Viral Marketing – More than a Buzzword

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The goal of the study is to formalize the concept of viral marketing (VM) as a close derivative of contagion models from epidemiology. The study examines in detail the two common mathematical models of epidemic spread and their marketing implications. The SIR and SEIAR models of infectious disease spread are examined in detail. From this analysis of the epidemiological foundations along with a review of relevant marketing literature, a marketing model of VM is developed. This study demonstrates the key elements that define viral marketing as a formal marketing concept and the distinctive mechanical features that differ from conventional marketing.

INTRODUCTION

Marketers can gain significant advantages by harnessing the willingness of customers to pass along the marketing message at no additional cost to the firm. This potential for rapid and widespread propagation of the message is both attractive and elusive. Do marketers understand the parameters that allow rapid and effective spread of a marketing message through a 'viral' process? Understanding the nature of the spread of disease in a population from the perspective of an epidemiologist should significantly help marketers organize their thoughts on viral marketing campaigns in a more structured and disciplined manner. The theoretical model of viral marketing is presented based on tried and true mathematical underpinnings from the epidemiology literature. Practitioners have widely adopted the term viral marketing. Beyond the current interest in viral marketing, marketing theory has long been relying on epidemiological concepts. For example, Bass (1969) used an epidemic model per Bartlett (1960) as a foundation for his new product diffusion model. Van der Lans, et. al. (2010) also used a viral branching model to explain the electronic word of mouth propagation process.

In more informal contexts, terms from epidemiology, the study of diseases in populations, are often used to explain the viral marketing process. Arguably the most influential of these was Godin (2000) in his presentation of the idea virus. Other marketing practitioners (Lindquist and Sirgy, 2005; Rosen, 2009; Post, 2010; Southgate, et. al., 2010) have used terms such as contagion and infection to explain viral marketing. These concepts are exclusively derived from epidemiology. Understanding VM must start with a clear, useful, rigorous definition. After developing a definition of VM two models of infectious epidemic spread are presented in significant detail. Both the variables in the model and the mathematical interactions of the models should inform VM theory and usage. The two models followed by a discussion of the marketing implications of the models along with a proposed marketing model of VM. Finally, research implications are addressed.

DEFINITION OF VIRAL MARKETING

Viral marketing (VM) is often referred to as being a buzzword. It is, in fact, distinct from earlier marketing concepts that are closely related. It will be worthwhile for marketers to include this term as an accepted academic term with a unique and valuable meaning. For evidence of lack of clear definition, a number of textbook descriptions were examined. In Armstrong and Kotler's (2011) VM is "…the internet version of word of mouth marketing – Web sites, videos, email messages, or other marketing events that are so infectious that customers will want to pass them along to friends". Kerin et. al. (2011) is quite similar in its description. Boon and Kurtz (2011) describes the VM as "…efforts that allow satisfied customers to spread the word about products to other customers". Grewal and Levy (2010) describe VM as a process that encourages pass along among consumers. Pride and Ferrell (2011) include the element "…is a strategy to get consumers to share a marketer's message, often through email or online video, in a way that spreads dramatically and quickly". From the set we see that there is a significant divergence in viewpoints. Is it a process, a strategy or a phenomenon? Is it limited or defined by the medium? Does it require success to be viral, e.g. dramatic and fast spread?

Answering the questions above with reference to epidemiology should help clarify the definition. A definition adopted by the World Health Organization (Last, 2001) includes three key elements, 1.) cases in excess of normal occurrences, 2.) cases occurring over a defined period, 3.) the population must be defined.

In addition the definition implies that a threshold number of cases must be met. Lagorio, et. al. (2008) state "epidemiologists are obliged to define a minimum number of people infected, or threshold to distinguish between a so-called outbreak (a small number of individuals where no large intervention is called for), and an epidemic".

If a marketing effort "goes viral" it is analogous to an epidemic or pandemic in that the marketing message moves through a population by person-to-person transmission in a relatively rapid and self-replicating manner. The medium of transmission is not as an important distinction as whether an epidemic has occurred. This would imply that in marketing the message can be transmitted through an email, a video, a tweet, or a purchase. VM is not limited to any one medium of transmission. Forwarding of email jokes is a typical example, along with sharing of a YouTube™ video. Purchase of a socially noticeable product such as Silly bandz™ among pre-teens would also represent a viral marketing success. Viral marketing existed prior to the introduction of the internet, for example the Pet Rock™ or Hula Hoop™ fads of the last century. It is the distinction of "going viral" that makes the term valuable. Our definition is as follows.

> Viral marketing is a marketer-initiated consumer activity that spreads a marketing message unaltered across a market or segment in a limited time period mimicking an epidemic. Important implications of this definition are centered on the question of what makes an epidemic. An infectious disease epidemic is caused by a virulent pathogen that is self-replicating (the next generation is the same as the prior), has a strong transmission rate, does not cause an immediate die-off of the infected individuals and, finally, includes infection in a significant proportion of a population.

Prior and closely related academic concepts are not minimized or made obsolete by the addition of viral marketing as an accepted marketing term rather than a buzzword. Word of mouth communication (WOM) is a valuable target for marketers to focus upon. Brooks (1957) describes WOM as "networks of interpersonal communications" and Yong (2009) adds to this definition: "among consumers about products and services". WOM can power up a marketing campaign or communicate product attributes well, but it seldom becomes self-replicating. What is generated is a verbal representation of the product experience or the marketing message. Most often WOM acts as a multiplier as an adopter tells a number of contacts of their experiences. Seldom does the contact repeat the message, especially in a complete and accurate form. Diffusion of innovation (DOI) is another area that is not the same as viral marketing yet shares some of the same fundamental mechanics. Typically in a DOI context a product class is introduced and many marketing messages and products follow. The power of WOM to spread acceptance of the product class to the more cautious elements of the population follows the epidemic model to some extent. The aspect of DOI that does not match the viral marketing model is the self-replicating aspect of successful viral campaigns. In addition typically the DOI model does not evolve over a limited time period.

From the trade press, Godin's (2003) purple cow effect is another case that could "go viral". When there is a purple cow effect, a marketer will gain additional awareness and interest. This is not sufficient to consider the introduction of a purple cow product a viral marketing strategy. Some product introductions can be purple cow types of products, gain awareness and interest, yet not "go viral". Still, marketing of these products is significantly powered-up by the uniqueness of the product. The previously mentioned fad (Silly bandz™) products likely would be classified as viral marketing using our definition and be a purple cow at the same time.

