Understanding the Effects of Message Design on Firm-Mediated Online Social Interactions: A Randomized Field Experiment

Completed Research Paper

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Abstract

Recent advances in IT have provided firms unprecedented ability to manage online social interactions. Despite growing popularity, few studies have examined firm’s optimal design choices in firm-mediated social interactions. We examine whether and how a firm can enhance effectiveness of online social interactions, by simply varying message shared by referrers. We focus on two pieces of information in message – information of sender’s purchase status and information about existence of referral rewards – and their impacts on recipient’s purchase. Collaborating with an online deal platform, we conduct a randomized field experiment testing effectiveness of different firm-mediated messages. We find that 1) information of sender’s purchase leads to more purchases from recipients; such effect is larger for products with strong uncertainty and network effect; 2) the incremental effect of Referral Rewards information crucially depends on the nature of product. The findings will guide optimal message design at aggregate and individual level.

Keywords: Field experiment, Social influences, Network effect, Information asymmetry, Information systems design
Introduction

Social interactions have an important impact on consumer choices and have been studied extensively (Godes et al. 2005, Trusov, Bucklin, and Pauwels 2009, Schmitt, Skiera, and Van den Bulte 2011, Berger 2011, Moe 2014, Pfeiffer and Zheleva 2012). With the rapid advances in information technologies, a large volume of social interactions and referrals are now created and disseminated through online channels in the form of website-mediated emails, social media posts, and mobile messages. An interesting aspect of the online setting is that while consumers are able to quickly disseminate online word of mouth about firms and products, firms are also increasingly able to mediate these interactions among customers. Firms have transitioned from being passive observers and moderators of online social interactions to becoming more active mediators (Godes et al 2005) of online social interactions and referrals. Today’s technologies provide firms the ability to mediate and manage various granular aspects of the social interaction process including - the motivations of the referrers, the channels of referral, and the message, among others. As noted by Godes et al (2005), despite the importance of social interactions, little research has been done on how firms may potentially use and impact them. This represents an exciting research opportunity. In particular, there are very few studies that have examined the optimal design choices for a firm seeking to maximize returns from firm-mediated social interactions. Our study seeks to fill this gap.

An important aspect of online social interactions is the message that is shared between senders and recipients. In the case of "firm-mediated messaging" among users, while the sender can choose the recipients with whom they share the messages (online word of mouth or referrals), the firm nevertheless, has the ability to control several aspects of the message and its content. Such firm-mediated messaging is increasingly the norm in a large number of online websites, retailers, and platforms. Despite the increasing use of such mechanisms by firms online, there is very little understanding of how different messages impact social interactions and their outcomes. Given the ability of the firm to partially control the content of the message that is shared between the sender and the receiver, our study seeks to examine whether and how a firm can enhance effectiveness of online social interactions, by simply varying the message shared by referrers with their social connections.

In this study we specifically focus on two key pieces of information contained in the message – information about whether the sender has purchased the product (i.e., the deal) prior to referral, and information about the existence of monetary rewards for referrals – and their impacts on the recipient's purchase decision. Motivated by previous literature on social learning, we hypothesize that information about the sender's purchase of a deal that she shares with her social connections serves as a social learning cue and such information could reduce the uncertainty and raise the expectation about the quality of the product or service for the recipient. At the same time, if network effects are present for the shared product/service (e.g. a concert, a winery tour, some gig in fashion), then information about sender's purchase may further increase recipient's purchase likelihood as she can gain additional utility from her friend's possession/participation of the product/service (Katz and Shapiro 1985, Farrell and Saloner 1985, Sundararajan 2006, Tucker 2006, Katona et.al. 2011). On the other hand, information about the presence of rewards for referral could undermine the credibility of the sender (Ryu and Feick 2007) and have a damping influence on the recipient’s likelihood of purchase. The impact of social learning and referral rewards, and their interaction effects, could also vary depending on the type of product or service offering. To understand the detailed mechanism, we examine their impact on outcomes for products/services of differing uncertainty (e.g., low uncertainty vs. high uncertainty products/services) as well as for products/services of differing “social-ness” (e.g., standalone versus social products/services). More specifically, we seek to answer the following questions:

1) Effectiveness of Message Design: Can a firm enhance effectiveness of online social interactions, by simply varying the message shared by referrers (also known as senders) with their social connections?

