The Effectiveness of Online Video Marketing on Facebook Using Susceptible-Infected-Recovered (SIR) Mode

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HIGHLIGHTS

- SIR models are not only being used in measuring the spread of contagious diseases but it also can be used to measure the virality of online marketing.
- The value of initial reproduction number , $R_0 > 1$, is the determinant for the virality of certain promotion.
- Based on the values of R_0 , there is not much different in the conclusion drawn from SIR with demography and SIR without demography.
- Based on the graphs obtained, the promotion of shawl with $R_0 > 1$ shows very fast virality and disseminated to a lot more Facebook users in a shorter time compared to the promotion of slimming product.

ABSTRACT

The advancements in technology and high-speed networks give advantages for entrepreneurs to promote their products and services in various forms of posting through social media platforms such as Facebook, Twitter, Instagram and many more. The effectiveness of the video posting in terms of the virality of the video, the time the video reaches the maximum number of viewers, and the flow of video spread are very important inputs for the marketers. Therefore, this preliminary study was designed to differentiate the effectiveness of two selected video posting on Facebook promoting two different popular products among women: shawls and slimming product. Susceptible-Infected-Recovered (SIR) models with demography and without demography was used in analysing the data since the nature of the dissemination of the video is similar to the spread of virus. The variables used in the analysis were the number of Facebook users who exposed to the video (Susceptible), received and shared the video (Infected) and stop sharing the video (Recovered). The finding shows the video promoting the shawl is more viral ($R_0 > 1$) as compared to the video promoting the slimming product ($R_0 < 1$) based on both SIR Model. Although the earliest number of users who received the shawl video was lower but the number of users who received and shared that videos increased tremendously until it reached the maximum number of 19.6 million viewers in 2 days and after that the number was slowly decreased. For slimming product, it started with higher number of viewers, but reached the maximum number of viewers of 10.3 million in 8 days and later the number was gradually decreased. Further study should be done because there are a lot of possibilities or factors that contribute to these findings.

Keywords: *Facebook; Online Marketing Video; Reproduction Number; SIR Model; Social Media Networks*

INTRODUCTION

Social media platform such as Facebook, Twitter and Instagram have grown rapidly along with the advancement in technology and they become a popular medium of communication. Among the social media networks, Facebook has become a primary source of news sharing (Baek, Holton, Harp & Yaschur, 2011) and the most popular network worldwide (Statista, 2019). More than 30 billion pieces of content are uploaded each month, such as web links and news stories (Glynn, Huge, & Hoffman, 2012).

Lately, most of the local businesses use video as their marketing medium to ensure the maximum amount of marketing message delivered to customers. However, online video techniques should eventually be used based on how potential customers act and how an organization can understand their behaviour (Schwarzl & Grabowska, 2015). It is important because video marketers may face major challenges such as costliness, time-consuming, and the inability to create engaging content (Boman & Raijonkari, 2017).

In order to fulfil the marketers need, Facebook has developed new features and functions related to internet marketing. In 2007, Facebook launched the Facebook marketplace, enabling users to upload advertisements post classified ads in categories of purchases, housing and jobs. This features help marketers to promote their product and services. A video platform in Facebook was launched officially in May 2007 to encourage users to upload video recordings from their video cameras. Facebook started rolling out business pages features to add "Feature" clip to the top of its videos section and started to allow users to stream video live. On the News Feed, streams are displayed and users can comment in real time. Live broadcasts are automatically stored on the streamer's page as a video post. So, through this platform, the marketers can easily promote and sell their products and services worldwide. Page Insights provide the last two years demographic data such as age, gender and location of the viewers to enable the marketers identify the target market.

For the marketers who use Facebook video as a marketing alternative to promote their products, they might expecting their products to become popular and viral since it is easy for people to affect and believe information posted at Facebook. It is also believe that the more viral the product, the more impact it give to society. However, how fast their products are sold may not only depends on the quality, creativity and the attraction of the video marketing. There are a lot more matters to be considered.

Because of that, after posting the marketing video on social network such as Facebook, there is a need especially for marketers to have an analysis on the spreading nature of the posted video. The raw data of number of likes and shares on Facebook is meaningless if there is no further analysis to see the pattern or cycle of spread, the day the spread reaches the peak and the duration of spread. Therefore, this case study was generally designed to differentiate the virality of video posting of two different products on Facebook. The specific objectives of this study were to measure or to identify the spreading pattern of product marketing through videos and to compare the growth and the decline of the number of viewers in regard video marketing based on Susceptible–Infected-Recovered (SIR) model. Originally, SIR models have been used to investigate the spread of contagious diseases such as dengue (Asmaidi et al. 2014; Side and Salmi, 2013) and tuberculosis (Side et al., 2017; Kalu and Inyama, 2012). Since the nature of the spread of disease and the spread of online video posting are alike, SIR model is applicable.