Whether a marketing action meets the definition depends on all of the components of the definition being met. The boundary lines are not bight-line distinctions. Thus it is hard to be certain that and introduction like the iPhone™ has "gone viral" based on our definition. If the marketing goal for the roll-out was to gain wide awareness among the potential target market and a typical consumer observing the iPhone™ in use by others creates a replicated message, then this was a clear case of viral marketing. If the goal was purchase/adoption, then the case could be made that penetration of the cell phone market was not deep enough to represent viral marketing. The phone clearly represents Godin's purple cow effect in either case.

The use of the term marketing message may need some clarification. The message may be very specific and require careful replication or the message may be more fundamental. An example of a less specific message would be the communication of the basic uses and value of a product. Thus, the use and value of a Hula Hoop™ is communicated completely once one sees someone playing with one. It can be replicated in full without cognitive effort or specific intent by the user.

Networks or social interaction, electronic or otherwise, are necessary for VM to work. WOM is a good example of this requirement. The advent of electronic media has greatly facilitated VM, but the social network need not be electronic. Good marketing that creates positive WOM success, good electronic social network marketing generating "likes" and some positive WOM would be a success. Alone these are not sufficient. A success of VM requires more. A self-replicating, fast moving, and compelling message is required.

If the definition and the understanding of the epidemiological foundations of VM are to be well understood, the models used by epidemiologists should be examined. The authors will consistently use the example of a message that the marketer wishes to propagate through a fast, consistent, effective and independent spread via a contagion process. The mathematical underpinnings of contagion analysis offer good insights into the variables involved in driving an epidemic. Moving the coefficients of the variables in the marketers favor increases the chances for success in designing and implementing a successful VM campaign.

In the following section, the authors first examine the epidemic model foundations and the applicability of the epidemic model to viral marketing. Then, we will discuss recommendations for future research on modeling viral marketing. Finally, the authors suggest that further epidemiological considerations beyond the elements covered by the specific models below will also enhance our understanding of the VM process.

THEORETICAL FOUNDATION OF VIRAL MARKETING

Examining the epidemic model foundations and the applicability of the epidemic models to viral marketing will help explain the connection between concepts in epidemiology and viral marketing and illustrate the value of the formal use of VM in marketing. The connection between epidemic models and viral marketing literatures has not been fully exploited in many viral marketing articles. The authors choose to examine two prominent epidemic models, Susceptible-Infective-Recovered (SIR) and Susceptible-Exposed-Infective-Asymptomatic-Recovered (SEIAR) model. These are relatively simple models yet offer many insights to help explain a general viral marketing model effectively.

In marketing Du and Kamakura (2011) use an individual level trial hazard model for multiple new products to measure contagion or, in marketing terms, interpersonal influence in examining the new product adoption process. Their study focuses on purchases across a panel of consumers of a grocery chain. The study identified most innovative and influential early adopters through examination of physical location and purchase history contained in a large panel. This study does not easily extend to the broader viral marketing context of social media, email sharing, YouTube™, etc. In comparison with the SIR model, the study simply identifies contagion rather than explaining the mechanisms.

Bass (1969) used underlying epidemic model per Bartlett (1960) as a foundation for his new product diffusion model. This is very similar to the models this research will examine. In a more recent study, van der Lans, et. al. (2010) describes a decision tree for participation in viral marketing campaigns. Their viral branching model (VBM) describes a branching process, using conditional expected probabilities of a stream of events. Allowing for geographic density variability changes the mathematics significantly (Diekmann, et. al., 1995), yielding potentially good predictive ability, but not much insight into the mechanics of the propagation process. We are mainly concerned with maintaining the behavioral connotations of the underlying epidemiological models. The models we propose are intended to cover a wide range of viral marketing situations such as traditional email campaigns, WOM and 'purple cow' marketing. Using the reduced form that assumes special density independence of susceptibles allows for better understanding of the mechanics.

Recent and prior success stories relating to VM and its variants in marketing have attracted attentions of many researchers and marketers. The examples of recent success stories typically focus on the media and modality of transmission such as Groupons™, Facebook™, Youtube™, and Twitter™. These developments have reignited interests in viral marketing. How do we identify the underlying set of interactions that allow a marketing message to 'go viral'? The most likely source of enlightenment would be epidemic models. It appears that the components of the most popular disease transmission model in epidemiology offers many insights and a clear mental model as guidance.

SIR Epidemic Model

In the field of marketing, analysis of a VM campaign has been explained often by a standard epidemic model (c.f., Leskovec, et. al., 2007; Phelps, et. al., 2004; Newman, 2002; Goldenberg, et. al., 2001; Granovetter, 1978). These studies represent additional uses of epidemiological models beyond mentioned above, specifically using or referencing the SIR model in their analysis. While the standard epidemic model explains the process of the viral marketing reasonably well, it also has its limitations in explaining the viral marketing process. The discussion below will cover the details of the SIR model as well as describing VM connections.

The SIR model developed by Kermack and McKendrick (1927) does not require incorporation of vectors or complicated stochastic processes. Thus, the model provides a simple and intuitive approach understanding and modeling viral marketing process using epidemiological view of the communicable disease spread by person to person contact. The susceptibles are individuals who are at risk of catching the disease. In the context of a person-to-person network, the equivalent of the susceptibles is potential consumers who may accept the message or utilize an offering from a firm. Marketers would call this group the target audience or the target market. In SIR model, the infectives have the disease and can transmit it to susceptibles. The equivalent of the infectives in VM is individuals who may pass on a message or conspicuously use a unique product. In SIR model, the recovered are individuals who have had the disease, but have recovered and can no longer transmit it. The marketing equivalent of the recovered is the individuals who has forgotten or are not interested in passing the message. For some of the infectious diseases, the recovered are always immune, for the other diseases, they can be re-infected. In VM context, this population can be potentially moved back into the susceptible group through creative marketing or social forces.

The following describes dynamics of the epidemic model. Assuming the total size of the population (N) is fixed, the accounting identity of these groups is:

$$N = S_t + I_t + R_t, \tag{1}$$

where S_t represents the susceptibles at time t, I_t the infectives at time t, and R_t the recovered at time t.

Initial conditions are:

$$S_0 = N - I_0 > 0, \tag{2}$$

where $S_0 > 0$, $I_0 > 0$ and $R_0 = 0$.

In SIR model, the number of infections among the susceptible population in a period of time depends on the rate at which the susceptibles contact the infectives and the transmissibility of the disease given contact. The most common assumptions used to describe this process are:

- The contact rate among individuals per period of time (δ) is fixed.
- Contacts among individuals are random and the probability (τ) that a contact between a susceptible and an infective resulting in transmission of the disease is constant during an epidemic.