2) Will the visibility of information about the sender's purchase in the shared message have a causal impact on the recipient's purchase decision?

3) Will the visibility of information about the existence of referral rewards increase or reduce the effect of information about the sender's prior purchase of the shared deal?

4) How do product characteristics, sender characteristics, recipient characteristics, and past social interaction affects the outcomes of referral?
Guided by theories of social learning and network effects, we illustrate the effect of revealing sender’s purchase status in Figure 1 and the effect of revealing additional information on referral reward program in Figure 2. Sender’s purchase (see Figure 1) serves as social learning cue and signals the quality of the product/service to the recipient. Recipients can learn from sender’s choice and infer the shared product/services of high quality (Iyengar et al. 2011). Consequently, such social learning cue is likely to be more valuable to the recipient for product/services characterized by high uncertainty (Nair, Manchanda and Bhatia 2010). However, for social products (characterized by a positive social network effect), there are additional gains from network effects resulting from the referrer’s purchase of the product/service (Katz and Shapiro 1985, Katona et.al. 2011). Consequently, information about the referrer’s prior purchase is likely to have a greater impact on the recipient’s likelihood of purchase for social products as compared to that of standalone products in both low and high uncertainty categories.

<table>
<thead>
<tr>
<th>Characteristics of Shared Deal</th>
<th>High Uncertainty</th>
<th>Low Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Product</td>
<td>Social learning &amp; Network Effect (Strongly Positive)</td>
<td>Network effect (Weakly Positive)</td>
</tr>
<tr>
<td>Standalone Product</td>
<td>Social learning (Positive)</td>
<td>(No Effect)</td>
</tr>
</tbody>
</table>

**Fig. 1: Impact of Sender’s Prior Purchase Information on Recipient’s Purchase Likelihood**

Information about the referral rewards program (Figure 2) can dampen the credibility of the referrer and the value of the signal provided by the referrer’s prior purchase. The recipient may infer that the sender’s actions are driven by monetary incentives, and may therefore discount the credibility of the signal conveyed by the sender’s purchase (Ryu and Feick 2007). This negative effect of the referral reward information is likely to be higher when there is greater uncertainty, because of high social learning effect. Further, referral reward information is also likely to have a stronger (negative) impact on the recipients’ purchases of social products compared to standalone products due to decreasing network effect – recipient may gain less positive utility from participating social activities with the sender. In summary, this ‘attenuation’ effect is likely to be stronger for high uncertainty products and more so for social product categories compared to standalone product categories (left part of Figure 2). On the other hand, referral reward is also likely to have a positive effect on purchase likelihood in the low uncertainty case as recipients may potentially get referral rewards through sharing after purchase (right part of figure 2).

Figure 3 summarize the hypotheses on the impact of prior purchase information, and the incremental effect of referral rewards information, on recipient’s purchase likelihood for products of different uncertainty and ‘social-ness’
To empirically test the above hypotheses, we design and conduct a large-scale randomized field experiment in collaboration with a leading daily deal platform in the US to study the causal impact of firm-mediated message on recipient’s behavior. The platform offers a wide range of daily deals for local services (e.g. restaurants, beauty and health, events) and standard products (e.g. electronics, cosmetics) at a sizeable discount and has a large customer base.

The results are encouraging and interesting. First, we confirm that message design indeed can enhance the effectiveness of online social interactions. Adding information on sender’s purchase to the message increases the probability of recipient’s purchase by 15% at aggregate level. The result is both economically and statistically significant, suggesting that seemingly minor changes in message design may potentially have a large impact on customer behavior. However, when information about the referral program is presented along with information about the sender’s purchase status, there is large and negative interaction effect. Our findings have implications for optimal message design for firms as well as online platforms.

We further examine how message design affects the effectiveness of online social interactions, by exploring the heterogeneity in treatment effect on different types of deals. The empirical findings largely confirm our hypotheses: First, information of sender’s purchase has the larger (positive) effect on products with higher uncertainty as well as on social products. The effect is largest for social deals with high uncertainty. Second, the incremental effect of information on referral reward differs dramatically for high uncertainty vs. low-uncertainty products. While adding information on referral reward may boost the likelihood of purchases for low-uncertainty commodity-like products, it reduces social learning effect.
for high-uncertainty products and has a significant negative effect. Interestingly, we find that such negative incremental effect is even larger for social products, indicating a further reduction in network effects caused by credibility concern.

