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ABSTRACT

In a recent paper, Batabyal (1997) has analyzed the decision making process in arranged marriages. In particular, Batabyal shows that a marrying agent's optimal policy depends only on the nature of the current marriage proposal, independent of whether there is recall of previous marriage proposals. In this paper, I continue this line of inquiry by focusing on the decision problem faced by a marrying agent who wishes to maximize the probability of getting married to the best possible person. *Inter alia*, I show that this agent's optimal policy calls for waiting a while, and saying yes to the first candidate thereafter.

Key words: Arranged marriage, decision making, uncertainty

JEL classification: J12, D81, D83

A DYNAMIC AND STOCHASTIC ANALYSIS OF DECISION MAKING IN ARRANGED MARRIAGES[1]

1. Introduction

"Marriage is popular," said Shaw, "because it combines the maximum of temptation with the maximum of opportunity." This popularity notwithstanding, economists have been interested in systematically studying marriage only since Becker (1973). Further, this interest has largely been restricted to the study of marriage in a deterministic setting, in the context of western societies. (Becker, 1991). In non-western societies, arranged marriages have been around for several centuries. Indeed, they are the rule rather than the exception in large parts of Africa, Asia and the Middle East.[2] Despite this phenomenon, economists in general have paid scant attention to arranged marriages. Consequently, very little is known about the nature of decision making in such marriages.

Given this state of affairs, this paper has two objectives. First, I shall formulate and analyze a model of decision making in arranged marriages. In particular, I shall focus on the following question: When should an agent wishing to have an arranged marriage say yes to a marriage proposal and not wait any longer? Second, I shall discuss some of the implications of my findings for our understanding of arranged marriages.

The rest of this paper is organized as follows. Section 2 provides an overview of arranged marriages and a brief review of the relevant literature. Section 3 provides a detailed description and an analysis of a stylized model of decision making in arranged marriages. Finally, section 4

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[2]See Mandelbaum (1970), Moore (1994), Otani (1991) and Rao and Rao (1982), for a more detailed corroboration of this claim.

concludes and offers suggestions for future research.

2. Arranged Marriages: An Overview

Becker (1991, p. 324) has noted that imperfect information is a key feature of decision making in the marriage market. This observation applies with equal force in the context of arranged marriages as well. The logic of arranged marriages tells us that because of a variety of reasons such as (i) imperfect and incomplete information stemming from limited social experiences and travel opportunities (Goode, 1963, p. 210), and (ii) the tendency of young people to seek pleasure (Auboyer, 1965, p. 176), young persons generally cannot be trusted to find a suitable partner for themselves. Consequently, parents, relatives, and increasingly matchmaking intermediaries, take upon themselves the task of looking for a suitable bride (or groom). While in western countries, the agent wishing to marry generally looks for a partner himself (or herself), in an arranged marriage this important task is not undertaken by the agent but by his (or her) family, friends and intermediaries.[3] The reader should note that this is a fundamental difference between arranged marriages and marriages in western nations.

The second germane aspect of arranged marriages concerns the marrying agent's decision. As Rao and Rao (1982, pp. 32-33) have noted, in contemporary arranged marriage settings, the agent wishing to marry has considerable autonomy over the actual marriage decision. In other words, while family and friends look for appropriate marriage prospects, it is the agent who decides when to say yes. This agent receives marriage proposals as a result of the investigative activities undertaken by others. His (or her) decision is to decide which proposal to say yes to. Clearly, this marriage decision

[3]For a more detailed description of the marriage related investigative activities of parents, friends and intermediaries, see Mace and Mace (1960) and Vatuk (1972).

is indivisible. For the purpose of this paper, I shall assume that it is irreversible as well.[4]

Recently, Batabyal (1997) has analyzed a model of decision making in arranged marriages. Batabyal shows that a marrying agent's optimal policy depends only on the nature of the current marriage proposal, independent of whether there is recall of previous marriage proposals. Batabyal's approach implicitly assumes that the marrying agent has already made a decision to get married; as such, the relevant issue in his paper involves determining when the agent should say yes to a specific marriage proposal. In this paper, I shall explore the nature of the marriage decision in a model in which the agent may not get married at all. This possibility arises because the marrying agent's objective involves maximizing the *probability* of accepting the best possible marriage proposal, when these proposals are received sequentially. As we shall see, in this scenario, the marrying agent's optimal policy (OP) involves waiting a while and saying yes to the first marriage proposal thereafter.

The theory of optimal stopping[5] can be used to comprehend the nature of the marrying agent's choice problem. I now use this theory to formulate and analyze a model of decision making in arranged marriages.

3. The Theoretical Framework

The model is based on Gilbert and Mosteller (1966) and the spirit of the analysis is closely

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[4]By making this assumption, I wish to capture the fact that in most societies in which arranged marriages are prevalent, social pressures are such that once the agent agrees to a marriage proposal, it is generally difficult for him (or her) to renege on the original decision, at least in the short run. I do not wish to imply that separation or divorce is never an option for the agent. Further, the reader should note that while the marrying agent's role described here is increasingly the prevalent one, it is not the only possible one. In some settings, the agent's role is essentially consultative. For more on this, see section 4.

