Optimal Advertizing

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Abstract

Online and offline media (e.g., Youtube, Facebook, TV) are the main modes of advertisement today. Which of these media types should a firm use in order to reach the widest audience possible? We answer this question, taking into account the fact that different media types share users who may channel information from one medium to another. A simulated information transmission system with three media types is conducted using as ingredients the coverage rate of each type as well as the probability that information received from one medium is transmitted to a different one. This simulation is implemented using data from the United States.

Key words: Social media, Information transmission system, Two-sided economy, Networks, link sharing, target audience, coverage rate

I. Introduction

Data from the Census Bureau of the United States shows that, 99.99 percent of the households in the United States have a working television set in their home. Thanks to the rapid development of the Information Communication Technology in the twentieth century, our lives have been tremendously changed by the Internet. The Nielsen Company mentioned in its report (2013.9) that 78 percent of the households in the United States are able to access the Internet. Social Networking has grown amazingly in the latest decade. Fifty-two percent of Americans have a Facebook page as of the end of the third quarter of 2013. However, the probability of information successfully delivered to a television audience is only 30 percent, 77 percent of Facebook users log on to their account daily.

If you are an advertiser with a budget constraint and can only invest in one medium, which one would you choose? What is the most effective medium for advertising? The one that has the highest number of users but the lowest effective delivery rate or the one who has fewer users but with a higher delivery rate?

This paper will show that a social media with the high user activity level is the best choice for advertisers, especially for the ones which require a high audience coverage rate. A survey initiated by Vizu Nielsen in October 2013, which sampled in excess of 500 American digital marketing and media professionals, found that thirty-nine percent of advertisers indicated that they would be shifting some of their offline

budget onto online paid social media advertising. Nearly one-quarter of the advertisers said that they would be shifting their budget away from online display to paid social media advertising. In order to study the effectiveness of each type of media under the “opportunity-to-see” standard for display advertisements, the focus will be on the efficiencies of the display advertisements compared with the social media with offline media and the online video sharing sites

When referring to the display advertisements, one should be aware of that these advertisements can be viewed in three ways: one, a display in breaks of offline broadcasting; two, a binding with Online Videos, and, finally dynamic banners on a webpage. These advertisements are non-manually ignorable, in other words, cannot be skipped over. For example, when someone watches a video online, they have to watch the injected display ad which comes with the video. A simulated information transmission system with the aforementioned media types is modeled through using the probabilities and relative sharing rates to calculate the coverage rates in order to determine which media type should be targeted. Our simulation exercise assumes that different media types share users, and so can be viewed as being connected to each other through links that are able to channel information. In this sense, our study is related to the literature on information diffusion and contagion (see, e.g., Pongou (2010) and Pongou and Serrano (2009, 2013) and the references therein).

II. The Model

In this section, we will introduce the model we will use. And we need to define the key concepts:

- **Target Audience:**

The target audience is the entire American population

- **Media type**

The term ‘media type’ typically refers to two forms of media that a target audience can access, one is called the offline media and the other one is called the online media. Offline Media includes: television, radio, outdoor banners, newspapers, magazines, and cinema. Online media includes: blogs, social networks, podcasts, video sharing sites. An important feature of the online media is that the audience can use the media anytime they want to.

- **Coverage rate**

Coverage is defined as the total number of people within your target audience that might see your message. Sometimes it is referred to as “reach”. Here we define the concept ‘coverage rate’ as the percentage of the target audience who receive the information.

- **Opportunity-to-see**

The number of times someone is likely to see a marketing message is known as the

"opportunity-to-see" (OTS).

- **Daily Active Users (DAU)**

Daily Active Users is defined as the total number of users who log to the webpage in any given day.

- **Exogenous Variables**

Flowchart 1 and Flowchart 2 give an overview of the simulated information transmission system and the exogenous variables used in the model.

We assume that there are three types of media (Flowchart 1) and ten identical groups of audiences in the economy. The sum of the ten groups of audiences is the whole population. These groups are identical with each other and do not have a preference ranking on media. The three types of media are: offline media (N_{off}), online video sharing media (N_{video}), and online social media (N_{social}).

Let i denote the media type and i={1,2,3}. We use i=1 to denote the online video media, i=2 denotes the online social media, i=3 denotes the offline media.

Let j be the media bundle, The bundles can be listed as: {1,2,3}, {1,3}, {2,3}, {1,2}, {1}, {2}, {3} (Flowchart 2). For instance, bundle {1,2,3} denotes an audience that can access all three type of media, however bundle {3} denotes that an audience only has a television set at home and is not able to access the Internet. We assume that using more types of media means one has to spend more time on information

collecting activities and the more opportunity cost he has to pay. Each of the audiences would have a media preference. Therefore, each member of the audience would choose a utility maximizing combination of social media.

Number of users/ Percentage of users (N) ---- Number of users refer to the percentage of total number of users out of the whole population. In this paper, the shares are multiples of ten for simplification. In particular, the whole population is divided into ten groups, each group has one-tenth of the total number of the target audience. $N= \{N_{j,}\ N_{off,}\ N_{video,}\ N_{social}\}$, $N \in N^{+}$, $N \in [0,10]$. For example, when we say N_{off} is 5, it is saying that the number of the offline media users is 50% of the total number of population.

Inter-media Transmission Propensity (a_i)---- The inter-media Transmission propensity can be defined as the percentage of the audience who uses two types of media and would like to transfer the information they received from the first medium to the second one. For instance, assume a_1 is the transmission propensity from Television to Youtube, then we can say that, of the audience who has access to both Television and YouTube, there will be a_1 percent of them who would like to share the information they got from the Television with YouTube.

User Activity Level (b_i) ---- The concept 'User Activity' is similar to 'Effective Delivery Rate'. It is a variable that measures the percentage of users who will receive the information directly from the medium in any given day. For example, as will be

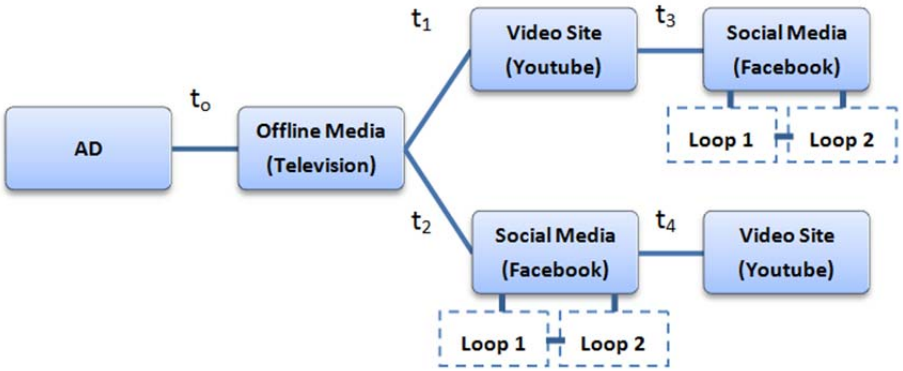
shown in the following sections, b_2 denotes the User activity of the online social network and it is defined as the percentage of DAU of the total users ($\frac{\text{DAU}}{\text{Total Users}}$*100).

Link-sharing ratio (r) ---- The link-sharing ratio is a measure of users' sharing activities. The ratio is calculated by dividing the amount of video shared by the number of videos viewed. It is assumed that neither the video displays on offline media nor the video displays on online video site can be shared inside the media, therefore the link-sharing ratio of those two types of media are considered to be zero. The link-sharing ratio of online social media r is a positive percentage. In some circumstances, this variable can be considered as an index of advertisement attractiveness. People who tend to share a link when they find it is interesting or strongly agree with it, the more audience who share the link after watching the video the higher the ratio will be.

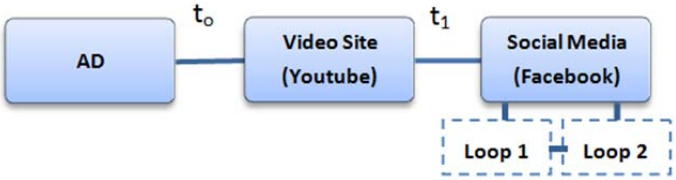
As we know, since r is a non-negative number which is always less than or equal to 1 ($r <= 1$), therefore, $\lim_{k\to\infty}(r)^k \to 0$. By doing the calculations, we found that the overall impact on information spreading will be no longer significant when k is larger than 2. Therefore, we introduce only two times of the inner transmission loops into the functions of the social media.