Identifying optimal design of firm-mediated message at a group level is a valuable endeavor, but not the end in itself. With the availability of large amount of data on the behaviors of senders and recipients and their historical interactions, as well as the ability to process requests in real time, firms can actually personalize firm-mediated messages at an individual level. While personalization is a common practice in the context of firm-customer interactions, personalization of firm-mediated customer-customer social interaction is still in its infancy. To investigate its potential, we explore the heterogeneity in sender and recipient characteristics as well as their past interactions. We identify heterogeneous treatment effects related to sender characteristics and past social interactions and discuss its implications to the firm.

Estimating the effect of message content of the sender on social contagion (recipient’s purchase and sharing) has been traditionally difficult for two reasons: first, the content of the message in interpersonal communications is usually unobservable to researchers; second, and probably more important, are issues of endogeneity (Manski 1993), i.e. content of the message may be correlated with the tie strength, the characteristics of the recommended product as well as external incentives, as interpersonal communications are often strategic (Crawford & Sobel 1982). Several approaches for identifying peer effects have been proposed, including dynamic matched sampling (Aral et.al. 2009), structural models (Ghose and Han 2010), ad hoc approaches (Christakis and Fowler 2007) and instrumental variables (Tucker 2008). However, most of above methods are not applicable to our study because of unobserved data and potential endogeneity issues. Our study overcomes this issue by using a randomized experiment to obtain unbiased estimates of causal effect of message on social interactions. This study is also among the first to analyze the potential of firm-mediated messaging and the findings of the study not only add to our understanding of the role of different messages on referral outcomes, but also provide valuable guidelines for optimal design of such information sharing mechanisms at group level and at individual level.

Relevant Research

There is a growing literature on social interactions (see Godes et al (2005) and Libai et.al.(2011) for excellent reviews) and our study is closely related to four streams of research.

The first stream is on the causal effect of peer influence. Numerous studies have established the existence of social influence through observational studies (Iyengar et al. 2011) and randomized field experiments (Aral and Walker 2012, Bursztyn et.al. 2012). The message is widely considered as the most fundamental factor driving social influence (Berger 2012). Our study, with its primary focus on firm-mediated messaging, extends the literature on peer influence by identifying the incremental contribution of different “components” of a message (e.g. purchase status of the sender) on recipient outcomes by enabling or disenabling specific features in the message. While prior studies (Aral et.al. 2011, 2012) have treated messages in online social interactions as a whole, we are able to decompose social influence at component level by varying different features of a message. In addition, the wide range of product characteristics included in our study will also enable us to differentiate between the two mechanisms of social contagion: social learning (wherewith the recipient infers the high quality of products from sender’s purchase) and network effects (wherewith the recipient gets additional utility from sender’s adoption of product, e.g. social events).

Our work also draws upon prior research on referral rewards. There have been a number of analytical models examining the optimal design of referral rewards from a firms perspective (for instance see, Biyalogorsky et al 2001, Kornish and Li, 2010, Xia et al 2011). A few experimental studies (Wirtz and Chew, 2002; Ryu and Feick, 2007) have examined the impact of referral rewards on the likelihood of referrals. A couple of studies (Tuk et al 2009; Verlegh et al 2013) that have focused on the role of rewarded referrals on recipient responses have been small scale lab experiments involving students. Ours is the first large scale field experiment to examine the role of the knowledge of monetary rewards for the referrer on the recipient’s outcomes. Our study also extends current work by analyzing the interaction effects between referral awards and recipient’s perception of the sender by manipulating features in the message.
Our work is also related to the literature on Group-Buying – specifically, the social network marketing mechanism embedded in the Group-Buying selling format (Jing and Xie, 2011). Existing research on Group-Buying largely focuses on the power of buying groups on suppliers (Che and Gale, 1997; Chen and Li, 2011). An exception is Jing and Xie (2011), who develop an analytical model to compare and contrast Group-Buying - a mechanism to motivate interpersonal information and knowledge sharing, with Referral Rewards program – a mechanism which uses monetary rewards to motivate existing buyers to spread product information to their peers. A key assumption underlying their model is that while Group-Buying requires the customer to make referrals before any transaction is completed, Referral Rewards programs allow the customer to make a referral after she has purchased the product. However, in a number of real-world Group-Buying situations, including ours, customers have the ability to share information about the deals both prior to as well as after their purchase. The separation of the sender's purchase status and her sharing behaviors provides us an unprecedented opportunity to examine the impact of the message content relating to the purchase (or the lack thereof) by the sender on recipients' behaviors.

