Propose with a Rose?
Signaling in Internet Dating Markets

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ABSTRACT

While a large literature on signaling exists, it is challenging to prove that signaling private information would affect outcomes in a real market and thus can be effectively used for market design. This paper provides clean supporting evidence based on a field experiment in an online dating market. Participants are randomly endowed with two or eight "virtual roses" that a participant can use for free to signal his/her special interest in other participants. We find that recipients accept a dating request with a rose attached more often, and therefore participants with eight roses have more dates than the rest.

Keywords: experiment, matching, signaling, market design, online dating

JEL codes: D82, A11, J12

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I. INTRODUCTION

In many markets, candidates vying for positions inundate employers/schools with applications, making it difficult to decide which candidates to offer a limited number of interviews, job offers, or admissions. For employers/schools, it therefore becomes important to assess not only the quality but also the attainability of an applicant. To overcome these problems, many markets have formal or informal preference signaling mechanisms in place.[1] Concerning U.S. college admissions, Avery, Fairbanks and Zeckhauser (2003) documented many ways in which a college tries to access students' preferences for it compared to other colleges when deciding whom to admit. An important channel is early admission, in which students can apply to only a limited number of colleges compared to regular admissions. Due to the opportunity cost, a college may infer that applicants in early admissions will be more likely to accept an admission than their counterparts in regular admissions. Another example is the signaling system introduced by the American Economic Association (AEA). Under the AEA signaling, every doctoral candidate is able to signal to only up to two universities of his or her choice. This mechanism is expected to help a department identify seemingly out-of-reach candidates who are in fact willing to accept its

[1] There are numerous examples of informal preference signaling. In the economics job market, for example, it is through advisors and their connections that graduate students on the market can convey their interest. In the law clerk market, law appellate court judges seem to be able to receive binding commitments from law students (see Avery et al., 2001). In U.S. college admissions, students are advised to show interest by visiting the college. For example, collegedata, at (http://www.collegedata.com/cs/content/content_getinarticle_tmpl.jhtml?articleId=10045), claims that "demonstrated interest" is factor of considerable importance to colleges: "Going on a college visit, talking with admission officers, or doing an enthusiastic interview can call attention to how much you really want to attend. Applying for an early decision may also make a good impression."

job offer.[2]

Although many papers theoretically study preference signaling and potential welfare gains from introducing a preference signaling mechanism,[3] the empirical literature has had difficulty showing that an agent has more success when the agent uses a signal (e.g., Avery, Fairbanks and Zeckhauser, 2003, for the U.S. college admission; Coles, Cawley, Levine, Niederle, Roth, and Siegfried, 2010, for the AEA signaling; Roth and Xing, 1997, for the markets of U.S. clinical psychologists; and Niederle, Proctor and Roth, 2006, for the U.S. Gastroenterology Fellowship match).[4]

The goal of this paper is to close this gap and provide empirical evidence that sending a preference signal can considerably improve one's chances of success. We conduct a field

[2] The AEA offers advice to participants, which includes: "The two signals should not be thought of as indicating your top two choices. Instead, you should think about which two departments that you are interested in would be likely to interview you if they receive your signal, but not otherwise (see advice to departments, above). You might therefore want to send a signal to a department that you like but that might otherwise doubt whether they are likely to be able to hire you." (see http://www.aeaweb.org/joe/signal/signaling.pdf).

[3] Examples of recent studies are Avery and Levin (2010) and Coles, Kushnir and Niederle (2011).

[4] A much-studied version of signaling is costly signaling (see Spence, 1973), where agents undertake various actions, in general visible to all participants, whose costs depend on the underlying trait to be signaled. Such costly signaling has, for example, been used as a partial explanation for education (for an early overview, see Weiss, 1995), conspicuous consumption (Veblen, 1899, Charles, Hurst, and Roussanov, forthcoming) and even in biology for the famous extravagance of the peacock's tail (Zahavi, 1975). It is difficult to show that costly signals sway the decisions of other agents (see the debates regarding the signaling value of education: Tyler, Murnane, and Willett, 2000, Tyler, 2004, and Jepsen, Mueser, and Troske, 2010, Martorell and Clark, 2010). Given the difficulty of proving the effect of costly signaling, it is not surprising that the empirical literature on preference signaling that does not even yield direct costs has faced similar difficulties.

experiment on dating, which shares the key features of the AEA signaling. A large online dating company organizes two special dating events with 613 participants, about 50 percent of whom are female. All participants are endowed with two "virtual roses" and a randomly chosen 20 percent of participants are endowed with eight. A participant can send dating requests to up to 10 different people by sending a pre-made electronic note, a *proposal.* Participants can attach at most one virtual rose, a digital image icon, when sending a proposal. The roses are described as a way to show special interest. Hence, roses are signals that everyone can send for free to anyone, and roses are costly only because they are in limited supply. If sending a preference signal increases a person's success, then we will observe that, all else being equal, attaching a rose to a proposal improve the chance of a proposal being accepted and thus the individuals endowed with eight roses will have a larger number of dates than the rest. These two predictions are indeed found in our experiment. An important finding is that this positive effect of sending a preference signal is driven by the increase in the acceptance rate due to attaching a rose when the offer is made to a participant who is a less desirable dating partner than the proposer.

Compared to other environments, our set-up offers three major advantages for testing the impact of preference signaling. First, we are able to collect a wide range of information about participants; furthermore, in the experiment, we have the same (even more) set of information about potential dating partners that is available to a participant. This feature is rarely possible in the real world because market participants, such as colleges, tend to have more detailed information about an applicant (e.g., application essay, high school performance) than a researcher can gather from a survey. Second, even though the market is decentralized, we observe not only accepted proposals but all proposals, because the market operates on the website of the dating company. Third, we are able to randomly select participants whom we

endow with eight roses when others receive only two. Such an intervention may be ethically more problematic in labor or education markets.[5] However, it will allow us to provide clean evidence that an agent who sent a preference signal can increase the chance that his or her offer is accepted. Furthermore, randomizing who receives more signals provides us with an instrument to control for possible endogeneity biases when estimating the effect of a rose that arise when participants attach a rose to offers that are more likely to be accepted anyway. Besides these three advantages, our study of online dating may itself be economically relevant because an important economic variable, marriage, is a result of dating,[6] and because online dating services are rapidly growing throughout the world.[7]

The experiment consists of two special online dating sessions in South Korea for people who are college-educated, never-married, aged between 26 and 38 for men, and 22 and 34 for women. We impose restrictions on participants' characteristics to reduce heterogeneity in observables, which may potentially segment the dating market. For the first five days of the event, a participant can browse profiles and send up to 10 proposals, and a proposal can be sent with at most one rose. Participants have two roses they can attach to proposals, with a randomly

[5] The main difference between the dating and employment environments is that the dating market is more continuous. As such, any dating website is portioning off a fraction of the "natural" dating market and manipulating it. It is much more problematic to influence a national or even international market such as the economics junior market that operates once a year and whose initial outcome may have a large impact on careers (Oyer, 2006).

[6] Marriage has received some attention following the seminal work by Becker (1973). Examples of empirical studies on marriage include Abramitzky et al. (2011), Choo and Siow (2006), Fisman et al. (2006) and (2008), Hitsch et al. (2010), Lee (2009).

[7] For example, in the U.S., major dating companies have been established since the mid-1990s and the market size was $932 million in 2011 (JupiterResearch, 2007). Online dating services are popular not only in developed countries but also in developing countries such as Korea, India, and China.

selected twenty percent of participants having eight roses. Once this period ends, each participant receives his or her proposals and observes whether they come with a rose. For the next four days, participants decide whether to accept each proposal; they can accept at most 10 proposals. After the acceptance phase, an accepted proposal results in the company sending a text message to provide the involved pair with each other's contact information. We predict roses to be useful because our participants in the online dating experiment are busy young people who are likely to be careful about how they spend their limited spare time. They may be interested in spending time on dating only when dates may turn into a relationship. As such, offers from desirable participants may be rejected, out of the fear that the interest may not be serious enough. Hence, roses may be particularly effective when they are sent to participants who are somewhat less desirable than the sender. We therefore expect roses to be useful in the way that signals appear useful for economics job market candidates, although of course the dating market differs in many ways from entry-level labor markets.

To study the effect of attaching a rose to a proposal, we classify experiment participants into one of the three groups – bottom (the least desirable group), middle, or top (the most desirable group)– according to the extent to which a participant will be considered desirable to the opposite sex as a dating partner. We conduct this classification by exploiting a separate dataset from the dating company that includes a much larger number of clients and detailed information on their outcomes. We predict a participant's desirability as a dating partner with a measure of dating success rates of his or her counterparts in that separate dataset.

We compare the acceptance rate of an offer with and without a rose using recipient fixed effects and the senders' desirability grade. We find that, overall, sending a proposal with a rose increases the probability that a recipient will accept the proposal by 3.3 percentage points, which

corresponds to a twenty percent increase in the acceptance rate. This effect is similar in magnitude to the increase in the acceptance rate by recipients when the dating offer came from sender in the middle, rather than bottom, category. This implies that, by sending a rose, a sender in the bottom group will be almost equally attractive as his or her counterpart in the middle group. Furthermore, these results are robust to various specifications, including one based on the instrumental variable approach.

A more detailed analysis shows that every recipient group responds positively to roses when the proposals are made by senders from a higher desirability group. That is, when a sender from the top desirability group makes an offer to a middle or bottom group recipient, this offer is significantly more likely to be accepted when a rose is attached. The same is true for offers with and without roses from middle senders to bottom recipients. The effect of a rose in all those instances is more than a 50 percent increase in the acceptance rate, which corresponds to twice the increase in the acceptance rate when moving the sender from the bottom to middle desirability group. Analyzing the effect of roses on proposers instead of proposals, we show directly that participants with more roses are more successful, in that they have more dates that they initiated.

