Evolution of Preferences and the Marriage Market

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Abstract

We examine the intergenerational transmission of preferences under different organizations of the marriage market. Random matching results in multiple stable equilibria, and assortative matching results in a unique stable equilibrium. We discuss our model's implications on the evolution of (i) female labor force participation in developed countries, (ii) gender norms in developing countries, and (iii) capitalistic spirit in preindustrial England.

Keywords: intergenerational transmission, marriage market, evolutionary games

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1 Introduction

In the standard economic analysis, preferences are often treated as fixed and exogenous. Recent theoretical contributions endogenize preferences by assuming that preferences evolve across generations over time. One approach assumes that preferences of the children are shaped by their parents and other role models through a cultural transmission process. Initiated by Bisin and Verdier (2001), a body of research in economics contributes to the explanation of a wide variety of cultural phenomena.[1] Bisin and Verdier (2000) and Bisin, Verdier and Topa (2004) explain the persistence of ethnic differences and the coexistence of religious preferences in the United States, respectively. Fernández, Fogli and Olivetti (2004) attribute the increasing female labor force participation in the United States to the intergenerational transmission of gender norms after a shock triggered by World War II. Doepke and Zilibotti (2006) provides a model to show that the rise of the middle class during the British industrial revolution is associated with the transmission of a work ethic and patience. Tabellini (2008) demonstrates that historical institutional qualities may have a long run impact on the current societal level of generalized trust through cultural transmission.

Another approach subjects preferences to natural selection and provides an evolutionary foundation for understanding why certain preferences are prevalent while others are not. The literature has focused on preferences such as risk preferences (Robson, 1996*a*; Roberto and Szentes, 2017; Robson and Samuelson, 2018), time preferences (Rogers, 1994; Robson and Samuelson, 2007, 2009), and social preferences including altruism, reciprocity and morality (Güth and Yaari, 1992; Güth, 1995; Sethi and Somanathan, 2001; Alger and Weibull, 2010, 2013).[2]

However, in these bodies of research, the transmission of preferences is usually assumed to be one-sided. In other words, the reproduction in the evolutionary process is assumed to be asexual. Intergenerational transmission of preferences is two-sided in reality since both parents can exert influences on their children. Consequently, how households are formed in the marriage market determines the effectiveness of parental influences. Therefore, marriage and sexual reproduction needs to be taken into consideration together for a complete picture of the evolution of preferences in human societies. To our limited knowledge, the intergenerational transmission of preferences under two-sided matching has not been systematically studied.[3]

In this paper, we study how preferences evolve when transmitted through both intergenerational and marital channels by incorporating two-sided matching. The matching technologies differ in

[1] See Bisin and Verdier (2011) for an extensive survey on the literature of cultural transmission.

[2] See Robson and Samuelson (2011) and Alger and Weibull (2018) for two surveys on the literature of preference evolution. See also Newton (2018).

[3] There are several exceptions that consider sexual reproduction and marriage. Fernández, Fogli and Olivetti (2004) considers a random two-sided marriage market. Bisin and Verdier (2000) considers sexual reproduction in a unisex population with assortative marriage. Robson (1996*b*) considers an assortative two-sided mating process. We will discuss in more details the difference between ours and theirs in the paper.

the degree of friction, ranging from the most frictional, random matching, to the least, perfectly assortative matching. Such a comparative approach to understand the impact of assortativeness of matching has been applied in the works on asexual preference evolution by Alger and Weibull (2010, 2013) and in the study of income inequality by Kremer (1997) and Fernández and Rogerson (2001).

The results demonstrate that the number and properties of equilibria crucially depend on the underlying two-sided matching technology. The matching technology influences not only who matches with whom but also, more importantly, individual choices that shape future generations' preferences and choices.

In the model, a continuum of men and a continuum of women constitutes a generation. Any individual can be one of two different preference types: a and b. Men's types are assumed to be transmitted across generations while women's types are determined by their choices. We assume homophily in types, that is, a type-a (type-b) man and a type-a (type-b) woman prefer each other. A woman's choice depends on who she can potentially marry to and the cost associated with the choice. More importantly, a woman's choice shapes her son's preference through intergenerational transmission.