III. The Functions

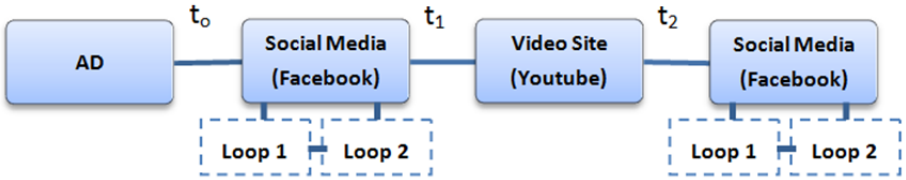
We set four models and each model stands for an information transmission path:



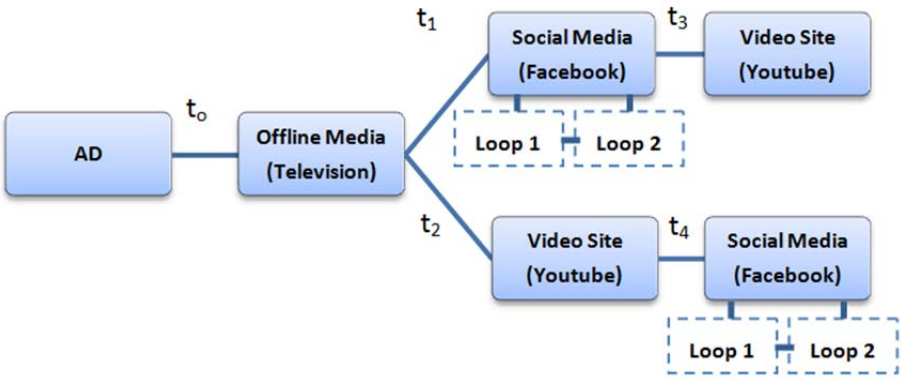
Flowchart 3 Model 1 Offline Media--- Video Site --- Social Media



Flowchart 4 Model 2 Video Site --- Social Media



Flowchart 5 Model 3 Social Media --- Video Site



Flowchart 6 Model 4 Offline Media--- Social Media --- Video Site

Period t indicates the time period when information was received by each media. Period t_0 is the initial period. In this period, the advertisement or information is initially injected into the media. Period t_1 is the first period that the information is transferred to another type of media besides the initial one. Period t_2 and the latter periods describe the information transmission processes between online media.

The transmission path in Model 1 and Model 4 are similar except for the difference in information receiving ranking between the Online Video Site and the Social Media. The relationship between the coverage rate and the information receiving ranking will be discussed in detail by comparing these two models.

Due to the 100 percent online-to-offline transmission barrier assumption, Model 2 and Model 3 do not include the Offline media. Videos can never be shared from online media to offline media. For instance, the offline media is television and the online media is Facebook, the audience who can both watch television and log on to

Facebook is unable to share a video from Facebook to Television. On the contrary, if the audience watched an ad-injected-video, found the advertisement interesting and want to share it on Facebook, he has to get it from the advertiser's official website and share the link with Facebook.

Introducing the functions of models:

Let us start with two equations

$M_{video} = (N_{12} + N_{123}) / N_{video}$

$M_{social} = (N_{12} + N_{123}) / N_{social}$

M_{video} stand for the penetration of the ones who use both the online video site and the online social media out of the total number of the online video site users. M_{social} stand for the penetration of the ones who use both the online video site and the online social media out of the total number of the online social media users.

- **Model 1 :**

t_0: Putting a display advertisement on the Offline Media initially.

The information will be received directly by the offline media users. However, not all of the offline media users are delivered the information because of the televised/broadcast time constraint. We assume b_3 is the percentage of offline media users who are using the media when the display ad is broadcasting. The equation below simply shows the number of audience who get the information directly from the offline media, where N_{off} stand for the total number of offline media users.

$S_1=N_{off}*b_3$

t_1: display ads shared from offline media (OFM) to online video site (OVS) (1st time)

We now move to the online video site. A key assumption made here is that all of the display ads can be found at the advertising companies' online official sites and the display ads can be downloaded and then uploaded to the online video sites or be shared from the official sites to the online social media. The proportion of offline media users who are users of online video site as well is $[(N_{13}+N_{123})/N_{off}]$, the probability that the online video site will receive the information from offline media is

$U1 = [(N_{13}+N_{123})/N_{off}] *b_3*a_1$

a_1 is the transmission propensity from offline media to online video site.

The number of new added audience in t_1 is V_1

$V_1 = U_1 *b_1*X_1$

$X_1 = N_{video} – (N_{13}+N_{123})*b_3$

Where X_1 denotes the number of OVS users who did not receive the information from OM directly.

t_2: display ads shared from offline media to online social media (OSM) (1st time)

On the social media sector, the proportion of offline media users who are also the users of online social media is $[(N_{23}+N_{123})/N_{off}]$. The probability that OSM would receive the information from OFM is

$Z_1 = [(N_{23}+N_{123})/N_{off}]*b_3*a_2$

a_2 is the transmission propensity from OFM to OSM.

The number of 1st time OSM new added audience D_1

$D_1 = Z_1*b_2*(X_2-V_1*M_{video})$

$X_2=N_{social}-(N_{23}+N_{123})*b_3$

The Exogenous variable X_2 is defined as the number of OSM users who did not receive the information from OFM directly.

Information spread inside online social media:

Loop 1: $E_1=D_1/N_{social}*r*b_2*(X_2-V_1*M_{video}-D_1)$

Loop 2: $F_1= E_1/N_{social}*r*b_2*(X_2-V_1*M_{video}-D_1-E_1)$

The OSM users is able to share the link as soon as they receive it and the users can only share the link once, in other words he will not share the link if he shared before.

From the above, the number of new added audience in t_2 is $(D_1+E_1+F_1)$

t_3: display ads shared from online video site to online social media (2nd time)

Continuing with the second step, part of the new added audience V_1 decided to share the link from OVS to OSM. After then, the information would spread inside OSM and generate more delivered-audience.

The probability that OSM will receive the information from OVS is:

$I_1=V_1/N_{video}*M_{video}*a_2$

The total number of new added audience in period t_3 is equal to $(J_1+J_2+J_3)$, where

$J_1=I_1*b_2*(X_2-V_1*M_{video}-(D_1+E_1+F_1))$

$J_2= J_1/N_{social}*r*b_2*(X_2-V_1*M_{video}-(D_1+E_1+F_1)-J_1)$

$J_3= J_2/N_{social}*r*b_2*(X_2-V_1*M_{video}-(D_1+E_1+F_1)-J_1-J_2)$

t_4: display ads shared from online social media to online video site (2^{nd} time)

Continuing with the third step, part of the new added audience in t_2 $(D_1+E_1+F_1)$ decided to share the link from OSM to OVS.

The probability that the OSM audience who got the information will upload it to OVS this time is

$G_1= (D_1+E_1+F_1)/N_{social}*M_{social}*a_4$

Then we can get the total number of new delivered-audience in period t_4:

$H_1= G_1*b_1*(X_1-V_1- (D_1+E_1+F_1+ J_1+J_2+J_3)*M_{social})$

Let $COVER_1$ denote the coverage which means the total number of delivered-audience in Model 1.

$COVER_1 = S_1+V_1+ D_1+E_1+F_1+ J_1+J_2+J_3$

- **Model 2 :**

t_0: injecting a display advertisement into the videos on online video site

In the first step, the information will be received directly by OVS users. Equation below calculates the number of audience who get the information directly from OVS, where N_{video} stand for the total number of OVS users, b_1 is the OVS user activity ratio.

$S_2 = N_{video} * b_1$

t_1: ads-injected-video share from online video site to online social media

Function $I_2 = M_{video} * b_1 * a_3$ describes the probability that OSM would receive the information from OVS. As soon as the information delivered to OSM, it could be spread inside OSM by the OSM users.