The experiment on internet dating shows unambiguously that by sending a preference signal, where everyone can send signals for free, although signals are limited in numbers, a proposer can increase the chance of being accepted. Senders are able to convey information to recipients using preference signals and recipients react to these signals. This is a necessary step in establishing the idea that a market intervention that introduces a signaling mechanism can have an effect on the final outcome.

The rest of this paper is organized as follows. In Section II, we describe the experimental

design. Section III reports who proposes a date to whom, and what determines whether a rose is attached to a dating proposal. Section IV analyzes the effect of a rose, and Section V concludes.

II. Experimental Design

II.A Background Information

We conduct a field experiment at a major online dating company in South Korea that also operates in China, Singapore, and the United States. Since 1991, the company has been helping clients find spouses from among clients of the opposite sex. The company provides two types of membership: regular and special. The main differences between the two are the cost, the length of service, the degree of the company's involvement in a client's search process, and the depth of supporting documents for legal verification of a client's information. A regular membership lasts for one year and costs about $900, whereas a special membership is for a one-time dating event that occurs, for example, on Valentine's Day, during the summer vacation season, or at Christmas time.

For regular members, the company suggests "suitable" dating partners based on its matching algorithm. To match members, the company creates an index (herein*, desirability index*), which is a sex-specific weighted sum of a person's characteristics, many of which have to be legally verified.[8] The desirability index is intended to predict how attractive a person would be to the opposite sex as a spouse. It ranges from 0 (least desirable) to 100 (most desirable). The desirability index is not visible to members of the dating site. Using a dataset from the company (separate from the experiment) collected by Lee (2009), we find that the desirability index is a

[8] A person's desirability index is calculated based on earnings, assets, job security (full time job or not), height, weight, a company-generated score based on the profile picture, a score based on the college attended and the chosen major, both of which are highly correlated with the score on the national college entry exam, birth order, and family characteristics (parent's wealth and marital status, and siblings' educational attainment).

good predictor of whether a client is attractive as a dating partner (see Section 1 of the online appendix).

Special members, who can only participate in special dating events, are asked the same set of questions as regular members but are not required to answer them all, and can also fail to submit some of the legal documents. The company constructs a verification score that is posted on the member's profile and ranges from 0 (no legal verification) to 100 (full legal verification).[9]

II.B EXPERIMENTAL DESIGN

Procedure

In summer 2008, the company advertised two sessions of the field experiment in Korea as one of its special dating events with a participation fee of $50. We limit participants to be Korean, college educated, never married, and aged from 26 to 38 for men and 22 to 34 for women. We impose these restrictions to reduce heterogeneity among participants and to create a thick market. While the market thickness may make it easier for participants to find a good match, it may also imply that participants may not have sufficient time to date all desirable candidates.

Each session of the experiment consists of two stages: the first is a proposal stage, which lasts five days; then there is a response stage of four days. In the proposal stage, each participant can browse profiles of other participants that contain their submitted information, including a head-to-shoulder photo and their verification score. Each participant can send a pre-made electronic note (herein *proposal*) asking for a date to up to ten participants of the opposite sex.

[9] To receive 100 percent verification, a participant needs to submit a copy of the national household registration form (for age, birth order, marital history and parents' marital status), diploma (for education) and proof of employment (for type of employment and industry).

Furthermore, each participant can attach up to one virtual rose per proposal. The virtual roses are a preference signaling mechanism specifically introduced for this event.

In the response stage, participants receive the proposals sent to them and see whether a rose is attached. Participants can accept up to 10 proposals but do not receive any information regarding whether any of the proposals they made are accepted. No new proposals can be made in the response stage. An accepted proposal (a date) results in the company sending a text message to the two involved participants including each other's phone numbers right after the response stage. Given the experimental design, each participant can have at most 20 first dates.

By separating the proposal stage from the response stage, participants, when deciding to whom to send a proposal, can not observe the proposals of others. Similarly, during the response stage, participants do not know whether any proposals are accepted or rejected. This simplifies the empirical analysis by preventing a participant from making his or her decisions based on the other participants' decisions (apart from responding to the proposals he or she received).

Treatments

The innovation in the dating event is to endow participants with virtual roses. The main analysis is to assess whether attaching a rose increases the chance of a proposal being accepted. The first treatment variable is to change the number of roses participants are endowed with. Eighty percent of participants receive two roses, while 20 percent receive eight roses. This allows us to directly assess whether participants with eight roses are more likely to have a proposal accepted. Furthermore, we will use the treatment status as an instrumental variable to control for endogeneity problems when assessing whether roses increase the chance of a proposal being accepted.

The experiment also includes a second, more psychological treatment. The motivation is

that many researchers document that women are more passive in dating and seem mostly to react to offers (Hitsch et al., 2010; Fisman et al., 2006; and Kurzban and Weeden, 2005). If woman and men differ in their preferences over spousal traits, then who marries whom may depend on who initiates matches. Furthermore, when marital surplus is not fully transferable, passivity in the mate search process may make women worse off.[10] The aim of the second treatment is to affect the behavior of women and men to reduce the gender inequality in the mate search process.

In the *female empowerment* treatment we randomly select 50 percent of female participants. During the proposal stage, we show them a banner that is built into the main webpage and visible whenever a treated participant is on the website, with the aim of encouraging them to initiate a proposal.[11] Finally, we have an equivalent treatment for men, called *male empowerment*, encouraging them to accept offers by women. We randomly select 50 percent of male participants who, during the response stage, see a banner on their website.[12] We find that these verbal encouragements have no impact. Thus, we control for them in our empirical analyses, but we will not discuss them further.

[10] There may be several core outcomes of who is married to whom, in which case the outcome preferred by all men is different from the women's preferred outcome (see Roth and Sotomayor, 1990, for an overview). A dating market in which men make offers may be closer to achieving the male optimal stable matching, the most preferred outcome by men. Lee (2009) provides evidence that matches would be quite different if women were to make offers.

[11] The banner read, in translation: "Will you wait until Prince Charming asks you out? Or will you take the lead to meet him? Dear client, did you find someone you want to date? Please do not let this opportunity pass you by. Contact him first and give him the opportunity to meet you."

[12] The banner read, in translation, "Congratulations! You received a dating request. Please give an opportunity to the one who has fallen in love with your charm!"

Information

A participant can access the online profiles of other participants, but neither knows the treatment status of other participants nor other participants' activities. Furthermore, participants were not informed that there were different treatments.

Data

The dataset consists for each participant of their characteristics, desirability index, verification score, the list of people to whom the participant sent a proposal and whether a rose was attached, the list of people from whom the participant receives a proposal and whether a rose is attached, and, for all those proposals, whether they are accepted, declined or simply ignored.

II.C PARTICIPANTS

There are 212 participants in the first and 401 in the second session. Roughly half of each session's participants are female. Thirty-three men and 25 women participate in both sessions. All participants meet the participation criteria, apart from four high-school graduates. About 20 percent of participants of each sex receive both eight roses and the empowerment treatment. About 37 percent of the remaining participants receive two roses and the empowerment treatment. All the remaining participants, except for three men, receive only two roses.

To check the randomization into the treatment status, we compare the characteristics of the three groups of participants using t-tests:[13] two roses and no empowerment (Group 1), two roses and empowerment (Group 2), and eight roses with empowerment (Group 3). We report results in Table I.

For female participants, the three treatment groups are not significantly different from one another in terms of desirability index or verification score. Concerning age and location, once again, there is no significant difference. For male participants, Groups 1 to 3 are

[13] Permutation tests yield qualitatively the same results.

comparable in terms of desirability index but differ in verification score. Furthermore, there are differences in age and likelihood of living in Greater Seoul. In light of these findings, we will always control for the characteristics that vary across groups, namely age, verification score, and location. As long as there is no unobservable heterogeneity across groups, we can study the treatment effects by controlling for these observable differences.

TABLE I PARTICIPANTS' CHARACTERISTICS BY TREATMENT STATUS

Treatment Status	Group 1	Group 2 [a)]	Group 3 [b)]
Number of roses	2	2	8
Perception or Empowerment	No	Yes	Yes
Male participants			
Number of participants	146	97	58
Age	32.14	32.07	33.10**
Greater Seoul (percent)	84.93	94.85**	81.03***
Desirability index by the company	75.28	74.45	76.43
Special members (percent)	47.26	42.27	19.97***
Verification – fully-verified (percent)	69.86	61.86	86.21**
Verification – not-verified (percent)	2.74	2.06	0.00
Female participants			
Number of participants	153	95	61
Age	29.54	29.48	30.13*
Greater Seoul (percent)	88.24	86.32	81.97
Desirability index by the company	78.58	79.62	79.97
Special members (percent)	30.72	21.05*	22.95
Verification – fully-verified (percent)	67.32	68.42	75.41
Verification – not-verified (percent)	3.27	5.26	1.64

Notes: The male participants in Groups 1 to 3 do not add up to 304 because three men are endowed with eight roses but are not in the empowerment treatment. Greater Seoul includes Seoul and Gyeonggi province. In column 2 (Group 2, a) we test whether the characteristics of participants in Group 2 are statistically different from those in Group 1. In column 3 (Group 3, b) we do the same for Group 3 compared to Group 2. In all cases, *, **, and *** indicate that using a two-sided t-test the difference is significant at 10%, 5%, and 1%, respectively.

III. PROPOSALS AND ROSES

III.A PARTICIPANT'S TYPE

For each participant, especially those who are regular members, we have a large number of characteristics, many of which are used to compute the desirability index. For regular members, we define the type to be their desirability index, age, and residential location. There are two reasons why we opt to use the desirability index as a summary statistic for how desirable

participants are to the opposite sex as dating partners. First, we obtain a different and much larger sample of regular members that fulfill the requirements of our experiment. We find that the variables we use to define a participants' type explain almost all the variations in a person's desirability as a dating partner compared to when we use all available characteristics (see Section 1 of the online appendix). Second, using the desirability index will make the interpretation of our results easier, though the findings remain qualitatively the same when we use alternative definitions of a participant's "desirability" (Section 3 of the online appendix).

