estimated model parameters and the RMSD-based validation, provide initial evidence that the proposed framework can represent and predict important aspects of meme dissemination and advertising effectiveness. The study consequently contributes both a theoretical extension to the quantitative study of memes and a practical framework for evaluating meme-based advertising. Further research involving cross-cultural datasets, multiple advertising-effect indicators, qualitative consumer evidence, and more complex diffusion structures could enhance the robustness and generalizability of the proposed model.

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