LITERATURE REVIEW

The discussion on this section is divided into two parts which are Facebook and online video marketing, and epidemic-based viral marketing model.

Facebook and Online Video Marketing

Social media are essentially internet-based platforms that promote communication, sharing of content, and various ways of working together (Boyd & Ellison, 2007). They enable a number of users to share and display with their number of contacts within the network and those generated by anyone else (Boyd & Ellison, 2007). Social media have become a global consumer phenomenon with the emergence of those social media platform especially Facebook. More than 500 million users today are active participants in the Facebook community alone (Kuss & Griffiths, 2011). Social media is the use of web and mobile technology to turn interaction into an interactive conversation. Social media can also be viewed as a first ever digital innovation that has revolutionized the world by keeping people on their toes with regard daily news, style and fashion. Social media has affected many aspects of human communication in recent times, thus affecting business (Edosomwan, Prakasan, Kouame, Watson, & Seymour, 2011). Social media is not only a place to market a company's products and services, but also a place to interact with clients in an attempt to solve their problems.

Recently, Facebook users can post anything in their status so that their followers can respond to their status either by clicking on like button, comment button or share button. If a user posts an update, it appears on the wall of the Facebook user and then it will appear in the news feeds. Facebook followers can respond to it either by clicking "like" or write a comment in the space and share the message. Facebook has expanded "like" button into "reaction" which is something new to the Facebook user. Long press on the Like button and you'll now see "love," "haha," "wow," "sad," and "angry," and posts will now show the mix of reactions they've received (Newton, 2016). In addition, Facebook has launched a new feature that allows users to upload GIFs to their comments. With the existence of those interaction features, the posted contents will affect the virality of the posting.

Typically, Facebook posts are simple messages, but they may contain links to images or videos. There are many types of video such as tutorial video, DIY video, marketing video and more that offered in social network especially in Facebook. Video is a strong interaction and advertising medium for rising sales and profit, attracting and educating buyers and customers of new products and services (Luo, Wang, & Han, 2013). Marketers choose online video as their alternative way to sell and advertise their product and to offer a service because it is easy for customer to recognize. Online video has been a powerful marketing tool for marketers around the globe because an attractive online video can result in a stronger marketing impact.

Epidemic-Based Viral Marketing Model

Epidemiology is a study of the distribution and determinants of health related states or events in specified population. It is well recognized as the scientific study of infection by the human population. Epidemiological knowledge is about looking, preparing and evaluating health problem control strategies. In this model, SIR and SEIR are two of the basic models being used in epidemiology. SIR model is the simplest model compared to SEIR model.

There are three categories of population in SIR model which are Susceptible (S), Infective (I) and Recovered (R). The Susceptible (S) are those are who are exposed to the disease. Infectious (I) is applicable to those are infected and can actively transmitting the disease. Recovered (R) is the group of individuals who have been infected and become resistant to infection. The purpose of using the SIR method is to design the spreading pattern of contagious diseases at a given time period for an amount of people in a closed inhabitant. SIR Model is an effective model to be used under the several assumptions. Among the assumptions are; the community is fixed, there is no genetic resistance, the only way a person may exit the susceptible group is to be infectious and the only way a person may leave the affected group is to rebound from the infection. Once the individual has recovered, the individual has gain immunity (Johnson & McQuarrie, 2009).

SIR models have been applied to study the transmission of infectious diseases such as influenza, dengue, and severe acute respiratory syndrome since the 1760s. This mathematical model shows its advantage in its epidemiological explanation of spreading mechanisms. It provides a deeper insight into the mechanism of disease transmission and monitor the rate of transmission. The SIR model can also be applied in many areas such as education, economics, finance, network, and computer science.

Online social networks, viral advertising, audience appreciation and the exchange of ideas were carried out for the field of networks using SIR model. For example, the epidemic marketing model is a viral information where the content is widely shared and embraced from individual to individual by the target group (Gardner, Sohn, Seo, & Weaver, 2013; Rodrigues & Fonseca, 2015). Internet forum users ' posting action will cause widespread posting and immediate response for others (Woo & Chen, 2012). Since the process of updating status only takes a few seconds, users will obtain the information instantly.