In our analysis, we partition participants according to their desirability index into three categories within each sex: the bottom 30 percent, the top 30 percent, and the remaining 40 percent (referred to as bottom, top, and middle, respectively). Since we have also special members whose information may not be fully verified, we include this information in the participants' type through three levels: fully, partially, or not at all legally verified.[14] Therefore, we define the type of a participant in the experiment based on four characteristics: his or her desirability index, which we group into bottom, middle and top; age; residential location; and legal verification level.

III.B Sending Proposals and Roses

Altogether 1,921 proposals are made, of which 66 percent (1,261) are made by men. Men are in fact significantly more active proposers than women in any dimension. They have a higher chance of making a proposal, 54.28 percent compared to the 36.89 percent for females (p = 0.00).[15] Conditional on sending a proposal, men send more proposals than women, 7.64

[14] Full verification requires the national household registration form, diploma, and employment verification. Partial verification requires the national household registration form.

[15] For all tests on proportions and means, the p-values correspond to a two-sided t-test. The rather careful selection of a dating partner may be due to the participants' characteristics in our sample. Most participants are full-time

compared to 5.79 (p = 0.00).[16] Figure I.A shows for each decile of the desirability index the percent of proposals made by participants of that level of desirability or lower.[17] Because the graph aligns with the 45-degree line, this suggests that one's own desirability is not a determining factor when deciding whether and how many proposals to make.

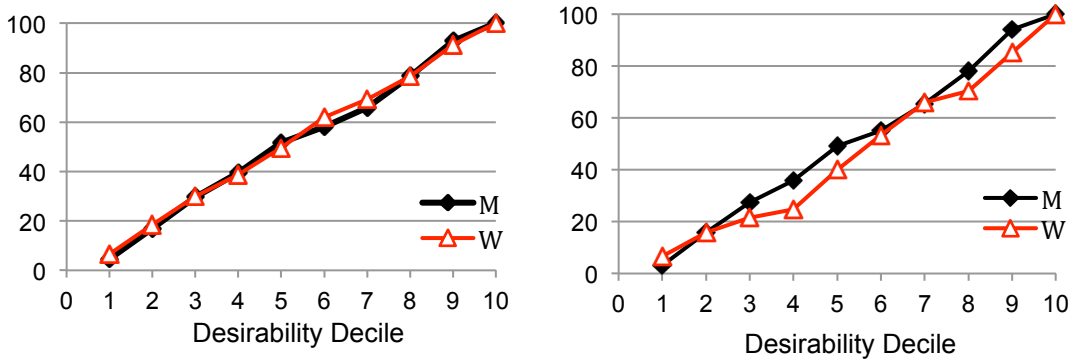

Figure I

Figure I.A: For each decile of desirability, where 1 is the least and 10 the most desirable group, the cumulative distribution function of proposals made.

Figure I.B: For each decile of desirability, where 1 is the least and 10 the most desirable group, the cumulative distribution function of roses sent.

The regressions on sending proposals reported in Table II confirm the gender differences and that the proposer's own desirability is not a determining factor. We use a linear regression model to estimate which participants send at least one proposal, and how many proposals are

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employees whose age is close to but slightly higher than the average age of first marriage in Korea, which implies that they may not want to waste their time on "not-so-good" dating partners.

[16] Conditional on sending a proposal, men are also significantly more likely than women to exhaust their proposals (53.94 percent compared to 27.19 percent, p = 0.00).

[17] We divide the desirability index by sex into deciles, where 1 corresponds to the bottom 10 percent of desirability index-rated participants.

sent (conditional on sending at least one).[18] The reported gender coefficient of -0.115 in column 1 shows that women are 11.5 percentage points less likely to send a proposal than men are. Column 4 shows that conditional on sending a proposal, women send 1.05 fewer proposals than men. The coefficients on the desirability index of the sender (S_Middle and S_Top) are not significant in any regression, showing that the desirability of the sender is not a significant predictor of whether and how many proposals participants make.[19]

TABLE II SENDING PROPOSALS

	Sending a proposal			Number of proposals (if > 0)		
Sender	All	Men	Women	All	Men	Women
	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.115**			-1.050*		
	(0.054)			(0.610)		
Male with 8 roses	0.239***	0.208***		0.677	0.709	
	(0.071)	(0.070)		(0.563)	(0.549)	
Female with 8 roses	0.035		0.056	0.388		0.369
	(0.080)		(0.080)	(0.838)		(0.898)
Female empowerment	0.037		0.048	-0.23		-0.271
	(0.064)		(0.064)	(0.706)		(0.749)
S_ Middle	0.001	-0.058	0.055	-0.264	0.269	-1.007
	(0.048)	(0.068)	(0.067)	(0.493)	(0.630)	(0.805)
S_ Top	0.061	0.073	0.028	-0.138	-0.028	-0.318
	(0.053)	(0.074)	(0.074)	(0.521)	(0.651)	(0.879)
No. of observations	611	304	307	278	165	113
R-sq	0.070	0.100	0.030	0.118	0.060	0.065

Notes: OLS estimates. In columns 1 to 3, the dependent variable is one if a participant sent at least one proposal and zero otherwise. In columns 4 to 6, the dependent variable is the number of proposals a participant sent. Female, Male/Female with 8 roses and Female empowerment are dummies for the described conditions. S_Middle and S_Top indicate whether the sender is from the middle or top desirability group, respectively. All regression models control for the verification level (none, medium, full), age, and a living in greater Seoul dummy. Standard errors are in parentheses. *, **, and *** indicate significance at 10, 5 and 1 percent, respectively.

[18] For regressions on whether a participant sent a proposal, that is columns 1 to 3 from Table II, the marginal effects from logit and probit models are very similar to the results from the linear probability model.

[19] The conclusions are robust to more flexible controls of a participant's desirability index (such as using a second order polynomial instead of dummy variables for three desirability groups).

Furthermore, while participants with eight roses seem slightly more active in all dimensions, only men were significantly more likely to make an offer compared to participants in the control who had only two roses. Finally, the empowerment treatment did not affect women in terms of whether they made a proposal or how many proposals they made.

A rose is attached to 670 proposals. A total of 38.70 percent (478) of proposals made by men come with a rose, compared to 27.58 percent (182) of proposals made by women ($p = 0.00$). Conditional on sending a proposal, men are more likely than women to use at least one rose (90.30 compared to 64.91 percent, $p = 0.00$). Conditional on sending a rose, men are also more likely to exhaust their roses, that is, to use up all their roses or use as many roses as proposals (75.17 percent versus 47.30 percent, $p = 0.00$). Once again, when considering who sends roses, Figure I.B suggests that participants of all levels of desirability evenly send signals.

The linear regressions in Table III confirm that women are significantly less likely to send at least one rose (column 1), and that participants of all levels of desirability are equally likely to use a rose (columns 1 to 3). Men who make more offers are also significantly more likely to use at least one rose, while the effect for women, though similar in magnitude, is not significant.[20] Conditional on using at least one rose and controlling for the number of proposals, women and men send a similar number of roses. Specifically, women only send 0.006 fewer roses than men (column 4). While desirability so far has no explanatory power, women in the bottom desirability group do not send as many roses as those in the middle or top group, conditional on using at least one rose (column 6). Similar to the proposal behavior, whether a female participant receives the empowerment treatment is not a statistically significant predictor for the participant's usage of

[20] For regressions on whether the participant sends a rose, that is columns 1 to 3 from Table III, the marginal effects from logit and probit models are very similar to the results from the linear probability model.

endowed roses. Finally, conditional on participants who send at least one rose, participants with eight roses use on average an additional 3.2 (for women) and 4.9 roses (for men). Women with eight roses are also somewhat more likely to use at least one rose. This implies that if roses increase the chance of an offer being accepted, participants with more roses should have more of their offers accepted, especially if they do not differ in terms of whom they make offers or send roses to.

TABLE III SENDING ROSES

	Sending a rose			Number of roses (if > 0)		
Sender	All	Men	Women	All	Men	Women
	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.222***			-0.006		
	(0.072)			(0.238)		
Male with 8 roses	0.031	0.035		4.936***	4.973***	
	(0.066)	(0.051)		(0.197)	(0.175)	
Female with 8 roses	0.170*		0.163	3.239***		3.263***
	(0.098)		(0.127)	(0.340)		(0.411)
Female empowerment	-0.061		-0.073	0.112		0.168
	(0.083)		(0.106)	(0.301)		(0.356)
No of proposals sent	0.019***	0.017**	0.019	0.219***	0.207***	0.234***
	(0.007)	(0.007)	(0.014)	(0.023)	(0.026)	(0.045)
S_ Middle	0.012	0.056	-0.043	0.368**	-0.061	1.272***
	(0.058)	(0.059)	(0.114)	(0.183)	(0.197)	(0.379)
S_ Top	-0.022	-0.079	0.066	0.307	-0.092	1.132***
	(0.061)	(0.061)	(0.124)	(0.196)	(0.211)	(0.402)
No. of Observations	278	165	113	223	149	74
R-sq	0.140	0.080	0.080	0.8219	0.8740	0.7012

Notes: OLS estimates. The sample includes participants who made at least one proposal. In columns 1 to 3, the dependent variable is one if a participant sent at least one rose and zero otherwise. In columns 4 to 6, the dependent variable is the number of roses a participant sent. Female, Male/Female with 8 roses and Female empowerment are dummies for the described conditions. S_Middle and S_Top indicate whether the sender is from the middle or top desirability group, respectively. No of proposals sent is the number of proposals that a participant made. All regression models control for the verification level (none, medium, full), age, and living in greater Seoul. Standard errors are in parentheses. *, **, and *** indicate significance at 10, 5 and 1 percent, respectively.

III.C WHO RECEIVES PROPOSALS AND ROSES?