Finally, our study (especially the personalization of message design) is also related to studies of factors moderating the effectiveness of WOM, including the sender and the recipient (Iyengar et al. 2011), tie strength, similarity between sender and recipient’s tastes or opinions, and network characteristics (Stephen and Berger 2012, Katona et.al. 2011). For instance, Naylor, Lamberton, and Norton 2011 find that word-of-mouth from similar others may have a more positive effect. Goldenberg, Libai, and Muller 2001 find that the influence of weak ties is at least as strong as the influence of strong ties for a given individual in social network. Stephen and Lehman 2009 find the transmitter and transmitter-recipient relationship characteristics as potential drivers of reception/listening. We complement this stream of research by examining the interaction effects of the above factors with two key components of the message.

Research Context

We collaborate with a daily deal platform in the US and design a randomized field experiment to study the causal impact of firm-mediated message on recipient’s behavior. The platform offers a wide range of daily deals for local services and standard products at a high discount and has a large customer base. On each deal page on the firm’s website, the platform provides channels through which customers (senders) can share these deals with their social connections. Customers (senders) can share deals with their friends by clicking specific channel buttons which are prominently displayed. Specifically, senders who wish to share through email can add a recipient’s email address and click “send”1. For email referrals, the platform will then automatically deliver emails to each recipient’s email address separately2. Every day, a large volume of shares are made by customers through the firm’s platform3. Typically, a user shares the firm-created message pertaining to the deal with her friends.

The platform uses a referral program to encourage social interactions. To participate in this program, a user is first required to purchase a particular deal first. Then, the user is given the option to share the deal with as many friends as desired. When three (or more) of the sender’s referrals purchase the deal, the sender gets a full refund of price she paid for the deal.

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1 A customized message box was available to record sender’s personal message to the recipients. But the function is disabled during the experiment session for all shares from post-purchase confirmation flow. Theoretically a sender could still type in personalized message if they go back to deal page and share the deal by clicking email sharing button there. But only a very small percentage of senders actually did so. We drop those few senders who customized their message for the purpose of this study.

2 Even though the sender may specify multiple recipients in a single ‘send’, each email is sent separately and hence, each recipient receives the email as a one-to-one personal share. Hence, we define each sender-recipient pair in a multi-recipient share as an “independent share”.

3 A fraction of the senders also share deals through their own channels (e.g. copy-paste the deal URL into their own social media or email account), leading to successful referrals. The firm has no control on the message content of such social interactions. Our field experiment focuses only on senders using the firm’s platform/website for sharing/referrals.
Experiment Design

As highlighted earlier, the objective of this study is to identify the effect of message design, i.e., effect of information about the 1) sender’s purchase status and 2) referral program, on recipient’s purchase. Using a 2 x 2 design (see Figure 9), we can identify the main effect as well as the incremental effects of information 2), on recipient’s purchase. After the sender confirms her share by clicking the ‘send’ button, she is randomly assigned to one of the four test groups (Figure 5). There are four groups for senders in our experimental setting (1 control (C), and 3 treatments (T1-T3)) that vary the visibility of sender’s purchase status and referral reward program, as illustrated in Figures 5-8.

Level of Randomization

We adopt an ‘inside-out’ design approach similar to that in Aral and Walker 2011. The randomization takes place at the level of the sender, i.e., all recipients of a sender for a specific deal that is shared received the same template. Randomization at the level of the sender (rather than at the level of recipients) allows for better control of potential spillovers between control and treatment groups and helps ensure that the stable unit treatment value assumption (SUTVA) is not violated. Such spillovers are more likely to happen within the local network of a sender as compared to across senders’ networks (Aral et.al. 2011). For instance, two friends of sender S are more likely to communicate about a specific concert deal (through sharing the deal or through other modes of communication) and influence each other’s decision as compared to recipients of two different senders. (however, this is still a possibility and we later discuss approaches to mitigate this concern). In addition, when the purchase status of a sender changes (i.e. the sender shares the same deal both before and after purchase), she may be randomly assigned to a new template. Also, when a sender shares a different deal, she may be randomly assigned to a new template.