With a constant δ, the reduction in the number of the susceptibles due to infection is proportional to the number of contacts. Also since contacts among members of the population are random, the number of contacts between the susceptibles and the infectives per period will be given by $\delta * S_t (\frac{I_t}{N})$.

With the constant probability (τ) of a contact between a susceptible and an infective resulting in disease transmission, the reduction in the number of the susceptibles due to infection per period is given by:

$$\frac{dS}{dt} = -\delta\tau \frac{S_t I_t}{N} = -\beta \frac{S_t I_t}{N}, \tag{3}$$

where $\beta = \delta\tau$ is called the infectivity parameter (see Sohn, 2007; Boulier, et. al., 2007).

The change in infectives will be given:

$$\frac{dI}{dt} = \delta\tau \frac{S_t I_t}{N} - \gamma I(t) = \beta \frac{S_t I_t}{N} - \gamma I_t, \tag{4}$$

where γ is the recovery(or removal) rate, a constant exit rate.

The change in the size of the recovered is given by:

$$\frac{dR}{dt} = \gamma I_t. \tag{5}$$

Consider equation (4) at the start of the outbreak:

$$[\frac{dI}{dt}]_{t=0} = \beta \frac{S_0 I_0}{N} - \gamma I_0. \tag{6}$$

In the epidemiology literature, an epidemic is defined as a situation in which the number of the infective increases beyond the number initially infected. In the marketing context, it would be a situation where a person-to-person network generates successful momentum for the marketer so the marketing message is broadly received by the target market consumers. From (6), whether $[\frac{dI}{dt}]_{t=0}$ is positive (the epidemic case), zero, or negative depends on

$$S_0 \frac{>}{<} \frac{\gamma N}{\beta} = \frac{N}{\sigma}, \tag{7}$$

where σ is called the "contact number" (Hethcote, 2000).

If $S_0 < N/\sigma$, then the number of the infectives declines from the very start and there is no epidemic. In the marketing context, the VM message transmission dies off rather quickly. Thus, equation (7) implies that there is a critical value of S_0, below which an epidemic does not start. If $S_0 > N/\sigma$, then an epidemic can start and the number of infectives initially increases until the susceptible population reaches $S_t = N/\sigma$. In the marketing context, it is equivalent to the communication reaching the majority of intended target market customers. In SIR model, the number of the infectives starts to decline at this point. After the disease stops spreading, it can be shown that the number of the susceptibles, S_∞, equals the number of the uninfected. The number of the never-infected, S_∞, among the unvaccinated must be less than N/σ, since it continues to rise and S_t continues to decline as long as $S_t > N/\sigma$. We show that

$$S_\infty = S_0 \, e^{-R_\infty \sigma / N}, \tag{8}$$

where R_∞ is the number of ever-infected. Since R_∞ equals $S_0 + I_0 - S_\infty$ and is the positive root of the transcendental equation,

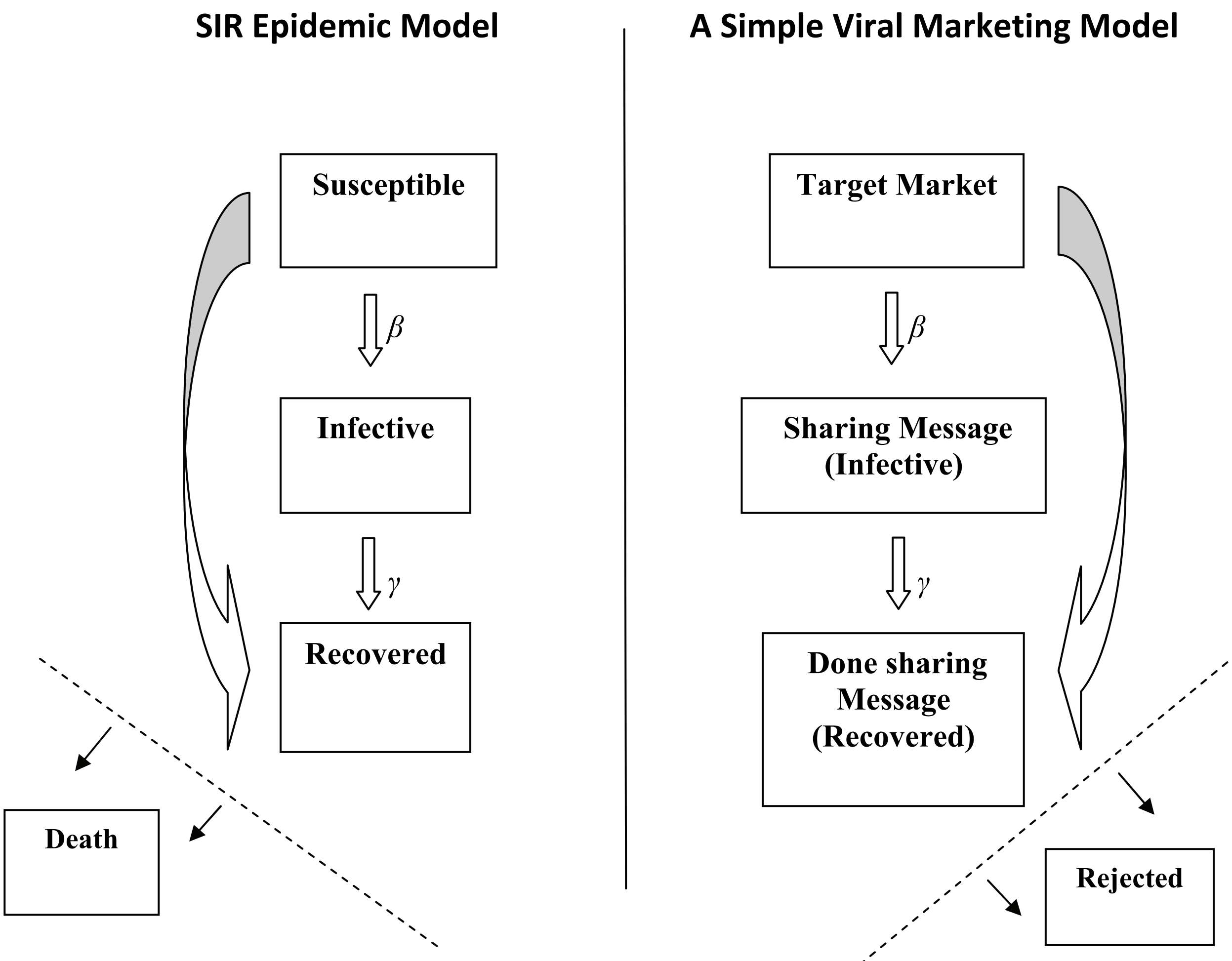
$$S_0 + I_0 - R_\infty = S_0 \, e^{-R_\infty \sigma / N}. \tag{9}$$