While desirability plays a small role when determining who sends proposals and roses, it is important for receiving proposals. This is a confirmation that, within our sample, the desirability index is a good predictor of how desirable a participant is as a dating partner. Figure

II shows the cumulative distribution function of proposals received by desirability decile. For both genders the function is below the 45-degree line, meaning that more desirable participants receive more proposals.

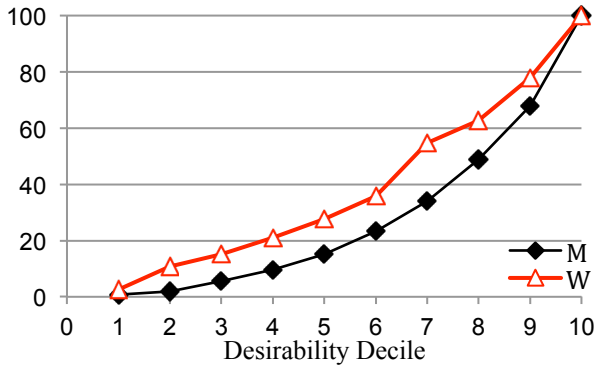

Figure II
For each desirability decile, the cumulative proportion of all offers received by recipients of that decile or lower.

In Table IV we report probit regressions to predict which 1,902 of the possible 102,064 proposals are actually made, based on sender and recipient characteristics.[21] We use "S_" to indicate sender and "R_" to indicate recipient characteristics and report marginal effects. We start with the regression that includes all participants in the first column. The positive marginal coefficients of 0.012 of "R_Top" means that a sender in the bottom group is 1.2 percentage points more likely to make an offer to a specific recipient if that recipient is in the top rather than the bottom desirability group. A sender in the top group is R_Top plus S_Top X R_Top, that is, 3.4 percentage points more likely to make an offer to a recipient in the top rather than the bottom desirability group. Overall, column 1 shows that senders are more likely to make offers to more

[21] We have 104 men and 108 women in Session 1 and 200 men and 201 women in Session 2. Two women in session 2 have no desirability index. Thus, the number of potential proposals between men and women with a desirability index is 102,064, that is 2*104*108 plus 2*200*199. The multiplication by 2 is because for a given male-female pair there are two possible proposals: the man can propose to the woman or the woman can propose to the man.

TABLE IV WHO SENT A PROPOSAL TO WHOM?

	All proposals			If Sender proposed		
Sender	All	Men	Women	All	Men	Women
	(1)	(2)	(3)	(4)	(5)	(6)
S_female	-0.003***			0.006***		
	(0.001)			(0.002)		
S_male with 8 roses	0.009***	0.010***		0.007***	0.007***	
	(0.001)	(0.002)		(0.002)	(0.002)	
S_female with 8 roses	0.002		0.002**	0.003		0.004**
	(0.002)		(0.001)	(0.003)		(0.002)
S_female empowerment	0.001		0.001	-0.002		-0.001
	(0.001)		(0.000)	(0.003)		(0.001)
S_Middle	-0.008***	-0.012***	-0.002	-0.015***	-0.019***	-0.005
	(0.002)	(0.003)	(0.001)	(0.004)	(0.005)	(0.004)
S_Top	-0.009***	-0.012***	-0.005***	-0.021***	-0.025***	-0.012***
	(0.002)	(0.002)	(0.002)	(0.004)	(0.005)	(0.004)
R_Middle	0.007***	0.005*	0.005***	0.014***	0.010**	0.013***
	(0.002)	(0.003)	(0.002)	(0.004)	(0.005)	(0.004)
R_Top	0.012***	0.005*	0.011***	0.023***	0.009*	0.028***
	(0.002)	(0.003)	(0.003)	(0.004)	(0.005)	(0.006)
S_Middle X R_Middle	0.006**	0.011**	0.000	0.012**	0.021**	-0.001
	(0.003)	(0.005)	(0.002)	(0.006)	(0.009)	(0.004)
S_Middle X R_Top	0.013***	0.016***	0.005	0.027***	0.030***	0.009
	(0.004)	(0.006)	(0.003)	(0.008)	(0.010)	(0.006)
S_Top X R_Middle	0.009**	0.014**	0.004	0.018**	0.025**	0.009
	(0.004)	(0.006)	(0.004)	(0.007)	(0.010)	(0.009)
S_Top X R_Top	0.022***	0.028***	0.014**	0.043***	0.049***	0.032*
	(0.005)	(0.008)	(0.007)	(0.010)	(0.013)	(0.016)
No. of proposals	102,064	51,032	51,032	49,496	29,104	20,392
Pseudo R-sq	0.065	0.065	0.1223	0.0659	0.0642	0.1506

Notes: Probit estimates. The dependent variable is one if a participant makes a proposal to a given recipient and zero otherwise. We report marginal effects at the mean of each regressor or in the case of dummy variables at zero. "S_" and "R_" denote sender and recipient characteristics, respectively. For instance, S_female is one if a sender is female and zero otherwise. "S_Middle X R_Middle" is one if a sender belongs to the middle desirability group and a recipient belongs to the middle desirability group. All regression models control for recipient and sender's verification level (none, medium, full), age, living in greater Seoul, the squared difference of age between a sender and a recipient and a dummy indicating whether the two are in the same location. Location has five categories: Greater Seoul, Gangwon, Chungcheong, Jeolla/Jeju, and Gyeungsang. Standard errors of the marginal effect are in parentheses. *, **, and *** indicate significance at 10, 5 and 1 percent, respectively.

desirable recipients compared to less desirable recipients, and, the more they do so, the more desirable they themselves are. When we restrict our attention to men only, this effect is

significant. Women, on the other hand, already send so many proposals to top recipients that only top desirable women are even more likely to make offers to top desirable men.[22]

The negative effect of 0.003 of "S_female" means that for a given pair of participants, the woman is 0.3 percentage points less likely to contact the man than the man is to contact the woman. Table IV further shows that men and women endowed with eight roses are more likely to make a proposal. Female empowerment, however, has no significant effect.

In the last three columns (columns 4 to 6), we restrict the sample to senders who sent at least one proposal.[23] All initial results are strengthened. However, the female dummy is now positive and significant. This is due to the restriction that the coefficients of other controls do not depend on gender. If we allow for the possibility that women send offers to the middle and top desirable partners differently than men, that is, if we include interaction terms such as S_female X R_Middle and S_female X R_Top, the marginal effect on the female dummy is negative, -0.14 and significant (p = 0.01 of the underlying coefficient with a standard error of the marginal effect of 0.00).

Being endowed with eight roses may affect not only whether senders are more likely to make an offer but also to whom. To assess this possibility, we run a probit regression identical to the one in Table IV, but with interaction terms between the treatment group of the sender and the desirability group of both sender and recipient.[24] Overall, the interaction terms are not

[22] Note that, consistent with the results from Table II, we find that participants from the bottom, middle and top desirability group are equally likely to make an offer.

[23] Hence, we have 41*108 + 124*201 potential observations for men and 23*104+90*200 for women.

[24] For example, we include for female senders with eight roses the variable "S_female with eight roses X S_Bottom X R_Bottom" that is the indicator "S_Bottom X R_Bottom" multiplied by whether a sender is female and endowed with eight roses.

statistically different from zero, suggesting that participants send proposals in a similar way in all treatment groups (see Section 2 of the online appendix).

We have seen that more desirable participants are vastly more likely to receive a proposal. If this is true for roses as well, we would expect participants to send roses to the most desirable potential mates they made offers to. Alternatively, roses could be used as a signaling mechanism in a market in which time is scarce, and participants may not be certain whether the other party is really interested. In this case, roses may not necessarily be sent to the most desirable potential dating partners (see Coles, Kushnir and Niederle, 2011, and Coles et al. 2010).[25]

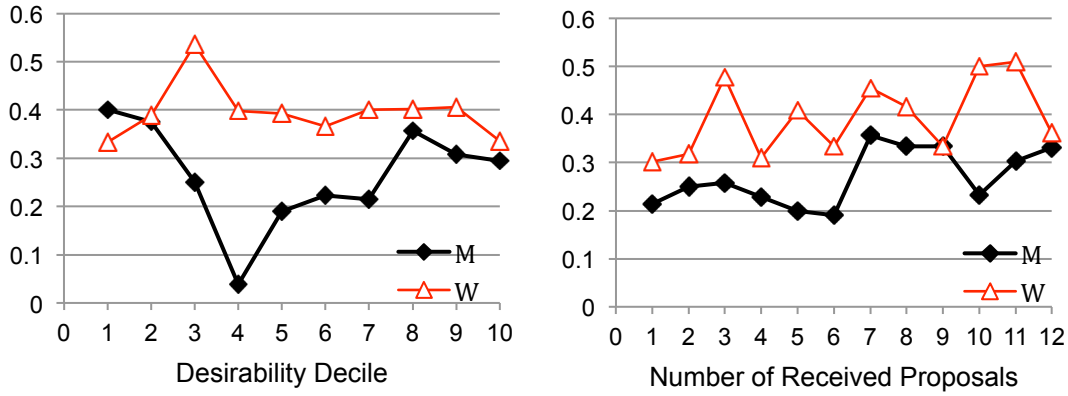

Figure III

Figure III.A: For each decile of desirability, where 1 is the least and 10 the most desirable group, the fraction of proposals accompanied by a rose.

Figure III.B: For each number of received proposals up to 12, the fraction of proposals accompanied by a rose.

[25] Recall that the advice for students on the AEA website on how to use signals starts with telling them that they should not send signals to their top two choices. Rather, students should send them to the departments that they believe may not interview them otherwise, as these departments may not realize their interest is serious enough to warrant one of the limited numbers of interview slots.