METHODOLOGY

The data collection and data analysis methods used in this study are explained thoroughly below.

Data Collection Method

The data was collected from two different video marketing of shawl and slimming product on Facebook posted by two top celebrities who are the founders of those two trending products. The video of shawl was introducing the new collection shawl. This video showed a model posed different colours of shawl. There was also a written description of the shawls and the date it would be launched. The video looked neat and was edited creatively since it had some soft music to make it looks elegant. Meanwhile, video content regarding to slimming product showed a conversation between the product owner and his testimony of the product. The testimonies were able to walk after taking the slimming product for several months. The video also showed the packaging of the product and there was also verbal description regarding the product in Malay language. The video promoting new design shawl was posted on 9 February 2020 and the video promoting slimming product was posted on 28 January 2020. The numbers of interactions in the form of comments, shares, likes and views for each of the video were collected after 7 days the videos was posted.

Method of Data Analysis

For SIR model, the process of analysis will start with formulation of the model, followed by calculating the basic reproduction number and finally obtaining the numerical solution.

SIR Model without Demographic Formulation

In SIR model without demography, the Facebook population is classified into three compartments which are susceptible, infected and recovered as shown in Figure 1.

Figure 1: Flowchart of SIR model without demography

The details of the compartments are:

$S(t)$ - Susceptible is the users of Facebook are expected to be exposed to marketing related video at time t,

$I(t)$ - Infected is the Facebook users who receive and share the marketing related video at time t,

$R(t)$ - Recovered is the Facebook users who stop sharing the marketing related video at time t.

Parameter α is the transmission rate of the number of Facebook users viewing and sharing the videos posting after the users are exposed to the video, while parameter $β$ is the recovery rate of the number of Facebook users stop posting among those who are receiving and sharing the video content (Rodrigues, 2016).

The total population, N at time t is

$$N(t) = S(t) + I(t) + R(t).$$

The SIR model without demography can be expressed as

$$\frac{dS}{dt} = -\alpha SI,$$

$$\frac{dI}{dt} = \alpha SI - \beta I,$$

$$\frac{dR}{dt} = \beta I.$$

The followings are the calculation of parameter α and β.

$$\alpha = \left(1 - \frac{\text{number of views}}{\text{number of Facebook users}}\right) \times \left(\frac{\text{Summation of like, comment, and share}}{\text{number of views}}\right).$$

$$\beta = \frac{1}{D} \quad \text{where D is the expected duration of viral content to be ended.}$$

For this model, the basic reproduction number, R_o is defined as the expected number of secondary cases produced by a single infection in a completely susceptible population. The formula for R_o is

$$R_0 = \frac{\alpha}{\beta}$$

There are three indications from the value of R_0 which are:

If $R_o < 1$, the number of Facebook users receiving as well as sharing the marketing video decreases.
If $R_0 > 1$, the number of Facebook users receiving as well as sharing the marketing video increases.
If $R_0 = 1$, the number Facebook users receiving as well as sharing the viral content is constant.

SIR model with Demographic Formulation

In SIR model with demography, the population to be considered is the same as the previous model; susceptible, infected and recovered except that the rate of the numbers of new Facebook users and the rate of the numbers of users who left Facebook account have been taken into consideration as well. In this study, we assumed that both rates are equal and denoted by ε. The illustration is shown in Figure 2.
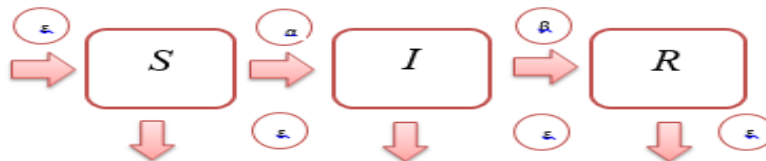

Figure 2: Flowchart of SIR Model with demography

The total rate of the population that does not change over time or in other terms is given as:

$$\frac{dS}{dt} + \frac{dI}{dt} + \frac{dR}{dt} = 0$$

The demographic SIR model can be expressed as:

$$\frac{dS}{dt} = \varepsilon - \varepsilon S - \alpha SI$$

$$\frac{dI}{dt} = \alpha SI - \beta I - \varepsilon I$$

$$\frac{dR}{dt} = \beta I - \varepsilon R$$

The parameters α and β are similar to the SIR model without demography as mentioned before. The basic number of reproductions denoted by R_0 is the average number of the α-related transmission (the rate of Facebook users receiving and sharing marketing-related video among those who exposed to video) and $\beta + \varepsilon$ (the rate of Facebook users that stop sharing the video among those who received it and the rate of Facebook users who just create Facebook account as well as those who deactivate their Facebook account). So, the new equation for each infectious person is therefore formulated as

$$R_o = \frac{\alpha}{\beta + \varepsilon}.$$

The indications or interpretations of R_o are the same as previously stated in SIR Model with demography.