First, under random matching, as the fraction of type-a (type-b) men increases, more women will be attracted to choose action a (action b) as there is a higher chance to marry with a type-a (type-b) man. Hence, the interaction between men and women takes a form similar to a coordination game. We find that generically there exist two stable equilibria, one with type a being dominant and another one with type b being dominant. There is an additional equilibrium with a more balanced distribution of types, but it is never stable.[4] Second, under assortative matching, the prospect of marrying a type-a (type-b) man is more lucrative when the proportion of type-a (type-b) men is small because of assortativeness, such that an overflow of women choose action a (action b), resulting in an increase in the prevalence of type-a (type-b) men. Therefore, the interaction between men and women takes a form similar to an anti-coordination game. We find that there always exists a unique stable equilibrium (with balanced proportions of both types in the population). Finally, the equilibria in the environment in which some match randomly and some match assortatively resemble those under the perfectly random setting when a sufficiently high proportion of couples are matched randomly and resemble those in the perfectly assortative setting otherwise. All marriage markets can be characterized as either predominantly assortative

[4]Several interesting models in the literature of cultural evolution feature multiplicity of equilibria. Hazan and Maoz (2002) and Fernández (2013) study the evolution of female labor force participation (FLFP). In their models, an increase in the FLFP rate in the population has a positive effect on a women's incentive to work either because it decreases the negative impact on her household utility or because it provides her a better public signal on the cost of working. See also Luigi Guiso and Zingales (2018)'s model with multiple social norms, Belloc and Bowles (2018)'s and Besley and Persson (2018)'s models with multiple institution-culture pair.

or predominantly random.

We can use these results to explain phenomena regarding the evolution of preferences. First, we can explain the difference in the growth rate of female labor force participation across countries. Consider type-a as men's marital preferences for a working wife (also as women's preferences for men who prefer a working wife) and action-a as the decision to participate in the labor force for a woman. Our model predicts that in a random matching environment, transitory changes are not always sufficient to move the social attitude towards working wives as well as the female labor force participation rate to what they are today (the type-a dominant equilibrium). A significant shock such as WWII is needed to enable the dynamic to escape from the basin of attraction of the type-b dominant equilibrium. In contrast, in an assortative environment, the dynamic always moves towards the unique equilibrium regardless of any shocks. Therefore, a transitory shock cannot move labor force participation to a higher level under assortative matching.

The paper is organized as follows. Section 2 provides the stylized model with one-sided investment that captures the main insight of the general model. Section 3 investigates equilibria under different matching technologies – random matching, assortative matching, and any matching that mixes random and assortative matching. Section 4 investigates the evolution of preferences after transitory and permanent changes. Section 5 provides the general model with two-sided investments. Section 6 discusses the implications of our model. Section 7 discusses related literature. Section 8 concludes.

2 A Simple Model

In this section, we propose a simple model to present the main insights. In the simple model, both men and women have two types. A man's type is inherited through intergenerational transmission, while a woman's type is determined by her choice. A motivating example would be that men's types represent their preferences for either a two-income household or a single-income household in which only the man works,[5] women's types reflect whether they participate in the formal labor force or not. In Section 4, we introduce the general model in which both men and women have types and choices and their types are determined jointly by inheritance and their own choices.

2.1 The Basic Setups

There is a unit mass of men and a unit mass of women every period. All men and women pair up, and each pair reproduces two children, one son and one daughter.[6] Each person is either type a or type b.

[5] These preferences reflect men's different gender role attitudes towards working women.

[6] Equivalently, each child is a male or a female with equal probabilities.

Let p_t denote the mass of type-a men in period t. Assume that men's types are determined through intergenerational transmission, which is specified in Section 2.2. Each woman chooses to become either type a or type b by choosing action a or b respectively before she enters the marriage market. After choosing their actions, all women enter the marriage market to find a male partner. Who they can marry is determined by the matching technology in the marriage market, which is specified in Section 3.

The cost difference in the actions a and b is heterogeneous. We normalize the cost of action b to 0 and denote the cost of action a by c. Assume the cost is distributed according to a differentiable and strictly increasing distribution F with associated density f. Assume the density f is single-peaked: there exists a $\widehat{c}$ such that $f(c) \leq f(c') \leq f(\widehat{c})$ for any c and c' such that $c < c' \leq \widehat{c}$ or $c > c' \geq \widehat{c}$.

Let $u_{t_w t_m}$ denote a type-t_w woman's utility from marrying a type-t_m man. Assume homophily in types: $u_{aa} > u_{ab}$ and $u_{bb} > u_{ba}$. We do not impose additional assumptions on the utility function.

The cost of choosing action a, the utility obtained through marriage and the matching technology jointly determine a woman's incentive to choose action a or b. Let q_t denote the proportion of women who chooses to become type-a in period t.

2.2 Intergenerational Transmission

Let $P(a|f,m) \in [0,1]$ denote the probability that a son adopts type-a given his father's type is $f \in \{a,b\}$ and his mother's type is $m \in \{a,b\}$. One can impose different assumptions on $P(a|f,m)$.