Figure III.A shows for each desirability decile the fraction of proposals that come with a rose. The figure suggests that receiving a rose is not based on the desirability of recipients, apart from possibly medium desirable men receiving somewhat fewer roses.[26]

In Table V, we use a linear model to regress whether a rose accompanied a proposal on the characteristics of the sender and the recipient. We use the full sample for columns 1 to 3, while columns 4 to 6 report results for senders who sent at least one rose. The coefficients pertaining to the desirability of the recipient are largely not significantly different from zero, which confirms that the decision to add a rose to a proposal seems not to be correlated with the characteristics of the recipient. Only in column 1 is R_Middle significant, but the coefficient is not significant when we consider men and women separately, or in any other regression. The results are the same when we condition on participants who sent at least one rose.

Consistent with our findings in Table III, proposals from senders that have eight roses are more likely to be accompanied by a rose. However, neither the gender of the sender nor the empowerment treatment significantly correlates with the decision to add a rose to a proposal.

As a final test of whether, on average, roses seem to follow proposals proportionally, we use an alternative measure of desirability. Specifically, Figure III.B shows the fraction of proposals accompanied by a rose depending on the number of proposals a participant received. When we define desirable participants as those who receive more offers, we confirm that all participants have the same likelihood of having a rose attached to a proposal. This is confirmed by a

[26] While the high fraction of offers with roses made to bottom men is not a significant deviation, because very few bottom men received offers, men in the fourth desirability decile are significantly less likely to have a rose attached to their offers than men in better desirability deciles.

TABLE V WHO SENT A ROSE TO WHOM?

	All proposals			Sender sent at least one rose		
Sender	All	Men	Women	All	Men	Women
	(1)	(2)	(3)	(4)	(5)	(6)
S_female	-0.043			0.037		
	(0.040)			(0.048)		
S_male with 8 roses	0.577***	0.576***		0.585***	0.584***	
	(0.025)	(0.026)		(0.027)	(0.027)	
S_female with 8 roses	0.454***		0.441***	0.463***		0.448***
	(0.043)		(0.043)	(0.053)		(0.057)
S_female empowerment	-0.017		-0.009	0.016		0.022
	(0.038)		(0.038)	(0.049)		(0.051)
S_Middle	0.068	0.056	0.151	0.045	0.027	0.206
	(0.062)	(0.071)	(0.142)	(0.066)	(0.072)	(0.177)
S_Top	-0.059	-0.083	0.202	-0.066	-0.089	0.203
	(0.072)	(0.078)	(0.227)	(0.079)	(0.083)	(0.252)
R_Middle	-0.082*	-0.049	-0.070	-0.073	-0.044	-0.036
	(0.049)	(0.056)	(0.106)	(0.052)	(0.057)	(0.131)
R_Top	-0.027	-0.056	0.109	0.006	-0.029	0.205
	(0.049)	(0.058)	(0.104)	(0.053)	(0.059)	(0.129)
S_Middle X R_Middle	-0.012	-0.038	-0.009	-0.016	-0.039	-0.064
	(0.073)	(0.083)	(0.158)	(0.078)	(0.085)	(0.198)
S_Middle X R_Top	-0.027	-0.033	-0.085	-0.038	-0.052	-0.136
	(0.071)	(0.084)	(0.151)	(0.076)	(0.085)	(0.189)
S_Top X R_Middle	0.129	0.105	-0.033	0.104	0.096	-0.087
	(0.082)	(0.090)	(0.240)	(0.089)	(0.095)	(0.269)
S_Top X R_Top	0.082	0.107	-0.177	0.074	0.107	-0.207
	(0.080)	(0.089)	(0.233)	(0.088)	(0.095)	(0.262)
No. of proposals	1,902	1,245	657	1,615	1,153	462
Pseudo R-sq	0.280	0.300	0.220	0.280	0.310	0.250

Notes: OLS estimates. The dependent variable is one if a rose is attached to a given proposal and zero otherwise. "S_" and "R_" denote sender and recipient characteristics, respectively. All regression models control for recipient and sender's verification level (none, medium, full), age, living in greater Seoul, the squared difference of age between a sender and a recipient and a dummy indicating whether the two are in the same location. Location has five categories: Greater Seoul, Gangwon, Chungcheong, Jeolla/Jeju, and Gyeungsang. Standard errors are in parentheses. *, **, and *** indicate significance at 10, 5 and 1 percent, respectively.

regression that mirrors Table V while replacing the recipient's desirability group with the number of proposals a recipient received (see Section 3.1 of the online appendix).

In a manner similar to our analysis of proposals, we examine whether the treatment group affects to whom proposers send a rose. We use a regression similar to the one in Table V with interaction terms between the treatment group of the sender and characteristics of both the sender

and recipient. Overall, we find no evidence that the treatment group affects to whom roses are sent (see Section 4 of the online appendix).

IV. The Effect of Roses

IV.A Acceptances and the Effect of Roses

After the proposal stage, participants have four days to respond to offers they received. They can accept at most 10 proposals, actively reject proposals, or simply not respond. Of the 1,921 proposals, 295 are accepted, 445 were explicitly rejected, and the rest are not responded to. Among the 394 participants who received at least one proposal, 152 always give explicit rejections or acceptances, 104 give either explicit or implicit responses, and the remaining 138 participants do not respond to any proposal. Of all proposals, 15.35 percent are accepted. Men accept 20.76 percent of their proposals, which is significantly higher than the 12.53 female acceptance rate ($p < 0.01$). We have 15 couples who proposed to each other, and they all accepted each other, but with three women not responding.

The average number of acceptances among participants who receive an offer is 0.8 for men, and 0.7 for women.[27] Even among the 16 men and 40 women who receive 10 or more offers, the average number of accepted offers is only 1.76 (2.25 for men and 1.58 for women, not significantly different). The highest number of accepted offers is 8, which implies that the restriction of being able to accept only 10 offers is not binding. These results suggest that participants have high opportunity costs of time. This implies that there may be situations in which quite desirable dating partners are rejected because the participant believes the chance of a

[27] While the average number of accepted offers is similar between women and men, women are significantly less likely to accept an offer than men (16 versus 29 percent, $p < 0.01$). This is because women on average receive 5.9 offers, while men only receive 3.9.

successful date to be too low. That is, participants may base their decision not only on how desirable a dating partner is. Participants may also care about their chances that the date may lead to a successful series of dates, that is, participants may value information that indicates whether the dating partner is very interested. Therefore, when a participant decides which among various dating partners to accept, and worries about how serious the requests are, then information that a specific dating request is "special" might very well be taken into account. In other words, an offer with a rose may have a higher chance of being accepted than an offer without a rose. When roses do help overcome the concern that a candidate is not sufficiently serious about his or her proposal, then we would expect this to be the case especially for middle and bottom desirable participants. This is because top desirable participants may not have to worry about being sufficiently desirable. Middle and bottom desirable participants, however, may worry they are simply a "back-up plan." As such, we would expect middle and bottom desirable participants to be especially responsive to roses when they are sent by potential dating partners whom they fear may not be interested: that is, by dating partners who are more desirable than they are.

We start by examining the extent to which a recipient changes his or her acceptance decision depending on whether a proposal is accompanied by a rose. For this analysis, we construct a dependent variable that is one if a proposal is accepted and zero otherwise.[28] We use two types of regression models. In Model A we assume that all recipients react to a rose the same way. In Model B we allow for the possibility that the response to a rose may depend on the desirability of the recipient.

We regress in Table VI the acceptance of a proposal on whether a rose is attached, recipient fixed effects, the sender's age and legal verification level, a dummy indicating whether

[28] This means we treat "no response" as an explicit rejection. In Section 7 of the online appendix, we present evidence that this is justified.

the sender lives in greater Seoul, the squared age difference between the sender and the recipient and a dummy indicating whether the sender and recipient live in the same location (Greater Seoul, Gangwon, Chungcheong, Jeolla/Jeju, and Gyeungsang). Recipient fixed effects allow for recipient specific reservation values when accepting a proposal. In Model A we include dummies for the desirability group of the sender of the proposal (S_Middle and S_Top). In Model B we include, in addition, interaction terms between receiving a rose and the desirability group of the recipient. For instance, "R_Bottom Rose" is one if a proposal is accompanied by a rose and sent to a bottom group recipient.

While we have an unusual amount of information about candidates and observe all communications, it may, in principle, still be the case that endogeneity may account for the positive coefficients of "roses" in the regressions described so far. For example, it may be that participants observe information not present in the data available to us that informs them whether a match would have a particularly high value and hence whether an offer is likely to be accepted. If participants attach roses to offers that yield higher match qualities due to unobservable characteristics, estimating the effect of a rose based on the difference in the acceptance rate between offers with and without roses would bias the results in our favor. To address the concern regarding endogeneity, we take an alternative approach based on instrumental variable estimation. That is, we use the treatment status of the sender, whether the sender is endowed with eight roses, as an instrumental variable with whom we instrument the dummy variable indicating whether a proposal has a rose attached. Recall that participants are randomly assigned to be endowed with two or eight roses; furthermore, other participants do not know whether a sender had two or eight roses. Therefore, whether the sender has eight or two roses should not be correlated with the decision of the recipient whether to accept an offer conditional on