![Figure 9: Illustration of random assignment of sender into test groups based on her purchase status on the specific shared deal](image-url)
Figure 5-8: Templates in the randomized field experiment

(Left Up) Message Template for Control Group C
(Right Up) Message Template for Post-purchase treatment group T1
(Right Bottom) Template for referral reward treatment group T2
(Left Bottom) Template for post-purchase & referral reward treatment group T3

Data

The randomized field experiment lasted for a 8-week period and resulted in a large and random sample comprising more than 20000 unique senders (i.e. more than 5000 senders in each test group, i.e. C and T1-T3). The number of recipients who were exposed to the deals in our study period exceeds 50000 (the sender may share a deal with multiple recipients). The data for our study comes from customer-to-customer email shares/referrals through the platform. For every firm-mediated email share, we record the unique hashed identifier of the sender (customer ID), the recipient (hashed email address), the shared deal, as well as the assigned test group. We record the purchase status of the sender, the number of
recipients she specifies in the batch of sent messages, the timestamp of share. Purchase decisions of the recipient are also included. Finally, the refund status of the sender for her referrals is also recorded. We further augment the above main dataset with the historical data on sender and recipient’s purchase history before experiment as well as price and subcategory of deals. The resulting dataset enables us to analyze the impact of message design at a granular level (i.e. heterogeneous treatment effect or moderating effect of sender, recipient, product characteristics)

**Empirical Findings**

Consistent with the level of randomization in the experimental design, we present our results at individual sender level (instead of recipient level). As a check of the randomization, we present in Table 1 the tests of equality of the sender-level covariates across four test groups in post-purchase share. As expected from the random assignment, the sample is well balanced across the covariates at different level. Further test between test groups at pair-level confirms the validity of randomization (not presented here due to limited space)

<table>
<thead>
<tr>
<th>Covariates</th>
<th>P-value (C=T1=T2=T3) (Post-purchase Share)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Referrer/Sender Characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>Total Number of Past Purchases (before test)</td>
<td>0.26</td>
</tr>
<tr>
<td>Total Spending (before test)</td>
<td>0.21</td>
</tr>
<tr>
<td>Days after Creating Account</td>
<td>0.54</td>
</tr>
<tr>
<td><strong>Recipient Characteristics</strong></td>
<td></td>
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<tr>
<td>Total Number of Past Purchases (before test)</td>
<td>0.53</td>
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<tr>
<td>Total Spending (before test)</td>
<td>0.55</td>
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<tr>
<td>Days after Creating Account</td>
<td>0.78</td>
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<tr>
<td><strong>Social Tie Characteristics</strong></td>
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<tr>
<td>Average number of shares between a pair</td>
<td>0.45</td>
</tr>
<tr>
<td>Percentage of reciprocal tie</td>
<td>0.67</td>
</tr>
<tr>
<td><strong>Shared Deal Characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>Average price</td>
<td>0.57</td>
</tr>
<tr>
<td>Category of Deals in Share (8 categories dummies)</td>
<td>all &gt;0.2</td>
</tr>
</tbody>
</table>

**The Effect of Message Design at Aggregate Level**

We first present main findings for post-purchase sharing scenario (see Table 2 in the appendix).

1) (Effect of information about sender’s purchase) There is a large increase on the average number of referral purchases in post-purchase treatment over control. The increase is sizable and statistically significant at 0.01 level.
2) (Interaction Effect) Interestingly, once information about referral reward is added in the post-purchase treatment, the effect on recipient’s purchase is attenuated and the increase over control becomes less significant. This drop is statistically significant at 0.10, indicating the negative interaction effect of information about referral reward with information about sender’s purchase.

3) (Effect of information about referral reward) Finally, the difference between reward treatment and control is relatively small and not statistically significant. Adding sender’s purchase status in the reward treatment does not change the take-up rate of recipients.