FINDINGS AND DISCUSSIONS

The numbers of comments, shares, likes and views after seven days the videos were posted on Facebook are shown in Table 1. It shows that the slimming product having higher numbers in each variable as compared to the shawls'.

Table 1: Number of Comments, Shares, Likes and Viewers for Both Marketing Videos After Seven Days Posted

Variables	Shawls	Slimming Product
Number of Comments	33	859
Number of Shares	13	483
Number of Likes	710	6500
Number of Views	4.3K	296

Analysis of Parameter Value

The number of daily active Facebook users in Malaysia is considered as total population, N. The total population (Facebook users), N is 23.1(million). The initial conditions for the video promoting shawl and slimming product are as the followings respectively:

$$S(0) = 21.35, \quad I(0) = 1.75 \quad \text{and} \quad R(0) = 0.$$
$$S(0) = 21.18, \quad I(0) = 1.92 \quad \text{and} \quad R(0) = 0$$

The calculated values of parameter α and β for both video are listed in Table 2. Apparently, the transmission rate, α for the video introducing new collection of shawls is higher than the value of α for slimming product video. It shows that the video of shawl gets the attention from Facebook users faster than the other one because it was presenting a new product. The users were eager to share the video once they got the posting. However, the values of transmission rate, β for both video are the same. It shows that the chances of the Facebook users to leave the posted video are the same, regardless of what form of videos they are viewing.

Table 2: Values of Parameter α and β

Parameter	Shawls	Slimming Product
α	0.1758	0.0262
β	0.143	0.143

Table 2 shows the calculated reproduction number, R_o for each video for both SIR models, without demography and with demography. In both model, the R_o of video promoting shawl is greater than 1 $(R_o > 1)$ which indicates that the content was viral. The number of shares and viewers were increasing very fast even though the number of views and the other interactions are low after seven days it was posted. In

contrast, the number R_o for slimming product indicates that the number of Facebook users who receive and share the viral content are expected to decrease $(R_o < 1)$, although during the observation day, the number of views are high. Thus, the video promoting slimming product is expected to be no longer widespread among Facebook users after the video being observed (seven days after the video posted).

The shawl video is expected to become viral since many Facebook users from wide range of ages, starting from teenagers to the oldsters, are always attracted to the new trend of products such as shawls. Different from the shawl videos, the slimming product video was not viral because the product seems related to only obese Facebook users only. The product may be already existed in the market and have been introduced in the earlier promoting video. The values of R_o for both video contents using SIR model with demography is smaller as compared the values using SIR model without demography. It might be due to the effect of the rate of the new Facebook users and the rate of the users who closed their account (ε) that being considered in the SIR Model with demography.

Table 3: The Reproduction Number, R_o

Product	SIR With Demography	SIR Without Demography
Shawls	2.467	1.193
Slimming Product	0.184	0.178

SIR Model without Demography Solution

The graphs in Figure 3 and Figure 4 show the spread of the selected videos' content using SIR Model without demography. The time frame for both contents is 25 days. Figure 4 shows that the number of Facebook users exposed (Susceptible) to the video promoting shawl drops to nearly 0 on day 2 and stay constant afterword. The number of Facebook users who received and shared the content (Infected) increases drastically and reaches 19.6 million of active Facebook users in Malaysia on day 2 but it slowly decreases to 0.4 million of active Facebook users on day 25. Apparently, it takes nearly 25 days for a number of Facebook users to stop sharing the video (Recovered).

Based on Figure 4, the number of Facebook users exposed to the video promoting slimming product. (Susceptible) drops drastically until day 15 and then continue decreasing slowly to 0.5 million of Facebook user on day 25. The number of Facebook users who received and shared the content (Infected) increases slowly and reaches the maximum number 10.3 million of Facebook users on day 8. After that, the number is slowly decreasing to 1 million of Facebook users who received and shared the video on day 25. Lastly, almost 21 million of Facebook users stop sharing the video (Recovered) in 25 days.