TABLE VI EFFECT OF ROSES

Model	FE-R	FE-R-IV	FE-R	OLS	FE Logit	FE-R
	(1)	(2)	(3)	(4)	(5)	(6)
Recipients	All	All	Active	All	All	2 roses
Model A						
Rose	0.033**	0.041	0.054**	0.030*	0.443**	0.034*
	(0.016)	(0.029)	(0.025)	(0.018)	(0.201)	(0.018)
S_Middle	0.048**	0.047***	0.079**	0.074***	0.811***	0.052**
	(0.019)	(0.017)	(0.031)	(0.020)	(0.298)	(0.022)
S_Top	0.178***	0.177***	0.293***	0.191***	2.284***	0.181***
	(0.020)	(0.018)	(0.033)	(0.021)	(0.312)	(0.023)
R-sq (log Lik.)	0.50	0.50	0.46	0.13	-242.37	0.49
Model B						
R_Bottom Rose	0.054	0.035	0.087	0.003	0.935	0.071
	(0.047)	(0.054)	(0.071)	(0.047)	(0.598)	(0.052)
R_Middle Rose	0.078***	0.064**	0.097**	0.082***	0.677**	0.068**
	(0.027)	(0.031)	(0.040)	(0.029)	(0.317)	(0.031)
R_Top Rose	-0.001	-0.002	0.013	0.003	0.131	0.006
	(0.021)	(0.025)	(0.035)	(0.024)	(0.292)	(0.024)
S_Middle	0.047**	0.047**	0.079**	0.072***	0.815***	0.051**
	(0.019)	(0.019)	(0.031)	(0.020)	(0.299)	(0.022)
S_Top	0.176***	0.177***	0.290***	0.189***	2.283***	0.180***
	(0.020)	(0.020)	(0.033)	(0.021)	(0.314)	(0.023)
R-sq (log Lik.)	0.50	0.50	0.46	0.13	-241.18	0.49
No. of proposals	1,902	1,902	1,153	1,902	796	1,516
No. of recipients	393	393	226	393	103	310

Notes: Columns labeled FE-R report OLS estimates with recipient fixed effects. FE-R-IV of Model A follows the same specification as Model A of column (1) but instruments Rose with whether the sender is endowed with 8 roses and reports second stage regressors. The F-statistic of the excluded instrument is 442.45. FE-R-IV of Model B follows the same specification as Model B of column (1) but instruments R_Bottom Rose, R_Middle Rose and R_Top Rose with the predicted probability of attaching a rose interacted with the recipient's desirability group (for details see Section 5 of the online appendix). The Cragg-Donald's F-statistic of the three excluded instruments is 1,141.30. FE Logit reports logit model estimates with recipient fixed effects. The dependent variable is one if a recipient accepted a given proposal and zero otherwise. "S_" and "R_" denote sender and recipient characteristics, respectively. All regression models control for sender's verification level (none, medium, full), age, living in greater Seoul, the squared difference of age between a sender and a recipient and a dummy indicating whether the two are in the same location. Location has five categories: Greater Seoul, Gangwon, Chungcheong, Jeolla/Jeju, and Gyeungsang. Column 4 includes in addition control variables for recipient characteristics: number of proposals made, number of roses sent, number of proposals received, a dummy for whether at least one rose was received, the number of roses received, and the recipient's characteristics corresponding to those of senders (verification level, age, living in greater Seoul, R_Middle and R_Top). Standard errors are in parentheses. *, **, and *** indicate significance at 10, 5 and 1 percent, respectively.

observables. However, having eight roses is significantly correlated with a proposal being accompanied by a rose. [29] As we discuss below, the results using IV estimates are very similar to those from standard regressions, confirming that roses affect acceptance behavior.

Before analyzing the effect of a rose, note that both Model A and B show that the more desirable the sender is, the more likely it is that a recipient will accept that proposal. For example, compared to a proposal from a sender in the bottom desirability group, an offer from a sender in the top desirability group is about 18 percentage points more likely to be accepted. For a medium group sender, the advantage is still around 5 percentage points. To evaluate the size of these effects, we note that the overall acceptance rate of offers is 15.20 percent when we restrict our attention to offers where both senders and recipients have a desirability index.

Column 1 of Model A shows that attaching a rose significantly increases the probability of being accepted by 3.3 percentage points. This corresponds to a 20 percent increase compared to the overall acceptance rate. Furthermore, this positive effect of sending a rose is comparable to (and about three-quarters of) the benefit of being in the middle desirability group relative to being in the bottom group. This implies that, by sending a rose, a bottom group sender will be almost equally attractive as his or her counterpart belonging to the middle group. When we restrict our attention to male and female recipients separately, the effects barely fail to be significant (columns 2 and 3). The marginal effect is, however, similar in size, and, once again, is comparable to the advantage enjoyed by middle desirable senders. Furthermore, note that a one-

[29] See Section 5 of the online appendix for details including identification assumptions and a formal description of the IV model.

sided test estimating whether roses increase the acceptance rate would yield significance.[30]

In the IV regression we first regress whether a proposal is accompanied by a rose on the treatment status of the sender (two or eight roses) and regressors from the baseline specification. We find that having eight roses significantly predicts whether a proposal comes with a rose (F-stat 442.45). Column 2 of Table VI reports the estimates from the second stage with standard errors that take the first stage estimation errors into account. We find that sending a rose increases the chance of acceptance by 4.1 percentage points and this effect is significant in a one-sided test ($p = 0.084$). Note that this estimate of the effect of a rose is not statistically different from the baseline estimate at a conventional level ($p = 0.794$) and, if anything, has a slightly larger value. Hence, although roses directly affect the acceptance rate, the effect seems not to be driven by endogeneity effects.

The results regarding the effect of a rose are robust across various specifications and sub-samples.[31] In column 3, we restrict our attention to recipients who actively responded to at least

[30] Note that, in theory, a rational participant would never attach a rose if a rose were expected to yield negative returns, that is, to reduce the chance of being accepted. In that case, a participant could simply not attach a rose. As such, a one-sided test of the effect of a rose may be justifiable.

[31] Specifically, we perform the following two exercises (for details see Section 3 of the online appendix). First, instead of our baseline cutoffs (30th percentile and 70th percentile), we use the 20th and 80th percentile to classify participants into three desirability groups. We re-estimate Model A and find that a rose increases the acceptance of a proposal by 3.2 percentage points, almost identical to the baseline result. Second, we use the number of proposals a participant received as a proxy for the participant's desirability. We re-estimate Model A but include dummy variables of the number of proposals a sender received instead of the desirability index group dummies. We find that a recipient accepts a proposal by 3.4 percentage points more if the proposal is accompanied by a rose, an effect virtually identical to the baseline result.

one proposal.[32] In column 4, we use a linear regression model instead of a recipient fixed effects model and control for recipient characteristics such as the number of offers and roses both sent and received. In both cases, the recipient's response to a rose is qualitatively the same as in the baseline analysis in column 1. Likewise, a logit regression with recipient fixed effects where we report the coefficients of the latent index (column 5) yields similar results.[33] Finally, we assess whether participants endowed with two roses react to roses differently than those endowed with eight roses. Column 6 shows that results are virtually unchanged when we restrict our attention to recipients who had only two roses compared to all recipients (column 1).[34] This is not too surprising since the effect of a rose is the difference in the acceptance rate of an offer with a rose

[32] We have 56 individuals who participated in both sessions, and 39 of them received at least one proposal in the second session. We examine whether recipients respond to a rose differently in their second session. To do so, we re-estimate Model A but include the interaction between a rose and a dummy variable that indicates the second session and two-time participants. Note that 215 out of 1,921 proposals are sent to two-time participants. We find that there is no statistical difference in terms of recipients' response to a rose in their second participation.

[33] We also run a regression where in addition to fixed effects for recipients we use fixed effects for senders instead of their desirability group. The estimated coefficient of a rose is 0.031 ($p = 0.104$), qualitatively the same as in the baseline regression (column 1), though just barely not significant (the s.e. is 0.019). However, we include an exceptionally large number of control variables, namely fixed effects for both recipients and senders, and the effect of a rose would reach conventional significance levels in a one-sided test.

[34] We also formally test whether the effect of roses on the acceptance rate depends on a recipient's treatment group. We re-estimate Model A while including an interaction term between receiving a rose and whether a recipient had 8 or 2 roses. The coefficient on the interaction term is not significant, indicating that the difference in the acceptance rate due to a rose is similar between recipients who themselves had 2 or 8 roses, see Section 6 of the online appendix.

attached compared to an offer without a rose. [35]

In Model B we allow for the possibility that the response to a rose may also depend on the desirability group of the recipient. Recipients in the top group of desirability have an overall acceptance rate of 12.03 percent, and are the most selective group. They do not appear to respond to roses very much, as "R_Top Rose" has a coefficient close to zero. While in some specifications the point estimate is even slightly negative, it is never close to being significant, and even fails to be significant in a one-sided test.

Column 1 of Model B shows that middle group recipients are 7.8 percentage points more likely to accept an offer with a rose than one without a rose. The overall acceptance rate for middle group recipients is 18.42 percent, so a rose results in a roughly 40 percent increase in the acceptance rate. Furthermore, under all specifications, the effect of attaching a rose is similar and generally larger than the effect of moving a sender from the bottom to the middle desirability group (which is 4.7 percentage points in column 1).

Recipients in the bottom desirability group overall have a positive response to a rose of 5.4 percentage points, but the effect is not significant. However, participants in the bottom group receive only a small fraction of all offers (12.04 percent), which may account for the large

[35] Participants who have two roses may view an offer with a rose as "special," while offers without a rose show perhaps "normal" interest. On the other hand, participants who have eight roses may not feel equally flattered when receiving a rose. However, for them, not receiving a rose may be a sign of really not being special, since, in their view, only 2 out of 10 offers are precluded from having a rose attached. Note that these two cases are in a way symmetric: either two out of ten offers are more special compared to other offers -- for recipients endowed with two roses – or two out of ten offers are less special compared to other offers -- for recipients endowed with eight. Due to this symmetry, it may not be surprising that the change in the acceptance rate in reaction to a rose is similar for recipients endowed with two or eight roses.

standard errors. Note that in almost all specifications, the effect of a rose is similar in size to the increase in the acceptance rate when the sender is from the middle rather than bottom desirability group. Since the overall acceptance rate for bottom participants is 19.21 percent, a 5 percentage point increase corresponds to about a 25 percent increase in the acceptance rate. Furthermore, in many specifications, significance would be achieved in a one-sided test.