Therefore the total new added number of delivered-audience in t_0 would be equal to $(D_2+E_2+F_2)$, where

Direct delivery: $D_2 = I_2 * b_2 * X_3$

Loop 1: First round internal-sharing: $E_2 = D_2 / N_{social} * r * b_2 * (X3 - D_{2)}$

Loop 2: Second round internal-sharing: $F_2 = E_2 / N_{social} * r * b_2 * (X3 - D_2 - E_{2)}$

With $X3 = N_{social} - (N_{12}+N_{123}) * b_1$

Let $COVER_2$ denotes the amount of audience coverage in Model 2.

$COVER_2 = S_2 + D_2 + E_2 + F_2$

- **Model 3 :**

t_0: put display advertisement on the online social media webpage

An important character of online social media is that information will not only be received but also can be shared inside social media. Then there are two types of

information delivery:

Directly: $W_1 = N_{social} * b_2$

Indirectly: Loop 1: $W_2 = W_1 / N_{social} * r * b_2 * (N_{social} - W_1)$

Loop 2: $W_3 = W_2 / N_{social} * r * b_2 * (N_{social} - W_1 - W_2)$

We do only two rounds of link-sharing because the effect from the third round is too small and can be ignored from data. W_1 denotes the number of audience who receive the information directly at the very first time. W_2 and W_3 calculate the number of audience who receive the information indirectly from people who is one of W_1 and shared the link inside the social media.

The number of information delivered audience in t_0 is $(W_1 + W_2 + W_3)$

t_1: ads share from online social media to online video site

G_3 below is the probability that an ad is shared to the OVS

$G_3 = (W_1 + W_2 + W_3) / N_{social} * M_{social} * a_4$

So the number of new added delivered-audience in t_1 is

$H_3 = G_3 * b_1 * (N_{video} - (W_1 + W_2 + W_3) * M_{social})$

t_2: ads share back from online video site to online social media

The probability of this transmission is:

$I_3 = H_3 / N_{social} * M_{social} * a_3$

Then the total number of new added delivered-audience of this period is equal to

(D_3+E_3+F_3), where

$D_3 = I_3 * b_2 * (N_{social} - (W_1 + W_2 + W_3) - H_3 * M_{social})$

Loop 1: $E_3 = D_3 / N_{social} * r * b_2 * (N_{social} - (W_1 + W_2 + W_3) - H_3 * M_{social} - D_3)$

Loop 2: $F_3 = D_3 / N_{social} * r * b2 * ((N_{social} - (W_1 + W_2 + W_3) - H_3 * M_{social} - D_3 - E_3)$

Let $COVER_3$ denotes the amount of audience coverage in Model 3.

$COVER_3 = W_1 + W_2 + W_3 + H_3 + D_3 + E_3 + F_3$

- **Model 4 :**

t_0: Putting a display advertisement on the Offline Media initially.

The number of audience who get the information directly from the offline media:

$S_4=N_{off}*b_3$ and $S_4=S_1$

t_1: display ads shared from offline media to online social media (1^{st} time)

The Probability OSM would receive this info from OFM is

$Z_4 = (N_{23} + N_{123}) / N_{off} * b_3 * a_2$

So the 1^{sr} time OSM new added audience is

$D_4 = Z_4 * b_2 * X_2$

Then, the total number of indirect delivered-audience which is generated by D_4 is (E_4+F_4). Where

Loop 1: $E_4 = D_4 / N_{social} * r * b_2 * (X_2 - D_4)$

Loop 2: $F_4 = E_4 / N_{social} * r * b_2 * (X_2 - D_4 - E_4)$

t_2: share display ads from offline media to online video site (1st time)

Probability OVS would receive this information from OFM is

$U_4 = (N_{13} + N_{123}) / N_{off} * b_3 * a_1$

Then the 1st time new added audience in t_2 is

$V_4 = U_4 * b_1 * (X_1 - (D_4 + E_4 + F_4) * M_{social})$

t_3: share display ads from online social media to online video site (2nd time)

We now move to the OVS sector following with the second step (t_1) of this Model. The probability that the 1st time OSM new added audience would share the ad to OVS is

$G_4 = (D_4 + E_4 + F_4) / N_{social} * M_{social} * a_4$

Then the number of new added delivered-audience in t_3 is calculated as:

$H_4 = G_4 * b_1 * (X_1 - V_4 - (D_4 + E_4 + F_4) * M_{social})$

t_4: share display ads from online video site to online social media (2nd time)

Following with the third step (t_2), information is shard from OVS back to OSM.

$I_4 = V_4 / N_{video} * M_{video} * a_3$ is the probability that OSM would receive the information.

Therefore, the number of OSM 2nd time new added delivered-audience is equal to $(J_4+J_5+J_6)$, where

$J_4 = I_4 * b_2 * (X_2 - V_4 * M_{video} - (D_4 + E_4 + F_4) - H_4 * M_{video})$

Loop 1: $J_5 = J_4 / N_{social} * r * b_2 * (X_2 - V_4 * M_{video} - (D_4 + E_4 + F_4) - H_4 * M_{video} - J_4)$

Loop 2: $J_6 = J_5 / N_{social} * r * b_2 * (X_2 - V_4 * M_{video} - (D_4 + E_4 + F_4) - H_4 * M_{video} - J_4 - J_5)$

Then we can calculate the total number of delivered-audience in the economy. We use $COVER_4$ to denote the number of coverage in Model 4.

$COVER_4 = S_4 + D_4 + E_4 + F_4 + V_4 + H_4 + J_4 + J_5 + J_6$

IV. Fitting the model to data

To illustrate how the model runs with real-world data and what implications there are, the model is fitted using the United States 2013 data. We bring in the online video site YouTube, the social networking Facebook and the offline medium Television as the three types of media in the model.

1. American Experience

Before introducing the data set, some brief background of the Americans ads market is provided.

The worldwide advertising budget keeps increasing, and the advertisers spend most of their budget on the television ads but become more reliant upon the social media ads. From the reports from The Nielsen Company, one can find that the global advertisers increased budgets in 2012 by 3.3 percent. The advertising investment in the United States was an impressive 5.1 percent increase. Television was the most favorite medium for advertisers and it took a 61.8 percent share of the advertisement

investment. On the other hand, the share of the Internet was only 2.6 percent. 70 percent of the advertisers spend less than 10 percent of their budgets on the social media. According to the numbers above, one may ask that ‘are the numbers of advertisement investment implying that the Social Media would be the last option a professional advertiser may choose?’ The answer is in the negative. A survey initiated by Vizu Nielsen in October 2013 that covered more than 500 American digital marketing and media professionals, found that over a third of advertisers indicated that they would be shifting some of their offline budget into online paid social media advertising. Nearly one-quarter or 23 percent of the advertisers said that they would be shifting some of their budget away from online display to paid social media advertising.

Why did advertisers decide to spend more money on social media advertising in the United States? Under the assumption of rationality and the Return on Investment (ROI) rule (a measure of the budget spent to achieve an objective, versus the income generated through the activity), the reason should be a higher level of cost-effectiveness. In other words, if one assumes an identical cost function, the advertising activities on social media should reach a larger audience coverage rate than the advertising on television or online video sites.

The conclusions in the following sections verify this hypothesis and discuss some of the variables’ effectiveness intervals in different types of media.

2. Data set

We fit the model as follows.

First, we directly calculate the exogenous variables in the model.

b_1	b_2	b_3	r	N_{video} （10%）	N_{social} （10%）	N_{off} （10%）
42%	77%	30%	80%	7	5	10

Table 2

- Online video site: YouTube

A report released in December 2013 from comScore indicated that 78 percent households in the United States are able to access to the Internet, and 86.9 percent of the American Internet audience viewed online video which means that nearly 70 percent Americans are able to open a YouTube page and watch videos whenever they wish. So we set $N_{video}=7$. However, as we know, there are many other online video sites which are available and as a result, not all of the online video viewers would choose YouTube. Therefore, the effective delivery rate of YouTube b_1 cannot be 100%. Actually, it is 42% according to a survey from GlobalWebIndex.

- Online social networking: Facebook

Data from Facebook.com shows that 52.5 percent (166 million) Americans have a

Facebook account as of the third quarter of 2013(N_{social}=5). The number of Daily Active User in that month in the United States was 128 million. In other words, 77 percent of registered American Facebook users logged in and visited Facebook through a website or a mobile device. Therefore, we set b_2, the Facebook effective delivery rate, at 77 percent. Data from Jeffbullas.com also shows that, in June 2013, American Facebook users watched 310.76 million videos which were uploaded by others, and, of those, 259.86 million of them were shared. Therefore, the probability that a video would be shared inside Facebook can be calculated as r = 259.86/310.76 = 80%.