The intersection point between the numbers of infected users and recovered users shows the point where the numbers of the video posting still actively circulated is starting to reduce. Based on Figure 3 and Figure 4, the circulation of video introducing shawls starts to reduce a little bit earlier (day 6) compared to the circulation of video promoting slimming products (day 9). This situation occurs may be due to the competition the marketers might face from other producers of similar product.
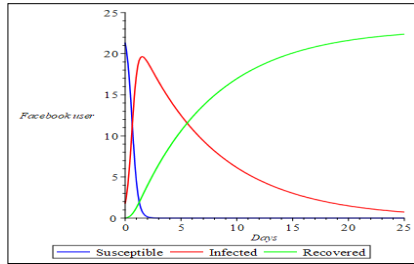
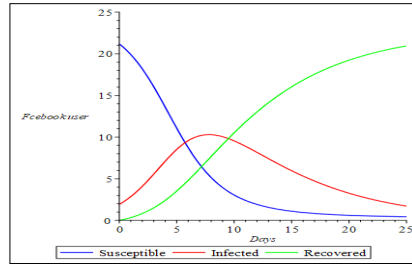**Figure 3**: The Spread of Video Promoting Shawl (Without Demography)

Figure 4: The Spread of Video Promoting Slimming Product (Without Demography)

The graphs in Figure 5 and Figure 6 show the spread of video promoting shawl and slimming product using SIR Model with demography, respectively. The video content of shawls in Figure 5 appears to be viral very fast for first two days before slowly decreasing. On the other hand, the graph of the dissemination of video promoting slimming product in Figure 6 shows the video content is disseminated among Facebook users in a slower rate. After day 8, the number of users receiving and sharing the video is gradually decreases. The result obtained from both videos are almost the same as in SIR model without demography.
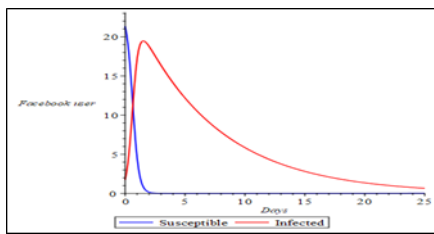

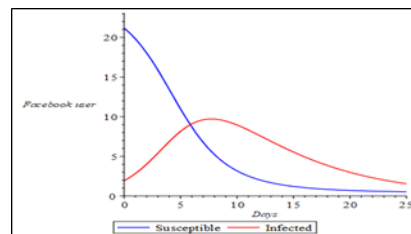**Figure 5**: The Spread of Video Promoting Shawl (with Demography)

Figure 6: The Spread of Video Promoting slimming Product (With Demography)

CONCLUSION AND RECOMMENDATIONS

Based on the value of R_0 shown in Table 3,, the video promoting shawl is more viral among Facebook users as compare to the video promoting slimming product either for SIR Model with Demography or SIR Model without Demography. The impact of the value of R_0 can be seen in Figure 3 until Figure 6. When value of $R_0 > 1$, Figure 3 and Figure 5 show that the Facebook users take shorter time to recognize and share the video about new design of shawl and hits the maximum number of viewers (19.6 million), two days later. However, video promoting slimming product with $R_0 < 1$, took 8 days to hit the maximum number of viewers (10.3 million). This situation shows that the faster a video being disseminated in the early stage of posting, the higher number of viewers going to be reached.

The video promoting shawl gained more attention as compared to video promoting slimming product. The actual reasons or factors contributing to the virality of the video cannot be considered in this case study since there is no information related to the followers of those two accounts. Only some assumptions able to be made based on the nature of the products. Normally, the trending product such as shawl becomes viral because the need, interest, demand and priority for the product is higher to the active Facebook users. The video presentation may also affect the willingness of the viewers whether to share the video or not. The

video promoting shawls can be considered as a very minimalist video. The video does not engage to a long conversation as in video promoting slimming product. There is also a written description of the product at the end of the video so that the users able to see and understand the description easily. Moreover, video promoting shawls uses English as the medium of communication which able to attract more Facebook users from inside and outside Malaysia to view and share the video. Meanwhile, the video of slimming product is in Malay language. Thus, the interaction among Facebook users will be limited.