The IV regression of Model B contains three endogenous variables. Following Wooldridge (2010, Ch 21), we use three instruments excluded from the second stage regression, which are the three dummies for the desirability group of the sender interacted with the predicted probability of attaching a rose (for details see Section 5 of the online appendix). The three instruments significantly predict whether a proposal comes with a rose (Cragg-Donald's F-stat 1,141.30). Column 2 of Table VI reports the second stage results. The results are qualitatively the same as baseline estimates. An F-test shows that we cannot reject that the three estimates are the same as the baseline estimates ($p = 0.937$).

In Table VII we allow for the possibility that the effect of attaching a rose on the acceptance rate depends on both the recipient's and the sender's desirability group. We expect roses to convey special interest and as such to sway recipients to accept an offer that they may otherwise reject, potentially out of fear that the sender is not sufficiently interested and hence ultimately not attainable. In that case, we expect roses to be especially effective in inducing a recipient to accept an offer whenever the offer is from a sender that is more desirable than the recipient. Indeed, we find that for all recipients, the effect of a rose is positive and significant when the sender belongs to a more desirable group than that of the responder, see column 1. That is, bottom recipients react significantly (both economically and statistically) to roses when they are attached to offers from medium and top desirable participants. For middle desirable

TABLE VII EFFECT OF ROSES

Model	FE-R	FE-R-IV	FE-R	OLS	FE Logit	FE-R
	(1)	(2)	(3)	(4)	(5)	(6)
Recipients	All	All	Active	All	All	2 roses
R_Bottom						
S_Bottom: Rose	-0.052	-0.026	-0.076	-0.024	-1.522	-0.041
	(0.064)	(0.074)	(0.096)	(0.063)	(1.401)	(0.074)
S_Middle Rose	0.125*	0.073	0.189*	-0.001	1.883*	0.122
	(0.070)	(0.078)	(0.107)	(0.068)	(0.962)	(0.076)
S_Top Rose	0.160*	0.073	0.275**	0.072	2.889**	0.170*
	(0.084)	(0.092)	(0.137)	(0.087)	(1.463)	(0.086)
R_Middle						
S_Bottom Rose	0.106**	0.097*	0.150*	0.076	1.246*	0.083
	(0.049)	(0.056)	(0.078)	(0.050)	(0.669)	(0.058)
S_Middle Rose	0.019	0.014	0.018	0.065	0.247	0.011
	(0.039)	(0.043)	(0.059)	(0.041)	(0.464)	(0.045)
S_Top Rose	0.124***	0.105**	0.151**	0.108**	0.892*	0.116**
	(0.040)	(0.045)	(0.060)	(0.045)	(0.464)	(0.045)
R_Top						
S_Bottom Rose	-0.003	0.007	-0.001	0.01	-0.654	0.018
	(0.044)	(0.053)	(0.070)	(0.046)	(0.919)	(0.051)
S_Middle Rose	0.034	0.034	0.060	0.026	0.57	0.033
	(0.032)	(0.037)	(0.051)	(0.035)	(0.425)	(0.036)
S_Top Rose	-0.033	-0.037	-0.031	-0.025	-0.069	-0.022
	(0.032)	(0.035)	(0.053)	(0.035)	(0.394)	(0.035)
S_Middle	0.041*	0.046*	0.071*	0.069***	0.677*	0.047*
	(0.023)	(0.025)	(0.037)	(0.024)	(0.368)	(0.026)
S_Top	0.171***	0.180***	0.281***	0.188***	2.182***	0.174***
	(0.024)	(0.026)	(0.039)	(0.026)	(0.370)	(0.027)
R-sq (log Lik)	0.50	0.50	0.47	0.13	-234.80	0.49
No. of proposals	1,902	1,902	1,153	1,902	796	1,516
No. of recipients	394	394	227	393	104	310

Notes: Columns labeled FE-R report OLS estimates with recipient fixed effects. FE-R-IV follows the same specification as column (1) but instruments the nine rose variables with nine dummy variables indicating the sender's and recipient's desirability group times the predicted probability of attaching a rose (see Section 5 of the online appendix). The Cragg-Donald's F-statistic of the nine excluded instruments is 296.38. FE Logit reports logit model estimates with recipient fixed effects. The dependent variable is one if a recipient accepted a given proposal and zero otherwise. "S_" and "R_" denote sender and recipient characteristics, respectively. All regression models control for sender's verification level (none, partial, full), age, living in greater Seoul, the squared difference of age between a sender and a recipient and a dummy indicating whether the two are in the same location. Location has five categories: Greater Seoul, Gangwon, Chungcheong, Jeolla/Jeju, and Gyeungsang. Instead of recipient-fixed effects, column 4 includes in addition control variables for recipient characteristics: number of proposals made, number of roses sent, number of proposals received, a dummy indicating whether at least one rose was received, the number of roses received, and the recipient's characteristics corresponding to those of senders (verification level, age, living in greater Seoul, R_Middle and R_Top). Standard errors are in parentheses. *, **, and *** indicate significance at 10, 5 and 1 percent, respectively.

recipients, the effect of a rose on the acceptance rate of an offer is positive and significant when the offer is made by a participant from the top desirability group. The effect is always more than twice the increase in acceptance when moving, as a sender, from the bottom to the middle desirability group. Column 1 shows the effect to be more than a 50 percent increase in acceptance rate for either the bottom or middle recipients.

The only surprising result is that offers from top desirable senders to top desirable recipients have a slightly lower chance of being accepted when a rose is attached. This effect is particularly large when looking at female responders. It is as if very desirable women do not favor men who are both desirable and interested. Finally, note that for all desirability groups of responders, the effect of roses is in general lower for senders that have the same desirability group as the receiver.

For Model C, we have nine endogenous variables. We use nine instruments excluded from the second stage equation, which are the nine dummies indicating the sender's and the recipient's desirability group times the predicted probability of attaching a rose (for details see Section 5 of the Online Appendix). These nine instruments significantly predict whether a proposal comes with a rose (Cragg-Donald F-stat: 296.38). Column 2 of Table VII reports the second stage results. The results are qualitatively the same as baseline estimates. An F-test shows that we cannot reject that the nine estimates of the IV regression are the same as the baseline estimates ($p = 0.989$).

To summarize, on the proposal level, an offer with a rose is almost twenty percent more likely to be accepted than an offer without a rose. Further analysis shows that the positive effect of a rose is driven by bottom and middle desirable recipients, who increase their acceptance rate by about 25 and 40 percent, respectively. In both cases, attaching a rose increases the chance of

being accepted by more than if the sender were to move from the bottom to the middle desirability group. Finally, an even more detailed analysis shows that an offer made from a sender who is in a superior desirability group compared to the recipient is always significantly, both statistically and economically, is more likely to be accepted when a rose is attached. The effect of a rose corresponds to a more than 50 percent increase in the acceptance rate.

IV.B The Effect of Roses for Proposers

In this section we assess whether roses help proposers be more successful. Proposers may be deemed more "successful" if they are more likely to have a date or have more dates. However, perhaps an even more accurate measure is to consider dates initiated by the proposer. First, proposers may be even more excited about dates they initiated independent of the desirability index of the dating partner. Second, initiated dates that are accepted may more accurately reflect the effect of roses on the senders' success in convincing recipients to accept their offer.

To assess whether roses help proposers have more initiated dates, we perform two analyses. First, we analyze whether participants who received eight roses are more successful than those that received only two roses. Second, we use the results from the regression analysis in Section IV.A to predict the outcome of participants if they had no roses, and confirm that we would then expect participants to be worse off. In this section, all our tests will be one-sided, since we assess whether roses help participants have their proposed dates be accepted.

First, we assess the treatment effect of endowing some participants with eight roses. For men, we compare participants who had two roses (baseline and empowerment treatment) to those with eight roses, where we restrict attention to men who live in greater Seoul and have full verification. This is because men in different treatments differed in their observables (see Section

TABLE VIII TREATMENT EFFECTS

	Baseline	Roses	Increase
Men (Groups 1&2 vs 3) No obs	***144***	***39***	
Have at least one initiated date	0.313	0.487	56%**
No of initiated dates	0.556	0.897	61%**
Quality adj. no of initiated dates	0.535	0.868	62%**
Men who made at least one offer	***79***	***30***	
Have at least one initiated date	0.570	0.633	11%
No of initiated dates	1.013	1.167	15%
Quality adj. no of initiated dates	0.975	1.128	16%
Women (Group 2 vs. 3)	***95***	***61***	
Have at least one initiated date	0.263	0.328	25%
No of initiated dates	0.421	0.705	67%**
Quality adj. no of initiated dates	0.403	0.688	71%**
Women who made at least one offer	***36***	***26***	
Have at least one initiated date	0.694	0.769	11%
No of initiated dates	1.111	1.654	49%**
Quality adj. no of initiated dates	1.063	1.614	52%**

Notes: Male participants include only men who live in greater Seoul and provided a full level of legal documentation. *, **, and *** indicate that the p-value of testing the increase in column 3, between the value in column 1 to the value in column 2 is significant at less than 10, 5, and 1 percent, respectively.

II.C).[36] Furthermore, the male empowerment treatment takes place in the response stage, that is, men in the baseline and the empowerment treatment should not differ in their proposal behavior or, as such, in outcomes corresponding to initiated dates. Since there are no observable differences among women in various treatment groups, we use all female observations. We compare outcomes among women who have two roses and are subjected to empowerment – that

[36] In Section II.C we show that men with eight roses are significantly less likely to be special members, and hence significantly more likely to have a full verification level, than men endowed with two roses. Note that offers from participants with full verification are more likely to be accepted than other offers. However, when we condition on the verification level, and whether men are from greater Seoul, then there are no more differences in observables between the two groups. Furthermore, since for these two categories the modal group is greater Seoul (87.50 percent) and full verification (70.72 percent), we restrict all male participants to have these characteristics. Jointly over 64 percent of male participants live in greater Seoul and provide full legal documentation and hence have a full verification level.

is, we compare women in the empowerment treatment to women who had eight roses because the latter group was also subjected to the empowerment treatment. The empowerment condition is administered in the proposal stage and hence can affect proposal behavior – although, as we see, not in a significant way.