- Offline media: Television

According to the data from the Census Bureau of the United States and the Nielsen Company, 99.99 percent of the households in the United States have more than one working television set at home, (N_{off}=10). The average number of American television-watching-hour is 4.8 per day. If we adjust the data by minus 8 hours sleeping time from 24 hours, then we can get the television effective delivery rate b_3 which is 4.8/(24-8)=30%.

3. Analysis

In this subsection, the model, using American data mentioned above, will calculate its results by changing a variable each time to analyze and illustrate how the exogenous variables affect the effective coverage of each type of media and the variables'

intervals that advertisers would put their display advertisements on the social media as well.

3.1 Network Structure of media users (N)

The structure of network is important for the prevalence of information (Pongou and Serrano (2009).Using more types of media means one has to spend more time on information collecting activities and the more opportunity cost has to be paid. Therefore, in an economy, each of the audiences wants to have a utility maximizing media bundle. The audience will choose the type and the number of media they have. The bundles can be listed as several sets below: {YouTube, Facebook, Television}, {YouTube, Television}, {Facebook, Television}, {YouTube, Facebook}, {YouTube}, {Facebook}, {Television}. Then, we can get four patterns of network structures based on the U.S. data:

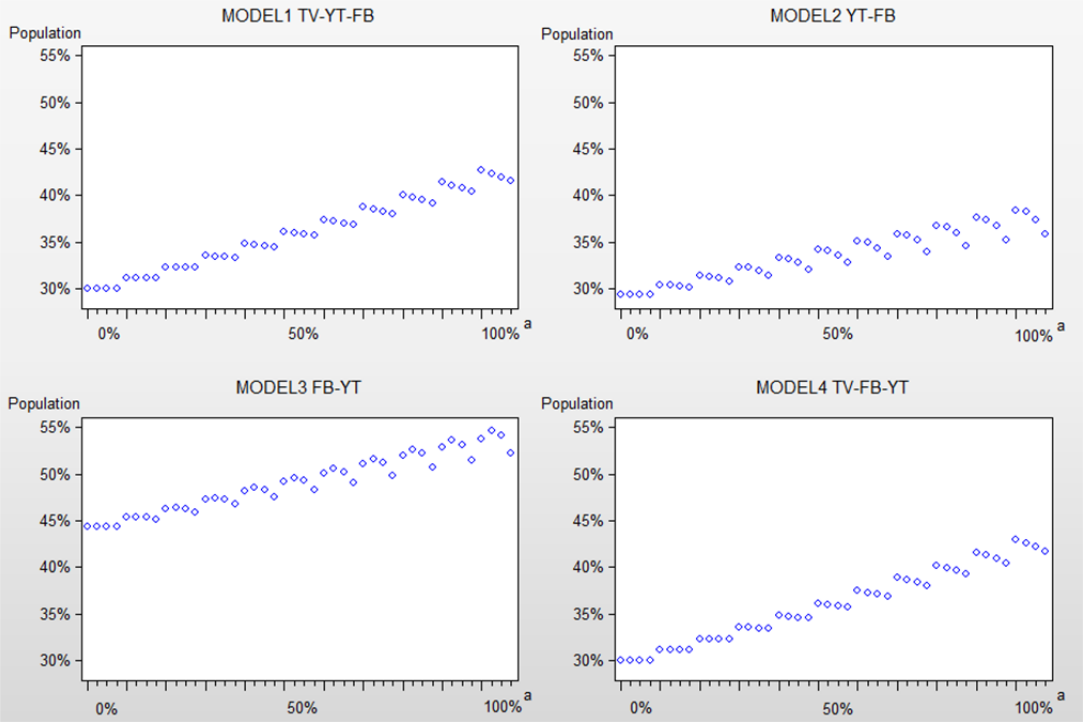
Bundle /Pattern	{YouTube, Facebook, Television}	{YouTube, Television}	{ Facebook, Television}	{YouTube, Facebook}	{YouTube}	{Facebook }	{Television}
(1)	50%	20%	0%	0%	0%	0%	30%
(2)	40%	30%	10%	0%	0%	0%	20%
(3)	30%	40%	20%	0%	0%	0%	10%
(4)	20%	50%	30%	0%	0%	0%	0%

Table 3.1 Patterns of network structures based on the American data

We create these patterns considering shares that are multiples of ten for simplification. All these patterns are consistent with the data. The percentages in each column denote the percentage of Americans who would choose that bundle as their optimal choice. For instance, in pattern (1), 50% {YouTube, Facebook, Television} means that there are 50 percent of Americans decide to receive information or news via all three types of media. Twenty percent {YouTube, Television} means that there is one-fifth of Americans who will use YouTube and Television and do not have a Facebook account. 30% {Television} means that 30 percent of Americans decided to get information from Television only and not via the Internet.

Then we calculate the coverage rate of each pattern of network structure to see how the relationship spread will affect the information transmission path.

The four scatter diagram in Graph 3.1 show the distribution of the coverage rate of the four models explained above. We calculated the coverage rate of each information structure pattern in each model. At the same time, we increase the inter-media transmission barrier in each model, to see whether a higher barrier level will give an impact on the structure pattern then lead to a different result compared to the pattern with lower barrier level.



Graph 3.1 Audience Coverage Rate of each model based on four patterns of network structures, the United States 2013.

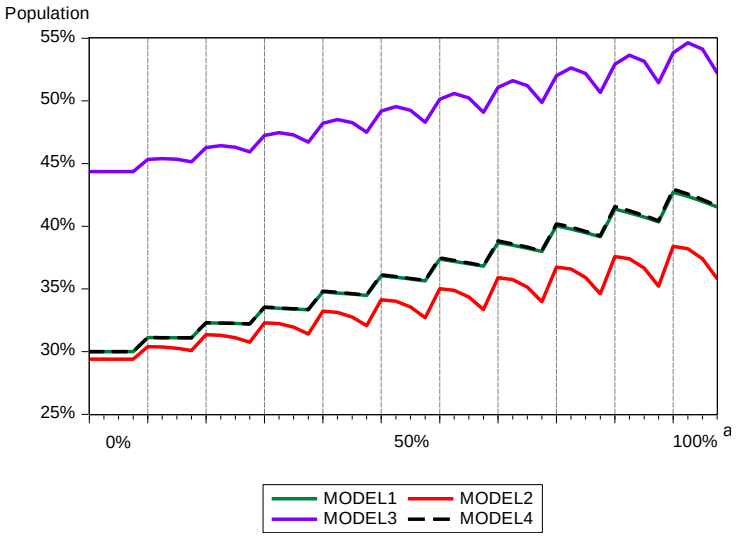
The result is straight-forward from Graph 3.1. Pattern (2) is the ideal pattern in MODEL3 which lays on the bottom-left and pattern (1) is the best one in the other three models. These findings imply that in an economy which has identical market share of each type of media as the shares in America, the more people use all three types of media {YouTube, Facebook, Television} the more audience will be able to see the display advertisement if an advertiser injects his display ad into Television or YouTube. However, if the advertiser decide to put his display ad on Facebook, the number of people who choose bundle {YouTube, Facebook, Television} will not be the only factor he should consider, but also the factor that the percentage of Americans choosing bundle {Facebook, Television} should not be zero.

3.2 Inter-media transmission barrier (1/a)

3.2.1 Identical inter-media transmission barrier ($1/a_1=1/a_2=1/a_3=1/a_4$)

The inter-media transmission barrier is defined as the reverse of the inter-media transmission propensity a_i. Transmission propensity is be defined as the percentage of the audience who use two types of media and who would like to share the information they got from the first medium to the second one. For instance, if a_1 is the transmission propensity from Television to Youtube, then we can say that, in the audience who can access both Television and Youtube, there will be a_1 percentage of them would like to share the information they got from the Television to the Youtube .