The regression results with controls (deal categories and char, sender char, recipient char) also confirm the insights of table 2, with nearly no difference in magnitude (result is not presented here due to page limit). In other words, on average, the sender in the post-purchase treatment generates more purchases. This effect is economically significant considering the large number of customers who share through the platform.

In addition, the test shows that the difference in referral purchase between post-purchase treatment and post-purchase & reward treatment is also sizable and statistically significant at 0.10 level. The drop can be attributed to a combination of negative effect on social learning and network effect as well as positive incentive effect.

Finally, we observe a small decrease in conversion in the reward treatment over the control treatment. However, such difference is not statistically significant. The effect does not vary with the additional information of sender’s purchase.

**Explore Mechanisms using product with different uncertainty and socialness**

We further look into how message design affects the effectiveness of online social interactions, by exploring the heterogeneity in treatment effect on different types of deals. The shared deals in our sample range across more than 40 subcategories. Following Lovett et.al 2013, we manually code and classify the subcategories into the 2*2 matrix as shown in table 3 (social & uncertainty as two independent dimensions). We then run analysis on the four cells separately. The empirical findings in table 3 (see appendix below) largely confirm our hypotheses: First, information of referrer’s/sender’s purchase has a larger (positive) effect on products with higher uncertainty as well as deals on social activities. The effect is largest for social deals with high uncertainty. Second, the increment effect of information on referral reward differs dramatically for high uncertainty vs. low-uncertainty deal. While adding information on referral reward may boost the likelihood of purchases for low-uncertainty commodity-like product, it reduces social learning effect for high-uncertainty product and cause significant negative effect.

Interestingly, we find that such negative incremental effect is even larger for social product, indicating further decrease in network effect caused by credibility concern.

**Heterogeneity in treatment effect**

We further explore the heterogeneity in the treatment effect for post-purchase share, which may help us better understand the underlying mechanism that leads to the effect. There are several important sources that would result in heterogeneity in treatment effect: characteristics of deals in sharing, sender’s purchase history, recipient’s purchase history and social tie. We have briefly discussed heterogeneity from deal characteristics in above section. In table 5, we present additional results on heterogeneity in treatment effect from other sources. We find that the strength of social tie between sender and recipient significantly moderates the treatment effect of different message design. Adding information about sender’s purchase leads to much higher lift for sender-recipient pairs with reciprocal social interactions (‘strong tie’), compared to those pairs without reciprocal social interactions (‘weak tie’), indicating the importance of tie strength in social learning and network effect. However, we did not find large heterogeneity in treatment effect from other sources (with the exception of recipient’s purchase history). In our ongoing work we will further explore the interactions between message design and different user and deal characteristics.
Conclusion

Our study has a number of implications for practice. As noted earlier, firm-mediated online social interactions are growing in popularity. Our study will provide valuable guidelines for firms seeking to manage such online social interactions through message design. The quantitative estimates and qualitative understanding gained from this series of component-level studies can guide the optimal design of messages for improving the effectiveness of social interactions. While this study focuses on two key components of the message, future studies can extend this agenda by examining other features.

Identifying optimal design of firm-mediated message at a group level is a valuable endeavor, but not the end in itself. With the availability of large amount of data on the behaviors of senders and recipients and their historical interactions, as well as the ability to process requests in real time, firms can actually personalize firm-mediated messages at an individual level. While personalization is a common practice in the context of firm-customer interactions, personalization of firm-mediated customer-customer social interaction is still in its infancy. To investigate its potential, we explore the heterogeneity in sender and recipient characteristics as well as their past interactions. We identify heterogeneous treatment effects related to sender characteristics and past social interactions and discuss its implications to the firm. We envision that in the near future when a firm gets a request of email share from a sender, it would extract product characteristics, sender and recipient’s purchase and interaction histories, calculate optimal content and message design, and deliver the content in real time in a personalized fashion. Our work is a step in that direction.