By dividing both sides of equation (9) by N, the equation becomes

$$s_0 + i_0 - r_\infty = s_0 \, e^{-r_\infty \sigma}, \tag{10}$$

where both sides of the equation equal the proportion of the never-infected (s_∞) (Murray, 1989). The marketing equivalent of this group is the proportion of the target market that has never been exposed to the marketing message. The portion of the target market that has never been reached will be smaller as the size of the infectivity parameter gets bigger. On the other hand, the proportion of the target market that has received the marketing message will be bigger as the infectivity parameter, β, becomes smaller. The SIR model and a simple viral marketing model are presented below.

FIGURE 1
A COMPARISON DIAGRAM OF SIMPLE COMPARTMENTAL MODELS



To clarify the model in Figure 1– each parameter will be examined in turn, starting on the epidemiology side. In SIR model, when a susceptible individual has a contact with an infective individual, the susceptible individual immediately becomes an infective individual with the probability of beta. On the other hand, with the probability of one minus beta, some of the individuals who have contacted an infective do not become an infective. After the contact, the infected individual starts to spread the disease to the susceptibles on random contacts, with the probability of beta, some of the contacted susceptibles become infectives, and the disease-spread process can be repeated multiple times afterwards. After certain time period, the infective who had been spreading the disease recovers from the disease and becomes no longer infectious (or dies from the disease). If the disease is infectious enough and the recovery rate is sufficiently slow enough, while the initial infective exits the infectious stage, the newly infected individual(s) will spread the disease again.

The gamma in the model is the rate at which the infective becomes a recovered. How long an infective continues to be infectious depends on the gamma parameter. If the exit (recovery) rate is high, the infective recovers rather quickly. Also note that deaths can occur from any stages in the process, but given death, the infective becomes no longer infectious (becomes a removed).

If a pathogen is highly virulent (given an optimal combination of contact rate and transmissibility, and exit rate, etc.), the disease will spread and infect a large number of people in a community, eventually causing an epidemic or a pandemic. The key to understanding the ability of a disease to cause an epidemic is driven by contact rate and transmissibility and moderated by the exit rate. Some models incorporate mutation rate of the pathogen as an important limiter or igniter of epidemics. This is not mathematically treated in our model, but should be considered in the overall understanding of epidemics.

On the other side of the model a parallel simplified depiction of the viral marketing process is offered. A marketer typically defines target market and thus a susceptible population for the message is subsequently defined. As potential customers are exposed to the marketing message either directly from the marketer or from a member of the target market who was previously exposed, with the probability of beta, the individuals reached become infectives by accepting the message. The infectives start to spread the message again to other target market customers/consumers while some may choose not to spread the message through social contacts. As time progresses, some of the infectives become removed from the infectives due to such effects as exhausting their email lists, forgetting, attention being diverted, or other exogenous process. Some may move to the rejected category if they no longer wish to spread the message or received negative feedback. The recovered may still have a positive view of the message while the rejected do not. The main purpose of the viral marketing campaign is creating a message that will spread based on the parallel processes seen in epidemic. The spread must be wide enough within the target market to meet the marketer's goal for the message. For instance, if the marketing goal is 60% awareness of a new product throughout the target market, then reaching that threshold through self replication of the message reaches epidemic proportions. When the message has optimal virulence and consistent high repetition rate, the message will go viral and the campaign becomes a success.

Interpretation of SIR Model in Marketing

In this section, we discuss the interpretation of SIR model in marketing context. From the equation (1), S_t (the susceptibles at time t) is closely equivalent to the target market or segment, I_t (the infectives at time t) is analogous to the set of individuals who are sharing the message or the sneezers according to Godin (2001) and R_t (the removed at time t) are the individuals who are done sharing (or not interested in) the message. Those outside the target market are not considered, in the epidemiology model they would be equivalent to a population who are not capable of contracting the disease. The equation (1) shows an accounting identity: sum of the S_t, I_t, and R_t equals the total population (N) or the entire target market in marketing. Following SIR model, if $S_0 > N/\sigma$ or $s_0 > 1/\sigma$ in VM, then the propagation of the marketing message can take off or the marketing campaign goes viral. If the proportion of the target consumers is large and the marketing message is powerful as well as easily transmissible enough, i.e., if the combined effects meets the threshold criteria of the message propagation, then the marketing message will spread. On the other hand, if $S_0 < N/\sigma$ or $s_0 < 1/\sigma$, the proportion of the target population is less than the inverse of the contact number with the combined effects of weak/costly transmissible message, then the number of the infectives declines from the very start; the transmission dies off rather quickly and the marketing message will not "go viral". Note that in this simple model, we do not assume a possibility of reintroduction of the marketing campaign although it is possible in practice. Thus, equation (7) implies that there is a critical value of S_0, above which the propagation of transmission does take off. In marketing practice however, there typically will be a new wave of marketing communication available which makes S_t bigger at some specific time. An alternative approach of modeling this example would be incorporating multiple independent introductions of infection in the model. The main idea of the simple epidemic model for VM is that if the message is compelling, fast moving, self-replicating, and easy to transmit, the message will more likely to spread. Thus the standard epidemic model is succinct enough to provide reasonable understanding of disease spread; it requires some modifications and special assumptions for the managerial application to viral marketing. The considerations for the epidemic model modification for the managerial application in marketing will be discussed in later sections. In the following section, the authors discuss an expanded epidemic model with more complicated disease propagation processes.