We give a set of values to a_i from 0 percent to 100 percent and get the following results:



Graph 3.2.1 Evolution of the coverage rates when a_i increases from 0% to 100%

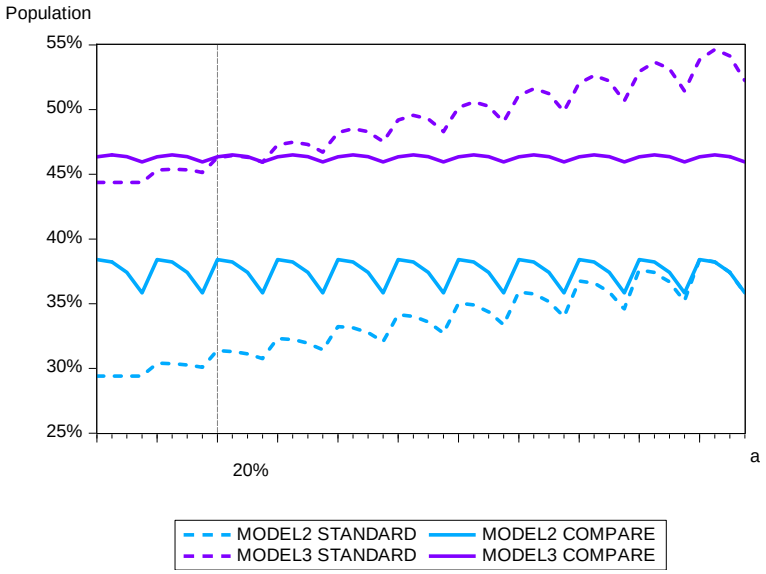
First of all, the coverage rate will not be affected by the order of the media in the sub-transferring process, but by the type of media that a display advertisement is first injected that mattered. From Graph 3.2.1, one can see clearly that the path of Model 1 is exactly overlaying on the path of Model 3, which means that the result of information transmission is identical between the path Television-YouTube-Facebook and the path Television-Facebook-YouTube, in other words the result is independent of media orders in the sub-transferring process.

Second of all, both the gap between Model 3 and Model 1 and the gap between Model 3 and Model 2 are constant, namely, approximately 15 percent of Americans. The coverage of Model 1 and Model 2 are similar. For example, in the United States, putting a display advertisement on Facebook, advertisers will reach the highest audience coverage rate if they compare with putting the advertisement on the Television or YouTube. What's more, there will be an additional 15 percent of Americans who would be able to get the information if the advertisement is initiated from Facebook than initiated from Television or YouTube. This could be one of the main reasons that, in the survey we mentioned above, many advertisers indicated that they are shifting offline or online video site budget into online paid social media advertisings.

Third of all, the lower the inter-media transmission barrier $1/a_i$ the higher the coverage rate for all the three types of media.

3.2.2 Different inter-media transmission barrier ($1/a_1 \neq 1/a_2 \neq 1/a_3 \neq 1/a_4$)

This time, let us evaluate a set of barriers $1/a_i$ which are more closer to the reality. Assume that the information transmission barriers from offline media to online media are infinite, then $1/a_1 = \infty$ and $1/a_2 = \infty$ or $a_1=0$, $a_2=0$. Assume the transmission propensity from YouTube to Facebook a_3 is 100% and the transmission propensity from Facebook to YouTube a_4 is 20%. Then we get Graph 3.2.2.



Graph 3.2.2 A higher transmission propensity can do nothing on the receiving side but its impact on the sending side is significant

We find that, the coverage gap narrows from 15% to 7%. What interesting is that if we compare the transmission propensity set $\{a_1,a_2,a_3,a_4\}=\{0\%,0\%,20\%,20\%\}$ with $\{a_1,a_2,a_3,a_4\}=\{0\%,0\%,100\%,20\%\}$, where $\{a_1,a_2,a_3,a_4\}=\{0\%,0\%,20\%,20\%\}$ is the control group and $\{a_1,a_2,a_3,a_4\}=\{0\%,0\%,100\%,20\%\}$ is the experimental group, a higher transmission propensity can do nothing on the receiving side but its impact on

the sending side is significant. This finding implies that, if you assume the transmission propensity from YouTube to Facebook a3 was 20% in period 1, and the YouTube Company (the sending side) got some technological improvement and made its transmission propensity a_3 from 20% to 100% in period 2, then there will be a 23.5% increase on its audience coverage from 31.5% of Americans in period 1 to 38.9% of Americans in period 2. The coverage rate of Facebook (the receiving side) will keep unchanged at 46.3% in both period 1 and period 2.

3.3 User Activity (b)

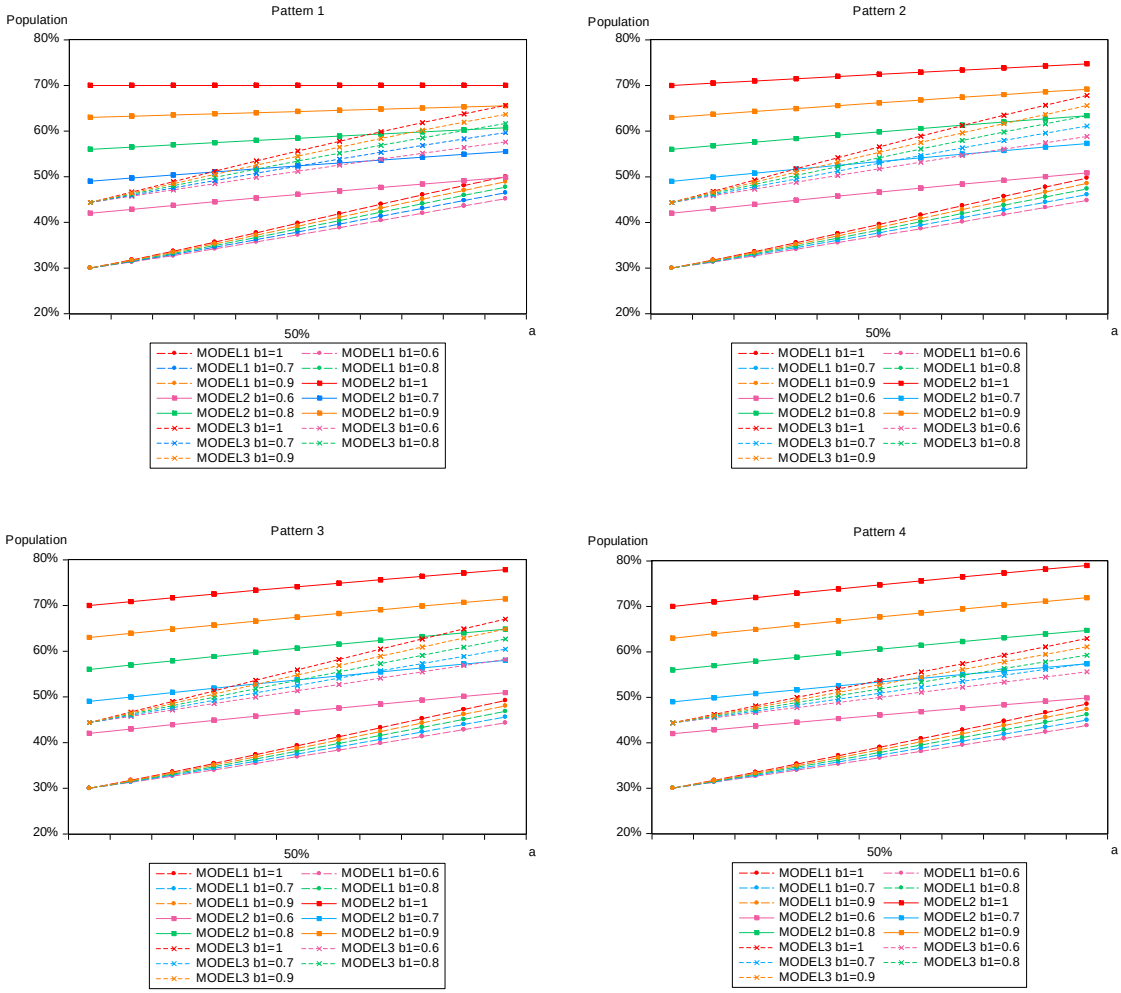
In the following context, we will show that the level of user activity is an important factor advertisers should consider. In order to derive our result, we will draw the evolution lines of coverage of the first three models, and do some comparison and analysis based on them.

3.3.1 User activity of the online video site YouTube (b_1)

b_1 denotes the User activity of the online video site YouTube and it is calculated as the percentage of all online video viewers who use YouTube to watch online videos.