[5]For more on this, see Dixit and Pindyck (1994) and Harris (1987).

related to that in Batabyal (1997). Consider a stochastic environment in which our agent who seeks to be married receives marriage proposals sequentially in discrete time. The environment is stochastic because the decision to get married depends on the receipt of marriage proposals; these are of uncertain quality. It is assumed that successive marriage proposals are statistically independent. In other words, a particular marriage proposal is received at time with a certain probability, independent of any previous or subsequent proposals. As discussed in section 2, this receipt of proposals is the result of investigative activities undertaken by the marrying agent's family, friends, and intermediaries.

I shall first focus on the case of a known finite number - say n - of marriage proposals.[6] Upon receipt of a proposal, our marrying agent must decide whether to accept the proposal (say yes to marriage) or reject the proposal (say no to marriage) and wait for additional proposals. If the agent accepts a proposal, i.e., if he (or she) says yes to marriage, then the question of subsequent proposals is irrelevant. Consequently, the stochastic proposal generation process terminates. The agent's decision to say yes or no is binding in the sense that a rejected proposal cannot be recalled at a subsequent point in time.[7] Our marrying agent has no access to any prior information about the probabilistic nature of the proposals. Upon receipt of a proposal, the marrying agent is able to rank the proposal in terms of its quality. As such, the only information that the agent is privy to is the relative rank of a proposal, as compared to previous proposals. The marrying agent's objective is to maximize the probability of accepting the best (highest quality) marriage proposal when all $n!$ orderings of the various proposals are equally likely.

[6]The asymptotic case, i.e., the $n \to \infty$ case, will be analyzed later.

[7]For a detailed analysis of the effects of recall on the decision to say yes in an arranged marriage, see Batabyal (1997).

From the standpoint of the marrying agent, the scenario described above involves acting in a sequential decision making framework. I shall refer to a proposal as a candidate if this proposal is of higher rank (quality) than any previously received proposal. Further, I shall say that we are in state $\boldsymbol{k}$, if the $\boldsymbol{kth}$ proposal, $1 \leq k \leq n$, has been received and it is a candidate. Let $W(k)$ denote the best decision that the marrying agent can make in this setting. Then it follows that

$$W(k)=\max\{P(k),\ R(k)\},\ k=1,\ldots,n, \tag{1}$$

where $P(k)$ is the probability that the highest quality proposal will materialize if the $\boldsymbol{kth}$ proposal is accepted and $R(k)$ is the best decision that the agent can make if the $\boldsymbol{kth}$ proposal is rejected.[8] Now conditioning[9] on the event that the $\boldsymbol{kth}$ proposal is a candidate, I get

$$P(k)=P\{prop\ \ highest\ \ of\ n\ \ prop/prop\ \ highest\ \ of\ k\ \ prop\}=k/n. \tag{2}$$

An explicit interpretation can now be given to $R(k)$. It is the maximal probability of accepting the highest quality proposal when the previous k proposals have been rejected by our marrying agent. The reader should note that (i) $P(k)$ is increasing in k and (ii) the case in which the first k proposals have been rejected is at least as desirable as the case in which the first $k+1$ proposals have been rejected. These two facts tell us that $R(k)$ is decreasing in k. Now because $P(k)$ is increasing in k and $R(k)$ is decreasing in k, we know that there must exist a proposal l such that

$$k/n=P(k)\leq R(k),\ k\leq l, \tag{3}$$

and

$$k/n=P(k)>R(k),\ k>l \tag{4}$$

hold. From equations (3) and (4), the nature of our marrying agent's optimal policy (hereafter OP)

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[8]In all the subsequent equations of this paper, highest means of highest quality, or alternately, of highest rank.

[9]For more on this, see Ross (1993, pp. 100-106).

can be determined intuitively. This OP says the following: For some proposal $l \leq n-1$, reject the first l proposals, i.e., say no to marriage, and then accept the first candidate proposal (say yes) that is received.

Having determined the nature of the marrying agent's OP, our next task is to compute the probability - $P_{OP}(highest)$ - of accepting the marriage proposal of highest quality when this policy is used. From Ross (1993, p. 100), it follows that this probability is given by

$$P_{OP}(highest) = \sum_{k=1}^{k=n-l} P_{OP}\{highest\ of\ n/k+l\ prop\ accepted\} \cdot P_{OP}\{k+l\ prop\ accepted\}. \tag{5}$$

Now following the line of reasoning that led to equation (2), the conditional probability on the RHS of equation (5) can be simplified. This gives

$$P_{OP}\{highest\ of\ n/k+l\ prop\ accepted\} = (k+l)/n. \tag{6}$$

The second probability on the RHS of equation (5) can also be simplified by writing this probability as a joint probability. This simplification yields

$$P_{OP}(k+l\ prop\ accepted) = \{l/(k+l-1)\}\{1/(k+l)\}. \tag{7}$$

With equations (6) and (7), the expression for $P_{OP}(highest)$ in equation (5) can be rewritten. This gives

$$P_{OP}(highest) = (l/n)\sum_{m=l}^{m=n-1}(1/m), \tag{8}$$

where $m = k+l-1$. The probability in equation (8) is what our marrying agent wishes to maximize. However, in the finite n, i.e., the finite number of proposals case, this maximization exercise cannot be performed in any straightforward manner.[10] Hence in what follows, I shall restrict attention to the asymptotic ($n \rightarrow \infty$) case.