References


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<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Sender-level Outcomes</th>
<th>p-value</th>
<th>Recipient-level Outcomes</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage lift in average number of referral purchases from each sender</td>
<td></td>
<td>Percentage lift in average net profit from each sender (net revenue from referral-referral reward to sender)</td>
<td></td>
</tr>
<tr>
<td>Effect of Information of Sender's Purchase (T1-C)/C</td>
<td>15.21%</td>
<td>0.001</td>
<td>17.60%</td>
<td>0.044</td>
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<td>Effect of Information on Referral Reward Program (T2-C)/C</td>
<td>-1.10%</td>
<td>0.753</td>
<td>3.17%</td>
<td>0.708</td>
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<tr>
<td>Joint Effect of Info of Sender's Purchase and Info on Referral Reward Program (T3-C)/C</td>
<td>7.67%</td>
<td>0.093</td>
<td>7.20%</td>
<td>0.401</td>
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<tr>
<td>Incremental Effect of Referral Reward Program when info on Sender's Purchase is presented (T3-T1)/C</td>
<td>-7.54%</td>
<td>0.095</td>
<td>-10.40%</td>
<td>0.239</td>
</tr>
</tbody>
</table>

Table 2: Main Effect of each Information and Incremental Effect of Referral Reward Information (only for Post-purchase Share)
<table>
<thead>
<tr>
<th>Characteristics of Shared Deals</th>
<th>Level of Uncertainty</th>
<th>High Uncertainty</th>
<th>Low Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Percentage lift in average number of referral purchases from each sender</td>
<td>Percentage lift in average number of referral purchases from each sender</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p-value</td>
<td></td>
</tr>
<tr>
<td>Effect of Sender's Purchase (T1-C)/C</td>
<td>43.9%</td>
<td>0.00</td>
<td>15.7%</td>
</tr>
<tr>
<td>Effect of Information on Referral Reward Program (T2-C)/C</td>
<td>-1.2%</td>
<td>0.90</td>
<td>20.6%</td>
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<td>Social Products</td>
<td>Joint Effect of Info on Sender's Purchase and Info on Referral Reward Program (T3-C)/C</td>
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<td>Incremental Effect of Referral Reward Program when info on Sender's Purchase is presented (T3-T1)/C</td>
<td>-45.8%</td>
<td>0.00</td>
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<tr>
<td>Standalone Products</td>
<td>Effect of Sender's Purchase (T1-C)/C</td>
<td>44.0%</td>
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<td></td>
<td>Effect of Information on Referral Reward Program (T2-C)/C</td>
<td>-31.0%</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Joint Effect of Info on Sender's Purchase and Info on Referral Reward Program (T3-C)/C</td>
<td>-5.7%</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Incremental Effect of Referral Reward Program when info on Sender's Purchase is presented (T3-T1)/C</td>
<td>-49.7%</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Table 3: Impact of Prior Purchase Information, and the Incremental Effect of Referral Rewards Information, on Recipient's Purchase Likelihood for Product of Different Uncertainty and Socialness
Table 4: Heterogeneity in Treatment Effect (past social interaction, product characteristics, sender characteristics, recipient characteristics)

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Percentage increase in treatment effect between sender and recipient with reciprocal social interaction in the past (compared to the treatment effect on sender-recipient pair without reciprocal communication)</th>
<th>p-value</th>
<th>Percentage increase in treatment effect of high price deal (compared to low price deal, based on 7 price tiers)</th>
<th>Percentage increase in treatment effect with more loyal sender (compared to less loyal senders; loyalty is measured by total number of past purchases)</th>
<th>Percentage increase in treatment effect for recipient with past purchase (compared to recipients without past purchase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of Information of Sender's Purchase on Recipient's conversion rate</td>
<td>210%</td>
<td>0.020</td>
<td>No significant effect</td>
<td>No significant effect</td>
<td>27%</td>
</tr>
<tr>
<td>Effect of Information on Referral Reward Program on Recipient's conversion rate</td>
<td>98%</td>
<td>0.394</td>
<td>No significant effect</td>
<td>No significant effect</td>
<td>No significant effect</td>
</tr>
<tr>
<td>Joint Effect of Info on Sender's Purchase and Info on Referral Reward Program on Recipient's conversion rate</td>
<td>980%</td>
<td>0.000</td>
<td>No significant effect</td>
<td>No significant effect</td>
<td>No significant effect</td>
</tr>
</tbody>
</table>

The percentage increase is calculated as following:
If the treatment effect of T1 is 0.05 and treatment effect in a subgroup is 0.10, then in percentage increase is $(0.10-0.05)/0.05=100\%$