SEIAR Epidemic Model

While the SIR model offers a simple view and insights of an epidemic's propagation process, a more comprehensive view of the communicable disease spread may offer additional insights into the viral marketing process. An expanded epidemic model, the Susceptible-Exposed-Infective-Asymptomatic-Recovered (SEIAR) model, is reached by relaxing and introducing certain assumptions to reflect more comprehensive view of the disease communication process. For example of an influenza epidemic, there is an incubation/latent period of approximately 1.9 days before the individual shows symptoms and becomes fully infectious (Hethcote, 2000). Even after the incubation period, some infectives show symptoms yet others do not. Following SEIAR model (Sohn and Boulier, 2012; Chowell, et. al., 2006), the population is divided into four groups: the susceptibles, the infectives, the exposed, and the recovered. Susceptibles (*S*) are individuals who are at risk of catching the disease. The exposed (*E*) are individuals who have been infected but are not yet infectious, in marketing, individuals received a marketing communication from peers or the marketer, yet, are not currently passing it on to others. The infectives have the disease and can transmit it. This group is further divided into two groups – the fully infectious (*I*) and asymptomatics (*A*). In marketing, the infectives are a group of people who are actively passing it on to others. The asymptomatics are the individuals who accepted the message but not passing it on to others. The recovered (*R*) are individuals who had the disease, but have recovered and can no longer transmit the disease. In marketing, these are individuals who may have forgotten the message now reject the message. D_t represents the number of deceased at time t. In marketing, these are people who have ultimately rejected the message at any given time t.

The total size of the population at time t equals the sum of these groups:

$$N_t = S_t + E_t + I_t + A_t + R_t + D_t. \tag{11}$$

Initial conditions are:

$$S_0 = N_0 - E_0 - I_0 - A_0 - R_0 - D_0 > 0, \tag{12}$$

where $S_0 > 0, E_0 > 0, I_0 = 0, A_0 = 0, R_0 = 0$ and $D_0 = 0.$

As in SIR model, the number of infections among the susceptible population in a period of time depends on the constant contact rate (δ) at given period and the transmissibility (τ) of the disease given contact. After contact, some proportion of the susceptibles becomes exposed after incubation period.

This model assumes also that the probability that an asymptomatic individual transmits the disease is a fraction (q) of the probability that a fully infectious individual transmits the disease. Thus the reduction in the number of the susceptibles per period is given by:

$$\frac{dS}{dt} = -\delta\tau \frac{S_t[I_t + qA_t]}{N_t} = -\beta \frac{S_t[I_t + qA_t]}{N_t}, \tag{13}$$

where β is also the infectivity parameter (Sohn and Boulier, 2012).

The number of exposed is:

$$\frac{dE}{dt} = \beta \frac{S_t[I_t + qA_t]}{N_t} - \alpha E_t, \tag{14}$$

where α is the rate at which the exposed become infectious.

The number of individuals who are fully infectious depends upon the following:

$$\frac{dI}{dt} = \rho\alpha E_t - (\gamma + \pi) I_t \,, \tag{15}$$

where γ is the recovery rate and π is the mortality rate among the fully infectious.

Asymptomatics are the remainder of individuals who convert from exposed to infectious and the change in asymptomatics is:

$$\frac{dA}{dt} = (1 - \rho)\alpha E_t - \gamma A_t. \tag{16}$$

Also, the change in the size of the removed population is given by:

$$\frac{dR}{dt} = \gamma[I_t + A_t]. \tag{17}$$

Finally, the change in the number of those who have died D_t is given by:

$$\frac{dD}{dt} = \pi I_t \,, \tag{18}$$

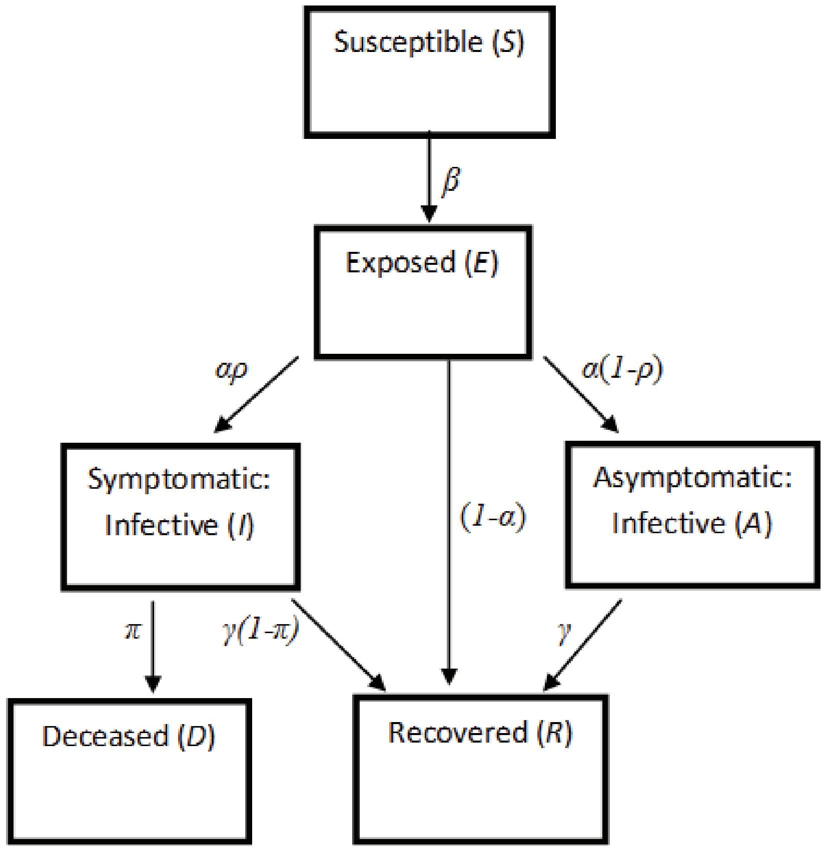
where π is the mortality rate among the infectives.

Figure 2 illustrates compartmental diagram of SEIAR model. Below is a summary of the variables in the two epidemiological models and a graphic depiction of the SEIAR model.

TABLE 1
SUMMARY OF THE VARIABLES USED IN EPIDEMIC MODELS

Epidemiology Terminology	Variable	Meaning
SIR Model Parameters		
Contact rate	*Delta* (δ)	the rate of contact among individuals per period of time
Transmissibility	*Tau* (τ)	the probability that a contact between a susceptible and an infective resulting in transmission of the disease
Exit rate (or recovery rate)	*Gamma* (γ)	the constant removal rate for exiting the infectious state
Infectivity parameter	*Beta*(β) ($\beta=\delta*\tau$)	the infectivity of the disease or contact rate times transmissibility
Contact number	*Sigma* (σ) ($\sigma=\beta/\gamma$)	a measure of virulence of the disease (only in a deterministic SIR model), or infectivity divided by exit rate
Additional SEIAR Model Parameters		
Mortality rate	*Phi* (π)	the mortality rate among the infectives
Rate of exposed becoming infectious	*Alpha* (α)	the rate at which the exposed become infectious
Fraction of exposed becoming an infective	*Rho* (ρ)	the fraction of the exposed who shows disease symptoms and fully infectious
Fractional probability of asymptomatic person transmits the disease	*q*	the reduced probability that an asymptomatic individual transmits the disease as oppose to a fully infectious individual transmitting the disease

FIGURE 2
SEIAR COMPARTMENTAL MODEL DIAGRAM



Discussion of Assumptions

It is worthwhile to consider the common assumptions of SIR and SEIAR models and their applicability to viral marketing. These models do not assume variability of spatial density of susceptibles. The inclusion of the geographic dispersion information in a marketing model and social networking virtual geography are beyond the scope of this paper.