On the day of observation is made, the number of followers of the account promoting slimming product is slightly higher (1914000) than the numbers of followers of the account promoting of shawl (1533499). It reveals that the number of followers will not be a determinant of the virality of certain posting. There are a lot of other determinants should be considered to identify the virality. In whatever reasoning being figured out, it might be justified if several other information such the demography of the followers, content of the video and the presentation of the content are taken into consideration in the analysis. Thus, it is more appropriate to study the dissemination of a certain product thoroughly through Page Insights of the owner for the account. However, this study is expected to be the starting point to identify the flow of graphs showing the dissemination of particular postings in social networks.

For the future study, the daily number of followers, likes, comments, shares and views should be taken, in order to compare with the values obtained from the graphs. This process might ensure the validity of the model. At the same time, this study is expected to be able to encourage the entrepreneurs to be more creative in developing more attractive videos to promote their products through social networks.

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CONFLICT OF INTEREST DISCLOSURE

All authors declare that they have no conflicts of interest to disclose.

REFERENCES

Asmaidi, Siantura, P., & Nugrahani, E. H. (2014). A SIR mathematical model of dengue transmission and its simulation. *IQSR Journal of Mathematics,* 10(2)*,* 56-65.

Baek, K., Holton, A., Harp, D., & Yaschur, C. (2011). The links that bind: Uncovering novel motivations for linking on Facebook. *Computers in Human Behavior*, *27*(6), 2243-2248.

Boyd, D. M., & Ellison, N. B. (2007). Social Network Sites: Definition, History, and Scholarship. *Journal of Computer-Mediated Communication, 13*(1), 210-230.

Boman, K., & Raijonkari, K. (2017). Online Video as A Marketing Tool: A Quantitative Survey on Video Marketing Habits.

Edosomwan, S., Prakasan, S. K., Kouame, D., Watson, J., & Seymour, T. (2011). The History of Social Media and Its Impact on Business. *Journal of Applied Management and Entrepreneurship, 16*(3), 79-91.

Gardner, J. T., Sohn, K., Seo, J. Y., & Weaver, J. L. (2013). A Sensitivity Analysis of An Epidemiological Model of Viral Marketing: When Viral Marketing Efforts Fall Flat. *Journal of Marketing Development and Competitiveness, 7*(4), 25-46.

Glynn, C. J., Huge, M. E., & Hoffman, L. H. (2012). All the news that's fit to post: A profile of news use on social networking sites. *Computers in Human Behavior*, *28*(1), 113-119.

Johnson, T., & Mcquarrie, B. (2009). *Mathematical Modeling of Diseases: Susceptible-Infected-Recovered (Sir) Model.* Paper Presented at The University of Minnesota, Morris, Math 4901 Senior Seminar.

Kalu, A. U., & Inyama, S.C. Mathematical model of the role of vaccination and treatment on the transmission dynamics of tuberculosis. *Generation Mathematics Notes*, *11*, 10-23.

Kuss, D. J., & Griffiths, M. D. (2011). Online Social Networking and Addiction—A Review of The Psychological Literature. *International Journal of Environmental Research and Public Health, 8*(9), 3528-3552.

Luo, L., Wang, Y., & Han, L. (2013). Marketing Via Social Media: A Case Study. *Library Hi Tech, 31*(3), 455-466.

Newton, C. (2016). Facebook Rolls Out Expanded Like Button Reaction Around The World.

Rodrigues, H. S. (2016). Application of SIR Epidemiological Model: New Trends. *International Journal of Applied Mathematics and Informatics, 10*, 92-97.

Rodrigues, H. S., & Fonseca, M. J. (2015). Viral Marketing As Epidemiological Model. *Arxiv Preprint Arxiv:1507.06986.*

Schwarzl, S., & Grabowska, M. (2015). Online Marketing Strategies: The Future is Here. *Journal of International Studies, 8*(2), 187-196.

Side, S., & Salmi, M. N. (2013). A SIR model for spread of dengue fever disease (Simulation for South Sulawesi, Indonesia and Selangor, Malaysia). *World Journal of Modelling and Simulation*, *9*(*2*), 96-105.

Side, S., Sanusi, W., Aidid, M. K., & Sidjara, S. (2017). Global stability of SIR and SIER model for tuberculosis disease transmission with Lyapunov function method. *Asian Journal of Applied Sciences*, *9*(*3*), 87-96

Statista (2019). Statistics. https://www.statista.com/statistics/264810/number-of-monthly-active-facebook-users-worldwide/

Woo, J., & Chen, H. (2012). *An Event-Driven Sir Model For Topic Diffusion In Web Forums.* Paper Presented at The 2012 IEEE International Conference on Intelligence and Security Informatics.