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[10]In the finite n case, one can provide approximations which give us lower and upper bounds on the optimal proposal that should be accepted by the marrying agent. For more on this and related numerical approaches, see Gilbert and Mosteller (1966, pp. 39-40).

For large n, the summand in equation (8) can be approximated well by the natural logarithm function. Using this approximation, I get

$$P_{OP}(highest) = (l/n)\log_e\{(n-1)/l\}. \tag{9}$$

Let $h(z) \equiv (z/n)\log_e\{(n-1)/z\} = P_{OP}(highest)$. Our marrying agent's optimization problem can now be stated. This agent solves

$$\max_z[(z/n)\log_e\{(n-1)/z\}]. \tag{10}$$

The first order necessary condition is

$$z^* = (n-1)/e. \tag{11}$$

Substituting z^* into $h(\bullet)$ gives

$$h(z^*) = \{(n-1)/n\}(1/e). \tag{12}$$

Equation (12) gives us a quantitative characterization of the marrying agent's OP. In turn, this leads to

Theorem 1: The marrying agent should reject the first $(1/e)$ fraction of marriage proposals and he (or she) should accept the first candidate proposal thereafter.[11]

Theorem 1 provides an answer to the "When to say yes" question. This theorem tells us that when faced with the prospect of receiving a large number of proposals sequentially, our marrying agent should initially say no to marriage, i.e., he (or she) should reject the first $(1/e)$ fraction of all proposals. He (or she) should then say yes to the first candidate proposal. The probability that the use of this OP will result in the best proposal being accepted is $(1/e) \approx 0.37$. This tells us that irrespective of how actively friends, family and intermediaries look for marriage proposals, if our marrying agent insists on saying yes only to the highest quality proposal, he (or she) may never get

[11]This statement uses the fact that $\lim_{n \to \infty}\{(n-1)/n\} = 1$.

married at all.

To intuitively see why an OP of the type described in Theorem 1 makes sense, recall the irreversibility of the marriage decision. This irreversibility implies that there is an asymmetry associated with the marrying agent's yes/no decision. From the perspective of this agent, a no decision always leads to future options, but a yes decision terminates the stochastic proposal generation process. Consequently, there is a premium associated with a no decision because this decision preserves flexibility. The policy described in Theorem 1 optimally trades off this flexibility premium with the likelihood that the highest quality proposal will be lost if the agent waits too long to say yes.[12]

Consider the issue of the robustness of Theorem 1. In this connection, let me note that the only two assumptions that we needed to obtain the result described in this theorem are (i) that the marrying agent know the relative rank of each marriage proposal and (ii) that the successive marriage proposals be statistically independent. The informational assumption is parsimonious and the independence assumption is quite standard. Consequently, it seems reasonable to say that these two assumptions comprise the minimal set of assumptions that is necessary to generate the result contained in Theorem 1.

Now suppose that these assumptions do not hold. The independence assumption is clearly crucial; if this does not hold then Theorem 1 will also not hold and the underlying problem will become substantially more complicated. While the marrying agent must have access to some information for his (or her) decision problem to be well posed, the exact form of the informational assumption is not that important. For instance, suppose that our marrying agent is not privy to the

[12]This is related to the "value of waiting" result in the investment under uncertainty literature. For more on this, see McDonald and Siegel (1986), Pindyck (1991), and Dixit and Pindyck (1994).

relative rank of a proposal. Instead, this agent only observes numerical scores from some distribution function. As long as these scores are independent and the distribution from which the scores are drawn is known to the agent, Theorem 1 will continue to hold.

4. Conclusions

In this paper I modeled the marriage decision in arranged marriages in a dynamic and stochastic framework. In this setting, in response to the "When to say yes" question, I provided an OP for our marrying agent. This policy involved a probabilistic comparison of the benefit from accepting a current proposal, i.e., saying yes now, with the benefit to be obtained by rejecting the current proposal and waiting for future marriage proposals. The asymptotic optimality of this policy tells us that the policy is best viewed as an optimal course of action over a long time horizon - such as a lifetime - during which our marrying agent can be expected to receive a large number of marriage proposals.

The analysis of this paper can be generalized in a number of directions. In what follows, I suggest two possible extensions. First, one can extend the analysis of this paper by studying arranged marriage situations in which the marrying agent's role is not definitive but only consultative. This will involve the analysis of a different kind of stopping problem. Second, suppose that the marrying agent learns the statistical properties of the stochastic proposal generation process. We would then have a dynamic problem with an element of inference as well as of decision. In this situation, one can analyze scenarios in which the marrying agent first goes through a period of learning and then he (or she) makes a decision. A study of these aspects of the problem will permit richer analyses of the connections between the information gathering activities of family and friends and the marriage decision in an arranged marriage context.

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