(1) Homogeneous population.

The SIR model assumes that individuals are homogeneous with respect to their susceptibility of catching the disease. Literature in the viral marketing field suggests that there is considerable heterogeneity existing in the population (Palka, et. al., 2009, Leskovec, et. al., 2007). For example, some consumers are more prone to accept a message from peers than are others.

(2) Contact rate (δ) and the transmissibility given contact (τ) are fixed. This implies β, the infectivity parameter, is fixed.

This particular aspect of the theory has been criticized by some modelers (Philipson, 1996). In the marketing field, the authors use the same offering for marketing message, and Leskovec, et. al. (2007) show the quality of WOM (whether the sharing individual is trustworthy or not) has major influence on the success in the decisions of the potential buyers.

The authors also argue that infectivity parameter may not be fixed across markets/regions or over time on a single market/region for the following reasons.

a. Originally, Kermack and McKendrick (1927) assumed that the contact rate depends on the size of population. In the marketing context, the contact rate may vary depending on the characteristics of the medium. The probability of spreading a Groupon™ would be different than the probability of sharing a YouTube™ video reference. In addition, the contact rate would likely vary across consumers. An individual who has a large social network on Facebook™ likely has a higher number of social contacts per day than a casual user.
b. Transmissibility given contact (τ) can vary for the following reasons:
    - Infectivity varies with effort involved in passing the message along. In the online world some items are easier to transmit and some media have features that facilitate transmission. Becoming a fan is an example of an easier transmission vehicle.
    - Transmissibility can vary if susceptibles have differential susceptibility to disease. The perception of novelty of the message will quite likely vary across the target audience. Similarly, saliency will similarly vary across consumers. Novelty would imply that β would decline over the course of marketing campaign. Saliency would simply add a stochastic element to β.

(3) Constant removal rate for the exiting infectious state.

When an individual is infected by a disease, the person will eventually recover or die from the disease, thus, exiting the infectious state. In marketing, the individual passing the message to others does not have to stop sharing the message after any set period. However, one may generally assume the frequency and speed of sharing by the passing individual will be considerably reduced after certain time period in the VM context.

(4) Infectious period is fixed and individuals who recover from the disease become no longer infectious.

For most diseases in an outbreak, there will be at least a reasonable period of immunity to the disease once recovered. In the marketing context individuals can be reintroduced to the message successfully with creative marketing.

To summarize, the assumptions of SEIAR model are restrictive for both epidemiological and marketing use. In spite of these restrictive assumptions, the face validity of the variables and the historic usefulness in modeling actual epidemics indicates that the model should be useful for a marketer's mental model of VM. All of the assumptions of the model do not map to the marketing context, however.

A VIRAL MARKETING MODEL

Viral Marketing - A Cognitive Process

The major distinction between the epidemiologic models and viral marketing process is that the epidemic models rely on the mechanical process of a disease spread by an infective. In other words, whether she/he wishes to spread the disease or not, the infective will spread the disease strictly due to contact. In the marketing context, if the exposed do not wish to share the marketing message to others, the message will not spread. It appears that a model for VM should be a close variation of either or both of the epidemiological models discussed above. Table 2 connects the epidemiological variables and terms to potential marketing managerial actions.

TABLE 2
MANAGERIAL IMPLICATIONS OF EPIDEMIC MODELS

Epidemic Model Variable or Parameter	Managerial Application	Under Marketing Control	Exogenous (not under marketing control)	Model Assumption Consideration
Infective (I_0)	Initial number of consumers who spreads the message (e.g., early adopters)	Direct communication of the marketing message to a lager initial propagation group	Timing of receipt, acceptance of message, entry or exit from target market	Not all infectives are equally infectious with the same probability
Susceptible (S_0)	Target market	Choosing the right target market, understanding target market, considering multiple segments	Difficult to precisely identify this group, often no clear boundary lines exist	Not all susceptibles are equally susceptible with the same probability; use model with different age groups, etc.
Removed (R_0)	Consumers who have rejected the message	Moving this group of people back into a susceptible group using marketing actions, e.g. reminder messages	Difficulty in identifying this group and the causes for rejection	Not a permanent and fixed category in practice, network externalities not included in SIR model
Infective (I_t)	Number of consumers giving message to others at any given time after launch	Repetitive marketing can maintain or increase this number, this is a different group from the initial propagating group	Beyond marketing control potentially creating excessive demand?	Not all infectives are equally infectious with the same probability
Susceptible (S_t)	Uninfected target market at any given time after launch	Only the initial definition of the target market	The group can change due to externalities, e.g. new consumers enter the relevant market	Model susceptible with different susceptibility
Removed (R_t)	Number of consumers who have considered the message and rejected it at any given time after launch	Delaying rejection by additional messages from network and/or reminder messages Additionally, conducting marketing research to understand rejection	Spontaneous generation of negative WOM given possible bad experiences, etc.	Not a permanent and fixed category in practice, network externalities not included in SIR model