Graph 3.3.1 shows the evolution of coverage of YouTube and Facebook when the YouTube User Activity varies from 60 percent to 100 percent. The dash lines stand for Facebook's coverage. Keeping the other exogenous variables unchanged, the interval that the coverage of Facebook dominates the coverage of YouTube is $b_1 \in$ [0%,60%]. This finding implies that, if other variables stay constant, then as long as

the percentage of active users out of total users is lower than 60 percent, Facebook would be the better choice for the advertisers. On the other hand, when $b_1 \in$ [80%,100%], YouTube would be the better. One should also consider the level of inter-media transmission barrier a_i if b_1 sets between 60% and 80%.



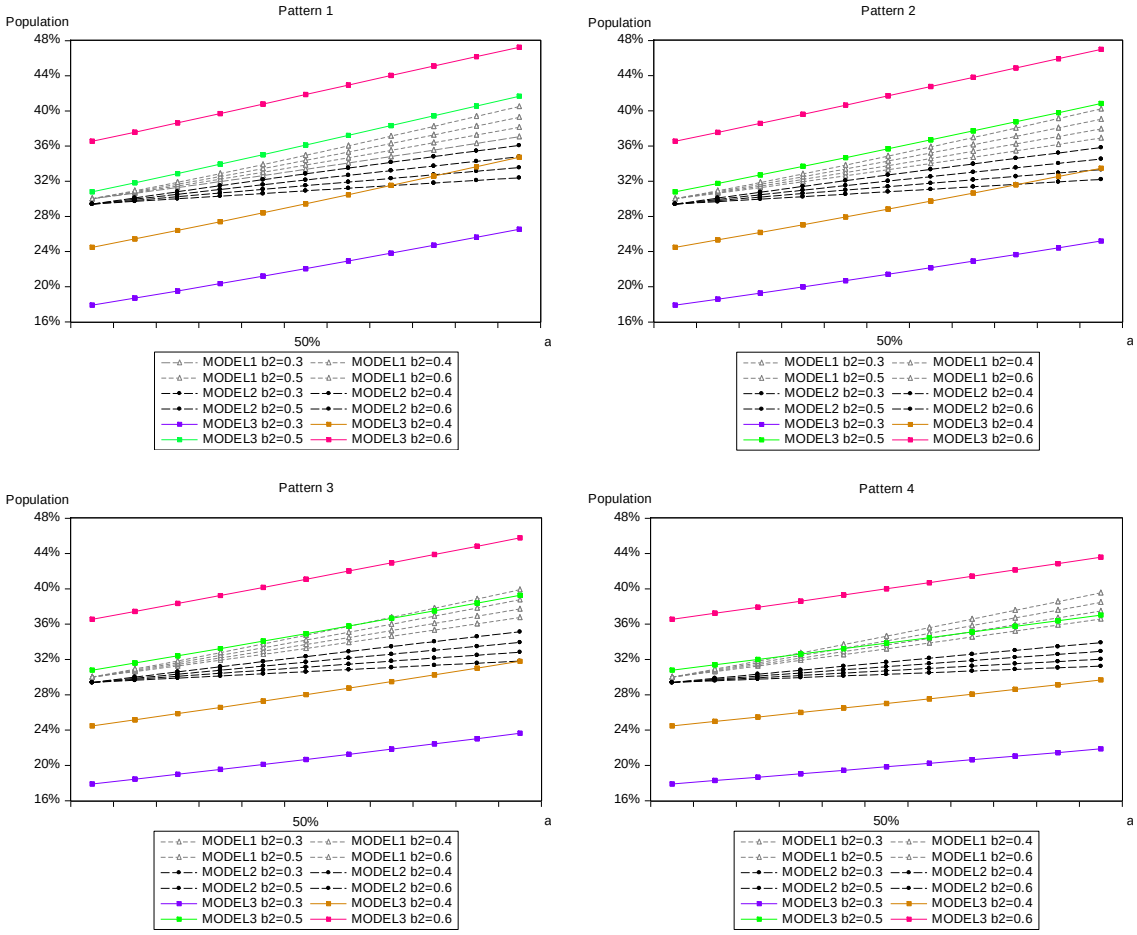
Graph 3.3.1 Evolution of coverage of YouTube and Facebook when the YouTube User Activity varies from 60% to 100%

3.3.2 User Activity of the Online Social Media Facebook (b2)

The variable b_2 denotes the User activity of the online social network Facebook and it

is calculated as the percentage of DAU out of the total users ($\frac{\text{DAU}}{\text{Total Users}}$).

Graph 3.3.2 shows the evolution of the coverage of YouTube and Facebook when the Facebook User Activity varies from 30% to 60%. The dashed lines stand for the coverage of YouTube. Keeping the other exogenous variables constant, the interval in which the coverage of Facebook would dominate the coverage of YouTube is $b_1 \in$ [50%,100%]. Only if the User Activity of Facebook is lower than 20% YouTube dominates. The findings here tell us that if other variables stay constant, then as long as the percentage of DAU is higher than 50%, Facebook is the better choice for the advertisers.



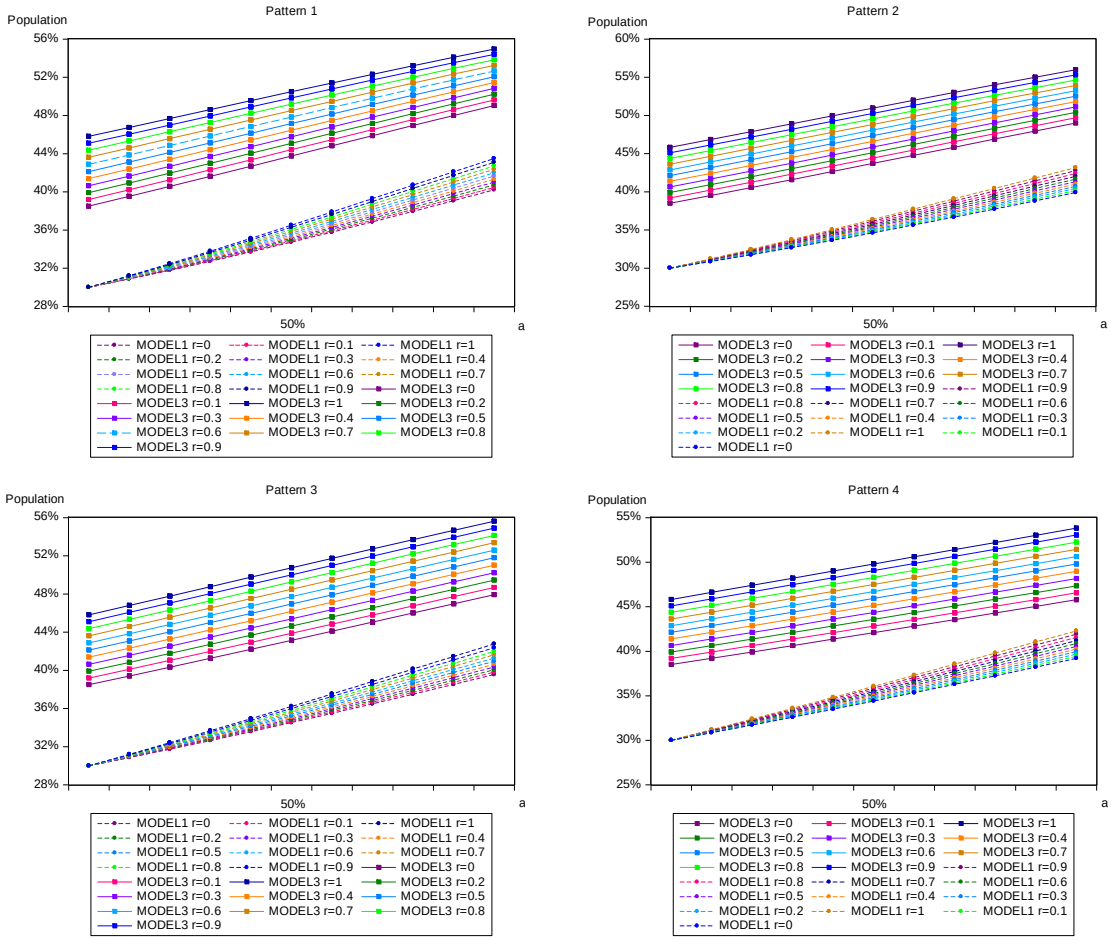
Graph 3.3.2 Evolution of the coverage of YouTube and Facebook when the Facebook User Activity varies