Table VIII shows the outcomes of male and female participants. Men are significantly more likely to have a date they initiated (that is, to have an offer of theirs be accepted) when they have eight roses; in fact that chance increases by more than 50 percent. Furthermore, men have significantly more dates they initiated when they are endowed with eight roses; this is an increase of more than 60 percent.[37] Finally, participants may care not only about the total number of dates but may prefer dates with more desirable partners. We therefore quality-adjust each proposal. For each proposer, we compute the weight of a proposal as the desirability index of the recipient divided by the average desirability index of participants who received at least one proposal. Men with eight roses have about 60 percent more quality-adjusted first dates than men with two roses. For women, the chance of having an initiated date increases from 26.3 percent to 32.8 percent when they have eight roses, but this 25 percent increase is not significant. Like men, women have significantly more initiated dates when endowed with eight roses; this is an increase of more than 60 percent. Furthermore, when quality-adjusting dates, the result remains virtually unchanged.[38]

In Section III.B we show that participants with eight roses are similar in their proposal

[37] When looking at all dates, not just those initiated by the sender, men with eight roses are still significantly more likely to have at least one date (34%, significant at the 5% level) and have significantly more dates (55% more, significant at 5%).

[38] When looking at all dates, not just those initiated by the sender, women with eight roses are only 1% more likely to have a date, and have only 12% more dates.

behavior to participants endowed with two roses, with the exception that men endowed with eight roses are more likely to make at least one proposal. To assess whether this is the main driving factor in Table VIII, we provide the outcomes based on the subset of participants who make at least one offer. While both men and women are still about 10 percent more likely to have a date they initiated when they are endowed with eight roses, the difference is no longer significant. Women still have about 50 percent more first dates they initiated when they are endowed with eight roses, a significant increase. For men, the increase is still 15 percent, but fails to be significant. Note, however, that the sample becomes small. The results remain virtually unchanged when quality-adjusting those dates.

A second way to assess whether the use of roses increases the chances for proposers to have dates they initiated is to use the results from the analysis in Section IV.A. We focus on participants who make at least one proposal. The row "Data" in Panel 1 of Table IX shows the average number of accepted proposals for each proposer. Next, we use the regression results similar to Table VII, where we run the regression in column 1 separately for men and women to predict for each proposer the likelihood with which his or her proposal is accepted. We aggregate results on the proposer level and present the outcome in the row "model prediction" with two-sided t-tests that compare those outcomes in parentheses. There is no significant difference between the predicted and actual number of accepted proposals. We therefore use the model to compute two counterfactuals. First, we predict the outcome if a participant had not used any of his or her available roses. In that case, we predict proposers to only have 0.962, instead of the actual 1.057, accepted offers, a significant drop of 9 percent (see column 1). When we consider women and men separately, the drop in accepted offers is basically the same (8 percent for men and 10 percent for women) but only the female drop is significant.

On the other hand, if proposers had used roses in order to maximize the number of accepted offers, they would have had significantly more acceptances, namely 1.179: a significant 12 percent increase compared to the actual outcome. This increase remains significant even when we look at women and men separately. Furthermore, compared to not using any roses, the date-maximizing use of roses results in an increase of initiated dates of 23 percent. Once again, the effects are similar in size and significant when we look at each gender separately.

While participants may prefer that more of their offers be accepted, they may have a preference about which offers are accepted. Specifically, they may prefer that offers to more rather than those to fewer desirable participants are accepted. We therefore use the same quality-adjustment for each proposal as before. The weight of a proposal is the desirability index of the

TABLE IX PREDICTING THE EFFECT OF ROSES

Senders	All	Men	Women
No. accepted proposals			
Panel 1. Actual			
(i) Data	1.057	0.958	1.202
(ii) Model Prediction	1.047	0.958	1.175
(ii) vs. (i)	(-1% / .428)	(0% / .500)	(-2% / .398)
Panel 2. Counterfactuals			
(iii) Not using roses	0.962	0.881	1.079
(iii) vs. (i)	(-9% / .047)	(-8% / .139)	(-10% / .096)
(iv) Optimal use of roses	1.179	1.055	1.357
(iv) vs. (i)	(12% / .026)	(10% / .091)	(13% / .076)
(iv) vs. (iii)	(23% / .000)	(20% / .009)	(26% / .006)
Quality-Adjusted No. accepted proposals			
Panel 3. Actual			
(i) Data	1.019	0.927	1.153
(ii) Model Prediction	1.019	0.927	1.153
(ii) vs. (i)	(0% / .500)	(0% / .500)	(0% / .500)
Panel 4. Counterfactuals			
(iii) Not using roses	0.940	0.856	1.061
(iii) vs. (i)	(-8% / .075)	(-8% / .149)	(-8% / .159)
(iv) Optimal use of roses	1.173	1.055	1.344
(iv) vs. (i)	(15% / .006)	(14% / .039)	(17% / .034)
(iv) vs. (iii)	(25% / .000)	(23% / .003)	(27% / .004)

Notes: In parentheses are shown the percentage change of the two relevant variables and the p-value of the corresponding one-sided t-test. Tests that compare the data versus the model prediction are two-sided, that is (ii) versus (i), as they do not test the effect of adding a rose.

recipient divided by the average desirability index of participants who received at least one proposal. We then compute the probability of a proposal being accepted times its weight and, for each proposer, we sum these probabilities. Panel 3 shows that the average quality-adjusted number of initiated dates is 1.019 for all participants who made at least one proposal, a number that our model matches exactly. This match is equally good when analyzing women and men separately. In the first row of panel 4, we report the quality-adjusted number of accepted proposals if senders had not used any roses. When we consider all participants, they would have about 8 percent less quality-adjusted initiated dates, a significant difference. The numbers for women and men separately are the same, though the 8 percent drops are not significant any longer. In terms of using roses to maximize quality-adjusted dates, compared to not using any roses, both women and men would have about 25 percent fewer dates. Compared to their actual outcomes, both women and men are not close, on average, to an optimal usage of roses.

IV.C Role of Roses: Substitution or Increase in the Number of Dates

Finally, we want to assess whether there is some indication that roses increase the number of proposals a recipient accepts, or whether they mostly serve to direct acceptances toward offers with roses and displace other acceptances. When a recipient shifts his or her acceptance from an offer without a rose to an offer with a rose by senders of the same desirability, he or she is likely to shift the acceptance to someone who may be more interested. However, this introduces a negative externality to the sender who does not use a rose. If, however, recipients who receive roses accept *more* offers, roses may help increase the total number of dates. To assess whether roses change the total number of acceptances, consider the following thought experiment. Take two identical recipients who have the same number of offers, with, however, one recipient having received at least one rose while the other received none. Will the former accept more

TABLE X ACCEPTANCE AND RECEIVING A ROSE

	All	Men	Women
	(1)	(2)	(3)
Receive at least one rose	0.259*	0.484**	0.087
	(0.139)	(0.237)	(0.156)
Female	-0.335**		
	(0.133)		
Constant	0.488***	0.432***	0.231**
	(0.097)	(0.117)	(0.106)
No. obs	97	49	48
R-sq	0.080	0.081	0.007

Notes: OLS estimates. The dependent variable is the number of proposals that a recipient accepted. Standard errors are in parentheses. *, **, and *** indicate significance at 10, 5 and 1 percent, respectively.

offers? To perform this analysis, we need to restrict ourselves to a sample where participants, while receiving the same number of offers, are about equally likely to have at least one rose or no rose. This is the case for middle desirable recipients who have received up to three offers. This corresponds to 60.25 percent of all middle recipients who received an offer.

In Table X we use a linear regression on how many offers participants accepted depending on whether they received at least one rose. Overall, participants who receive at least one rose accept 0.259 more offers than those who receive no rose. For that group, each responder accepts on average 0.412 proposals; hence, this corresponds to a 37 percent increase. Note that this effect is almost entirely driven by men.

V. CONCLUSION

This paper presents a field experiment in Internet dating that shows that sending a preference signal can affect outcomes. In our dating experiment, the participants are full-time employed, never married, college-educated Koreans. This group seems to have high opportunity costs of time, which is reflected in the relatively low number of dates they accepted. In the experiment, we show that preference signaling significantly increases the chance that an offer would be

accepted. Furthermore, we find suggestive evidence that signaling seems not to crowd out dating requests without an accompanying rose; rather, it increases the total number of dating requests accepted in the dating market.

Like any other empirical signaling paper, on costly signaling or preference signaling, we cannot assess whether the signaling mechanism improves welfare. While one can show in theory that preference signals can improve welfare (see Avery and Levin, 2010, Coles, Kushnir and Niederle, 2011), this is hard to demonstrate empirically for many reasons. The foremost is that the welfare criterion is not obvious. How should various dates be traded off? Would all participants having one date be better than only a few having multiple dates? Even counting the total number of dates may not be a good measure, as clearly some dates are more desirable than others.

Despite this limitation, this paper provides clean empirical evidence that in a real market, people indeed respond to preference signals and that using a signaling mechanism can generate a sizable impact on a person's outcomes. This evidence has important implications for researchers and practitioners who work on improving the efficiency of a market. They have so far mostly focused on turning decentralized markets into centralized ones, such as the market for medical residents and fellows (see Roth 1984, Roth and Peranson 1999, and Roth 2008).[39] Market design may be ready to help decentralized markets operate differently. One such way is to introduce preference signaling. This paper has shown that preference signaling may work. In a market in which interviews are costly, and in which agents can signal their preferences, this paper has shown that signals do affect who is matched with whom.

[39] Note that in the market for medical residents, the welfare implications of a centralized clearinghouse are also hard to assess. It seems, however, that centralized clearinghouses affect who is matched with whom (Niederle and Roth, 2003) and the timing of the match (Roth, 1984, and Niederle, Proctor and Roth, 2006).

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