Transmissibility (τ)	The probability accepting the message such that the recipient is willing to pass it along	Quality of the message 1. Cost 2. Effort 3. Value 4. Affection/ humor/etc. 5. Etc.	Environmental shifts such as cultural, fashion or consumer trends, etc.	Transmissibility can vary depending on target market and time, etc.
Contact rate (σ)	Number of contacts per day on average per person	Generally no control beyond on-line social network choice	Environmental shifts such as popularity and commitment to social networks	Constant contact rate may not be appropriate in marketing context
Infectivity parameter (β)	infectiousness of disease: multiplication of τ and δ	No direct control	See above	
Removal rate (γ)	The rate of individual ceasing to propagate the message	Memorability of the message, salience of the message, uniqueness of the message, etc.	Competing messages in the category increase the rate or reinforcements decrease the rate	Non-constant removal rate
Fixed infectious period	Limited time period the individual is propagating the message	Reminders may lengthen this period	Competing messages can shorten this period	Not constant, can be altered in practice
Infection by Asymptomatics or Symptomatics while they are unaware Disease vectors can be considered however these are not SIR or SEIAR model variables	Public consumption of exceptionally unique products aka "Purple cow" effect	No direct control of exposure, however uniqueness and perceptibility of the product can be influenced by marketing decisions	Context of usage of the product by the consumer	Not considered in the model, but vectors of disease is an epidemiological construct
Exposed (E_0)	Initial number of consumers exposed to the message	Direct communication of the marketing message to a lager initial group of target consumers	Timing of receipt, acceptance of message, entry or exit from target market	
Exposed (E_t)	Number of consumers exposed to the message at any given time after launch	Multiple introductions/ re-introductions of the message increase the size of the exposed consumers	Timing of receipt, acceptance of message, entry or exit from target market	
Asymptomatic (A_0)	Initial number of consumers exposed to the message yet are not sharing message with others	Influence the ease of sharing, salience, social pressure/rewards, etc.	Difficult to precisely identify this group, often no clear boundary lines exist	

Asymptomatic (A_t)	Number of consumers exposed to the message yet are not sharing message with others at any given time after launch	No direct control, but receipt of the message from a social contact may influence the individual's propagation behavior	Difficult to precisely identify this group	
Mortality rate (π)	The rate of individuals rejecting the message	Limited understanding of the target market interacting with the quality of the message	Competing messages or inundation of messages in the category may increase the rate	
A Rate of exposed becoming infectious (α)	The rate of exposed individual accepting the message	Increased understanding of the target market interacting with the quality of the message	External distracting events, either individual or broad based	
A Fraction of the exposed becoming an infective (ρ)	The rate of exposed individual becoming a message propagator	Queues to propagate imbedded in the message, medium's ease of use, etc.	As above	

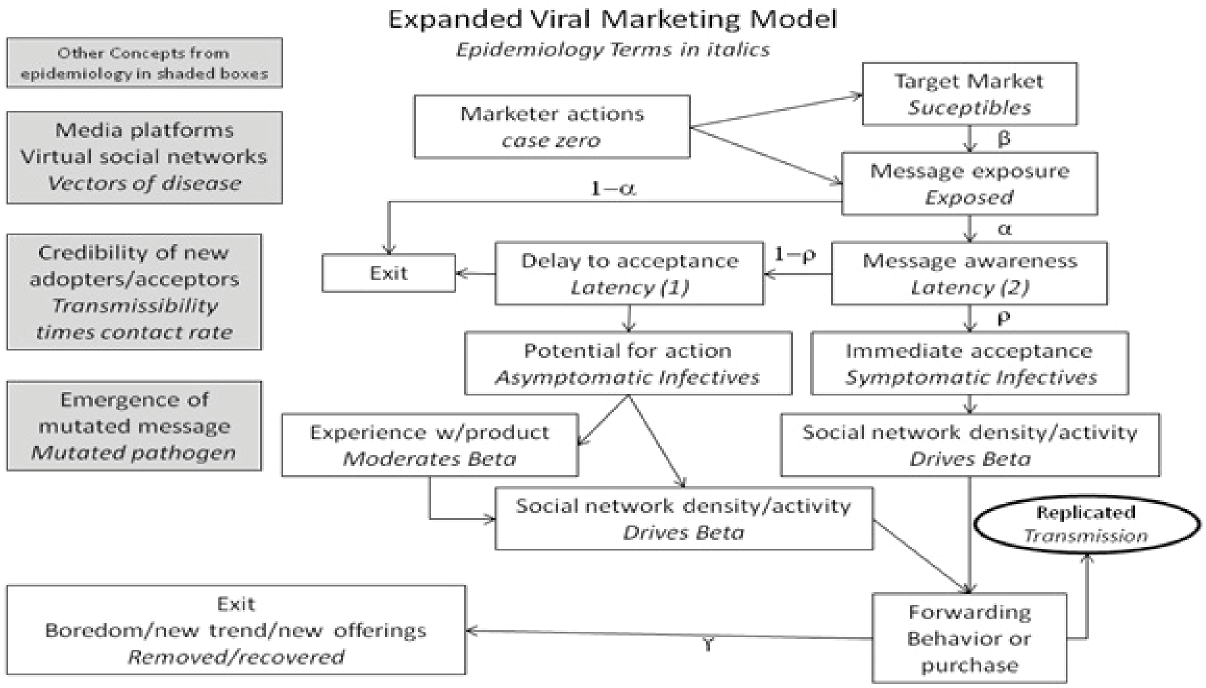
Viral Marketing Model

The model below is an amalgam of the two epidemiological models along with the marketing considerations that were addressed.

The expanded VM model connects the parameters from the epidemiological models. The marketer selects the target market and exposes a portion of the target to a message that they hope will become an epidemic within their target market. In the case of a planned VM campaign, the marketer is case zero, the first infected party. The exposed target member may or may not become sufficiently aware of the message to be able to transmit it; therefore acceptance may be immediate or it may have a delay. With some external reinforcement or reminder the individual may yet accept the message and be primed to potentially transmit it. The likelihood of replicating the message is then influenced by the individual's experience with the product or firm and the density or frequency of activity of the individual's social network. This simplifies the social network dynamics notably from treatments focused on the interactions within social networks (cf. Ansari, et. al., 2011; van den Bulte, 2007) but is sufficient for examining the general application of epidemiological models in marketing. The prime requirement for marketers employing a VM strategy is to achieve accurate, frequent and targeted replication of the message. Exposed consumers will eventually stop replicating the message due to exhausting their network, forgetting, or other causes. They will then be among the removed population. If the epidemiological parameters reach a critical level, the spread of the message will meet the requirements of an epidemic. The message will spread to a large number of target market members in a short period of time in an accurate form that can be replicated.

Three considerations from epidemiology that are not in the two models may be worth noting. In the grey boxes in the VM model are three epidemiology concepts that should be kept in mind. The first is the concept of vectors of disease. Malaria is carried by mosquitoes while marketing messages may be carried by social networks like Facebook™, video platforms like YouTube™, etc. Second, credibility of the source may strongly drive transmissibility. This is well documented in the WOM literature (see Trusov, et. al. (2009) for a review of WOM marketing from an internet social networking site).

FIGURE 3
AN EXPANDED VIRAL MARKETING MODEL



Finally, the concept of mutation rate should be considered. If the transmission medium is WOM, the mutation rate will be very high; if the medium is YouTube™, the message should have a much lower mutation rate. It will not be zero, however. Individuals may make parodies, dub over alternative sound, overlay images, etc.