from 30% to 60%

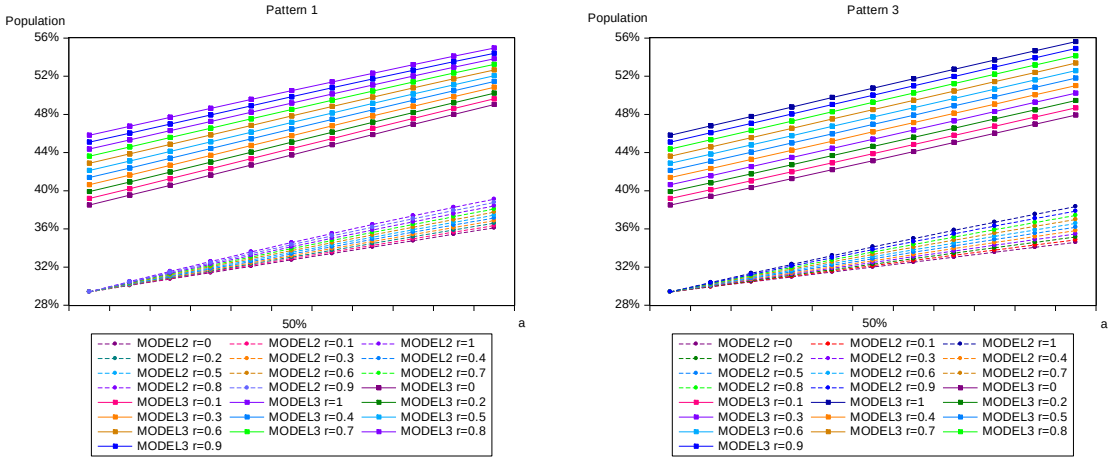
3.4 Link-sharing Ratio of the Online Social Media Facebook (r)

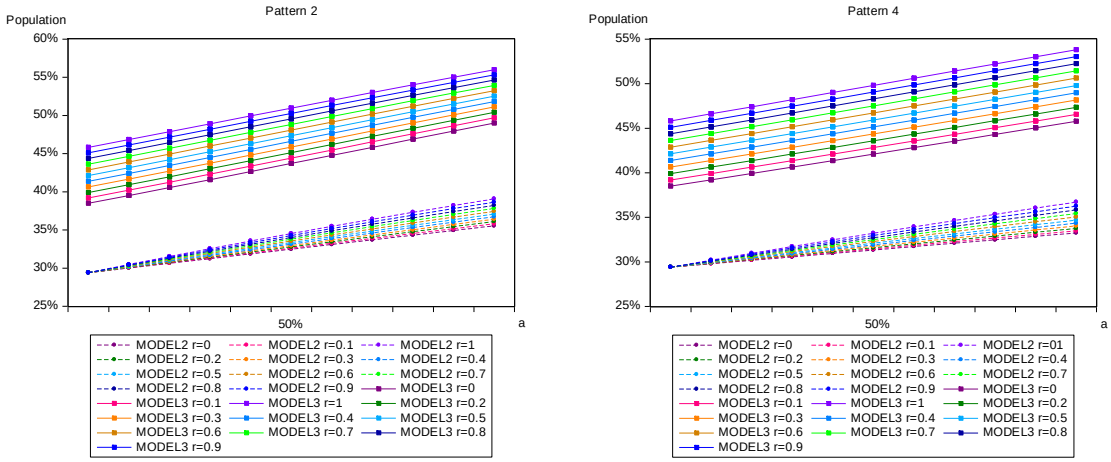
The link-sharing ratio is a measure of users' sharing activities. The ratio is calculated by dividing the amount of videos shared by the amount of video viewed in the given period. This variable can be considered as an index of ad attractiveness. People tend to share a link when they find it is interesting or strongly agree with it. The more the audience shares the link after watching a video the higher the ratio would be.

Graph 3.4.1 and Graph 3.4.2 shows the evolution of the coverage rate of YouTube, Television and Facebook when the Facebook link-sharing ratio r changes from 0 percent to 100 percent. From the graph we can see the impact that the link-sharing ratio has not significant, since it only contributes at most 7 percent of the population to Facebook, 10.4 percent to YouTube and as low as 3.3% to Television. The effectiveness of the link-sharing ratio on Television and YouTube shows a positive relation with the inter-media transmission propensity $a_{i.}$ These findings imply that when an advertiser is facing a high propensity, efforts to improve the attractiveness of a display advertisement and lifting its relative link-sharing ratio could be, theoretically, a positive choice but its improvement interval is narrow. According to the Return-on-Investment method, a measure of the budget spent to achieve an objective versus the income generated through the activity, investing too much budget on a display ad to pursue the best audiovisual effects may not be a rational idea.



Graph 3.4.1 Evolution of coverage rate of YouTube and Facebook when the Facebook link-sharing ratio r changes from 0% to 100%

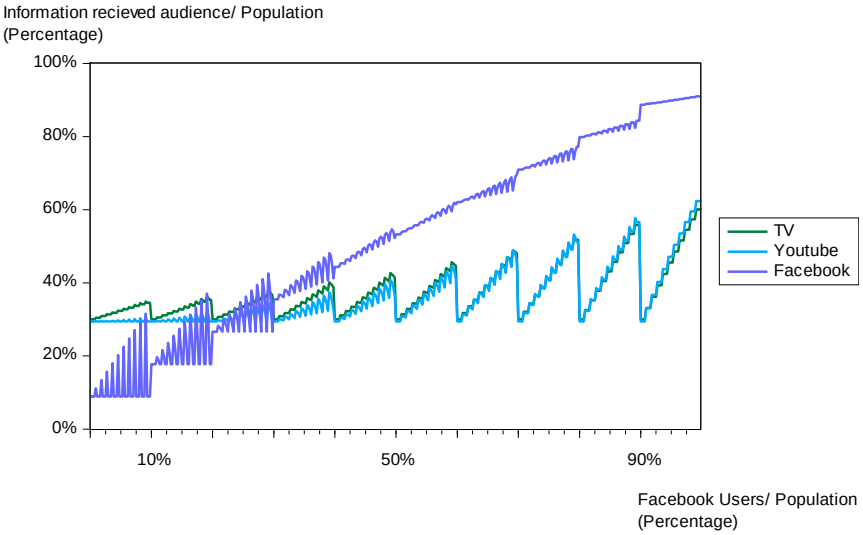




Graph 3.4.2 Evolution of coverage rate of Television and Facebook when the Facebook link-sharing ratio r changes from 0% to 100%

3.5 Number of Users of Social Media (N_{social})

Another important factor an advertiser should consider is the market share of the social media. In Graph 3.5 lines, the blue line describes the path of Facebook coverage rate while the other two lines belong to Television and YouTube. It is clear that as soon as the market share of Facebook goes above 30 percent, the blue line moves steadily upward and its coverage rate is in the ascendance. This implies that, based on the 2013 U.S. data, as long as the market share of Facebook is higher than thirty percent, the injection of a display ad into the Facebook pages will be the optimal choice for an advertiser. This result could also be applied to the choice of an efficient social media. For instance, if a social media has more than 30 percent of the market share and an Active User ratio as high as 77% then we can say it is the optimal choice of audience coverage.



Graph 3.5 Evolution of coverage rate of Television, YouTube and Facebook when the market share of Social media vary from 0% to 100%

V. Conclusion

By doing the empirical study of America Media-Audience Market, we get some conclusions and suggestions for advertisers.

Advertisers considering which type of media their display ads should be put on to generate the highest audience coverage level should pay attention to two factors --- the market share and the user activity level (for example, the ratio of daily active users out of total users for social media). The market share and the user activity level build the foundation of the audience coverage rate. In America, Facebook, whose market share is 50 percent and user activity level is 77 percent, is the best choice for

advertisers. We also find that comparing with offline media and online video sharing sites, the social media would be the best choice until its market share drops below 30%, if the user activity level maintains. On the other hand, if the market share of social media is fifty percent, social media will have the highest coverage rate as long as the user activity level of social media is higher than 50% or user activity level of online video site is lower than 60%.

We also find that the information transmission path or the link-sharing ratio of a video/display ad is not as important as we thought.