The VM model is offered as a mental model of the process and is most valuable as a general guide to translating the epidemiological understanding disease transmission into the VM process. The model offers a guide to how each parameter of the epidemiological models enters and therefore where the marketer can influence the likelihood of generating an epidemic, getting the message to "go viral".

The expanded model above and the discussion of epidemiology offer a starting point for additional work in the marketing discipline. In addition some central managerial implications fall out of the discussion and model.

RESEARCH DEVELOPMENT IMPLICATIONS

Marketing scholars may wish to pursue some specific implications from the above discussion. Here are eight potential areas of inquiry.

1. **Seeding strategy(planting a larger group of infectives to generate successful results)**
   Epidemics can have a case zero; however in marketing context, case zero is the marketer and the first round of contact. It is often under direct control. The mass simultaneous exposure is typical for the first set of target market members. Also having an effective set of early infectives should expedite propagation. The SIR model reflects a static population response as epidemic progresses. Thus, the math does not change as long as the analysis is focused on the time frame subsequent to case zero's direct contacts. This is a testable proposition. Rosen (2009) addresses some of these

issues but more is possible. Hinz, et. al. (2011) investigate optimal seeding strategy of specific viral marketing campaigns in both simulated and real VM contexts.

2. **Social network effects and peer feedback (launching a campaign to an effective group of people to generate successful results)**
   Tighter on-line social networks may be analogous to dense populations in an epidemic. In the SIR model, β would then be larger due to higher contact rate and higher transmissibility. The exit rate, gamma, component could be smaller if there was positive feedback as 'friends' respond to the forwarding or posting of the message. The net effect is a high virulence of the message due to each individual parameter's role. Hinz, et. al. (2011) study addresses some of these effective seeding strategies of viral marketing using different degree nodes. Although the seeding strategy study provided valuable data, sorting out the epidemiological variables for testing should be possible and provide rigors for the viral marketing framework.
3. **Reliability of the potential viral message**
   An important element of transmissibility is the confidence in the sender's reliability and integrity (Morgan and Hunt, 1994). Berger and Milkman (2012) study transmission of viral online contents in a news paper setting. Additional work in this area which separates this from contact rate and removal rate could be worthwhile to fully understand virulence. So far, current body of literatures on VM does not address issues of viral marketing when the message itself is not sufficiently 'viral'.
   Social conditions influence the context of how and why a message is received. A message will be more successfully forwarded if it adheres and facilitates to the interests of the receiver. Tie strength between the original receiver and the pass-along receiver influences the likelihood of forwarding. The stronger the tie between the two, the greater the chance of forwarding. When consumers have positive consumption experience, the consumer feels a need to share this and will forward the information (Palka, et. al., 2009). In terms of the epidemiological model the contact rate is an interaction of density and this idea of tie strength. This offers another avenue of exploration.
4. **Reliability of the potential viral message replication**
   Marketers may want to measure mutation rates for various vectors or media of transmission. The ability of the message to mutate in a text context is not the same as for a video context. How does this change the ability of a VM campaign to succeed?
5. **Cost of the sharing matters**
   A potential area of research interest is the total cost of transmission. As cost of adoption rises, the probability of transmission will drop. The cost could include dollars, time, perceived social risk to the individual, and cognitive effort. The lower the costs of forwarding the message, the higher would be Tau, transmissibility.
6. **Reducing removal rate – sustaining replication by the target market members**
   There are a few possibilities here.
   - A marketer may reduce the exit (removal) rate, gamma, by using reminders to the infectives to encourage additional sharing of the message.
   - An increase of salience to the target market should also reduce the removal rate.
   - A viral video exposure represents opportunities for deeper brand engagement, replaying of the information, and forwarding (Southgate, et. al., 2010). Southgate, et. al. (2010) also observed that brand is not as important as the creativeness of the message. Additionally, Watts and Peretti (2007) found that the propagation rate relates to the creative mechanisms; the better the creative mechanisms, the more likelihood the message will be shared.
     These should be testable or extendable.
7. **Consideration of counterproductive incentives**
   There is a possible saturation effect as contacts react negatively. This may increase the removal rate, gamma, for infectives as they receive negative feedback from peers. Also, the competitors may be actively working against a firm's viral campaign. They may offer substitute messages or

parody the firm's message. In either case, the removal rate would be increased. These are potentially testable.

8. **Market conditions, speed and timing of the introduction matters**
   The SIR model does not work in a vacuum. For instance, a flu case may not bloom into an epidemic if it occurs at the wrong time of year. For a marketer, if there is a strong environmental distraction an otherwise successful viral marketing launch may fail. Under what contextual situations does the VM model fail?
9. **Hierarchy model**
   Viral marketing campaigns can be targeted to any stage of the hierarchy of effects model. Awareness is a typical goal of a viral campaign. However, other stages can be targeted as well. Purchase can be enhanced by a viral campaign centered on a strong viral coupon-oriented campaign. Do the various stages have stronger or weaker potential for VM success?
   Note that the hierarchy of effects model can be used by the marketer to develop the appropriate message. The first model developed in the 1890s, and still in use, indicates the message must be exciting enough to win notice and draw the receiver in which will be lead to interest, desire and action/motivation. The second model developed by Lavidge and Steiner indicates if communication achieves consumer acceptance it becomes a viable option and will more likely be passed along. These two models indicate that if a marketer develops the correct message for the receiver, the message has a significant chance of being a contagion and passed on (Lindquist and Sirgy, 2005).

DISCUSSION

The epidemiological model offers a solid foundation and a number of good insights for understanding VM. Table 2 and Figure 3 offer some conceptual guidance for practitioners. However, there are a number of limitations that need to be considered.

(1) The SIR and SEIAR models assume that the probability of transmission in independent of geographical or special proximity of individuals. In an electronic world the "space" is not driven by physical distance. This may be a limitation if the virtual space is not uniform.
(2) Although infectious period is fixed in the epidemic models, the assumption may not be reasonable in the viral marketing context.
(3) The model does not identify takeoff threshold values directly. Many empirical studies would likely be necessary to quantify threshold values for epidemic spread to occur.
(4) These epidemiological models suffer from the fate of all mathematical models. When modeling, one must consider omitted variables. For marketers there are many variables within their control, so omitted variables are typically a problem for model specification.

While viral marketing has been used often in marketing, it has seldom been rigorously defined with a strong basis in epidemiology. Understanding the epidemiological roots of the concept offers more structure and strength to the understanding of VM.

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