The information transmission path is symmetric. For example, consider there are three media A, B, C. In the first step, information is shared from media A to media B and C, and then in the second step, information is shared between media B and C. The result shows that no matter which media type between B and C receives the information from media A first, the total number of information delivered audience are the same.

Different patterns of network structure in the economy will generate different coverage rates but the difference between patterns is small and not more than 1% of the population. Generally speaking, the more people use all three types of media the more people will be able to see the ads.

The link-sharing ratio of a video or display ad does not exert a significant effectiveness on audience coverage. Investing too much budget on display ads to

pursue the best audiovisual effects may not be a good idea. For example, link-sharing ratio only contributes at most 7 percent of population to Facebook.

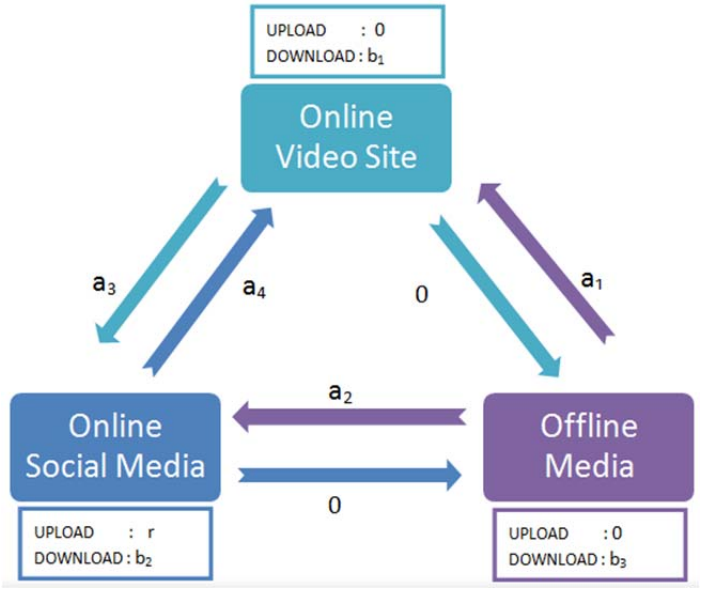
The last finding is that higher transmission propensity has no impact on the information receiving side but its impact on the sending side is significant. This finding is useful for advertisers when vacillating between two similar media, such as YouTube and Fox, which one has more sharing channels can be expected to generate higher coverage.

Although we have interpreted our model as a display ads transmission system and have fit America data to it, there are broader applications for the model. For example, it can also be applied to natural disaster alarms and election advertisement study. The results can be made more accurate by narrowing down the target audience by age, agenda, location, education, or occupation; data from facebook.com shows that their most active social networkers are female and 18-34-year-old people. Therefore, if we had to focus only on 35-year-old or older males, the parameters in the model would have to be modified as well and the result must have been different from the above. This paper can also help multinational corporations in their marketing strategy. Audience behaviors are extremely different across countries, making suitable advertising strategies crucial.

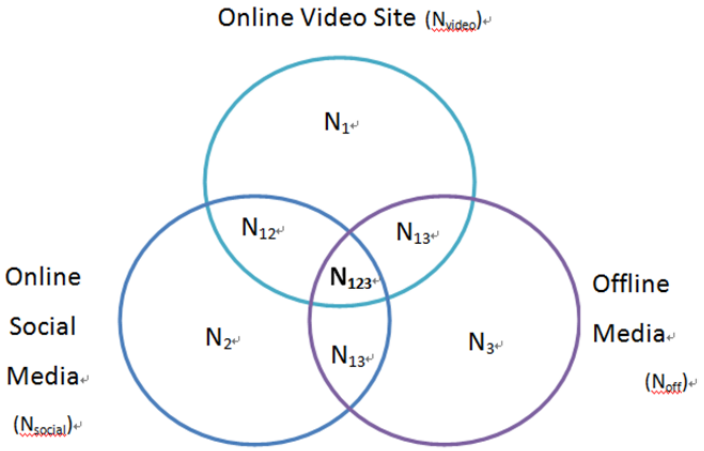
What’s more, another suggestion to advertisers is to conjunct social media with other

type of media. A survey from Vizu shows that doing advertising on social media can bring a significant brand lifting but the effect on product sale is not that efficiency. One of the reasons may be the consumer trust varies among different type of media.

VI. Appendix



Flowchart 1 Overview of the transmission system



Flowchart 2 $\sum N_i=10$, i={1,2,3,12,13,23,123}

VII. Eviews Functions

MYT = (NYT_FB + NTV_YT_FB) / NYT

MFB = (NYT_FB + NTV_YT_FB) / NFB

S1 = NTV * b3

U1 = (NTV_YT + NTV_YT_FB) / NTV * b3 * a1

X1 = NYT - NTV_YT * b3 - NTV_YT_FB * b3

X2 = NFB - NTV_FB * b3 - NTV_YT_FB * b3

V1 = U1 * b1 * X1

Z1 = (NTV_FB + NTV_YT_FB) / NTV * b3 * a2

D1 = Z1 * b2 * (X2 - V1 * MYT)

E1 = D1 / NFB * r * b2 * (X2 - V1 * MYT - D1)

F1 = E1 / NFB * r * b2 * (X2 - V1 * MYT - D1 - E1)

I1 = V1 / NYT * MYT * a3

J1 = I1 * b2 * (X2 - V1 * MYT - (D1 + E1 + F1))

J2 = J1 / NFB * r * b2 * (X2 - V1 * MYT - (D1 + E1 + F1) - J1)

J3 = J2 / NFB * r * b2 * (X2 - V1 * MYT - (D1 + E1 + F1) - J1 - J2)

G1 = (D1 + E1 + F1) / NFB * MFB * a4

H1 = G1 * b1 * (X1 - V1 - (D1 + E1 + F1 + J1 + J2 + J3) * MFB)

S2 = NYT * b1

I2 = MYT * b1 * a3

X3 = NFB - NYT_FB * b1 - NTV_YT_FB * b1

D2 = I2 * b2 * X3

E2 = D2 / NFB * r * b2 * (X3 - D2)

F2 = E2 / NFB * r * b2 * (X3 - D2 - E2)

W1 = NFB * b2

W2 = W1 / NFB * r * b2 * (NFB - W1)

W3 = W2 / NFB * r * b2 * (NFB - W1 - W2)

G3 = (W1 + W2 + W3) / NFB * MFB * a4

H3 = G3 * b1 * (NYT - (W1 + W2 + W3) * MFB)

I3 = H3 / NYT * MYT * a3

D3 = I3 * b2 * (NFB - (W1 + W2 + W3) - H3 * MYT)

E3 = D3 / NFB * r * b2 * (NFB - (W1 + W2 + W3) - H3 * MYT - D3)

F3 = D3 / NFB * r * b2 * (NFB - (W1 + W2 + W3) - H3 * MYT - D3 - E3)

S4 = NTV * b3

Z4 = (NTV_FB + NTV_YT_FB) / NTV * b3 * a2

U4 = (NTV_YT + NTV_YT_FB) / NTV * b3 * a1

D4 = Z4 * b2 * X2

E4 = D4 / NFB * r * b2 * (X2 - D4)

F4 = E4 / NFB * r * b2 * (X2 - D4 - E4)

V4 = U4 * b1 * (X1 - (D4 + E4 + F4) * MFB)

G4 = (D4 + E4 + F4) / NFB * MFB * a4

H4 = G4 * b1 * (X1 - V4 - (D4 + E4 + F4) * MFB)

I4 = V4 / NYT * MYT * a3

J4 = I4 * b2 * (X2 - V4 * MYT - (D4 + E4 + F4) - H4 * MYT)

J5 = J4 / NFB * r * b2 * (X2 - V4 * MYT - (D4 + E4 + F4) - H4 * MYT - J4)

J6 = J5 / NFB * r * b2 * (X2 - V4 * MYT - (D4 + E4 + F4) - H4 * MYT - J4 - J5)

COVER1 = S1 + V1 + D1 + E1 + F1 + H1 + J1 + J2 + J3

COVER2 = S2 + D2 + E2 + F2

COVER3 = W1 + W2 + W3 + H3 + D3 + E3 + F3

COVER4 = S4 + D4 + E4 + F4 + V4 + H4 + J4 + J5 + J6

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