Example 1: Homogamy marriage with a superior transmission technology.
$P(a|a,a) = 1, P(a|a,b) = P(a|b,a) = \frac{1}{2}, P(a|b,b) = 0$. *When both parents are of the same type, a son would adopt that type for sure. Otherwise, a son would randomly become either type-a or type-b. This example reflects that homogamy marriage has a superior transmission technology compared with mixed marriage, which is assumed in the model of Bisin and Verdier (2000) and is empirically supported by Dohmen et al. (2012) on the transmission of risk preferences and trust attitudes.*

Example 2: Mother-to-son transmission channel.
$P(a|f,a) = 1$ *and* $P(a|f,b) = 0$. *In this case, son's preferences are solely influenced by their mother's types. See Fernández (2013) and Fernández, Fogli and Olivetti (2004) for evidence supporting that men's preferences for women are significantly affected by their mothers.*

The above two examples are special cases of a more general specification. Assume that a son adopts his father's type with probability h and his mother's type with probability $1-h$, for

$h \in [0,1]$. When $h = \frac{1}{2}$, we have the first example. When $h = 0$, we have the second example. The value of h does not change the main results of the model. Therefore, for illustration purposes, we focus on the simplest case: $h = 0$. In this case, the evolutionary dynamic of preferences is simply characterized by

$$p_{t+1} = q_t.$$

Note that the intergenerational transmission model we consider here differs from Bisin and Verdier (2000, 2001) in two important ways. First, we only model the vertical transmission from parents to children without considering the oblique transmission in which children adopt preferences from peers or role models. We argue that adding the oblique transmission would not significantly affect the main insights of the model. To see why, suppose that a son instead adopts his mother' type with probability $\phi \in (0,1)$. Otherwise, the son randomly chooses a role model in the society and adopts the role model's type. In this case, the dynamic is given by

$$p_{t+1} = \phi q_t + (1-\phi)\frac{p_t + q_t}{2} = \frac{1+\phi}{2} p_t + \frac{1-\phi}{2} q_t.$$

Compared to the dynamic generated in the case without oblique transmission, the new dynamic would have the same stationary equilibria which are defined in Section 2.3, and behave similarly except the speed of convergence.

Second, we do not explicitly model the decision process of parents to transmit their types to their children, which is crucial for leading to the phenomenon of cultural heterogeneity in Bisin and Verdier (2000, 2001). The main insights of our paper are instead driven by the incentives in the marriage market determined by its two-sided matching technology. Adding the parents to children decision would not change either the number of equilibria or their properties. Therefore, we abstract away from the parents-to-children decision process for simplicity.

2.3 Equilibrium Notions

The intergenerational transmission process gives rise to a dynamic describing the evolution of preference. Subsequently, we are interested in the stationary equilibria of the dynamic under different matching technologies. In a stationary equilibrium, each woman chooses her type to maximize her expected payoff, and the proportions of type-a men are the same across periods. Any stationary equilibrium can be simply characterized by a cutoff cost c^*: any woman with a cost lower than c^* chooses to become type a and any woman with a cost above c^* chooses to become type b.

We say an equilibrium c^* is *stable under positive perturbations*, or *positive-stable*, if there exists an $\varepsilon > 0$ such that women's optimal cutoff converges to c^* when there is initially mass

$F(c^*)+\varepsilon$ of type-a men. Similarly, we say an equilibrium c^* is *stable under negative perturbations*, or *negative-stable*, if there exists an $\varepsilon > 0$ such that women's optimal cutoff converges to c^* when there is initially fraction $F(c^*)-\varepsilon$ of type-a men. We say an equilibrium is *stable* if it is both positive-stable and negative-stable, is *unstable* if it is neither positive-stable nor negative-stable, and is *partially stable* if it is neither stable nor unstable.

3 Equilibria under Different Matching Technologies

In this section, we analyze the equilibria of the simple model given different matching technologies. We first consider random matching, which can be considered as an environment with high frictions such that people are unable to sort according to types. Second, we consider assortative matching in which women are free to match with men they like, though they may need to compete with one another when there is a shortage of likable men. Given the assumption of homophily, the proportion of homogamy marriages will reach the maximum in such an environment. Finally, we investigate the intermediate cases by varying the level of frictions to achieve assortative matching.

3.1 Random Matching

First, suppose men and women are randomly matched to reproduce. That is, in period t, given proportion p_t of type-a men, any woman is matched to a type-a man with probability p_t and matched to a type-b man with probability $1-p_t$. Under the random matching technology, a woman's expected payoff of choosing a is $p_t u_{aa}+(1-p_t)u_{ab}-c$, and her expected payoff of choosing b is $p_t u_{ba}+(1-p_t)u_{bb}$. A woman chooses a if and only if

$$c \leq p_t(u_{aa}-u_{ba})+(1-p_t)(u_{ab}-u_{bb}) \equiv C_R(p_t).$$

Hence, given proportion p_t of type-a men, a woman chooses a if and only if her cost is below $C_R(p_t)$. Note that $C_R(p_t)$ has a positive slope $u_{aa}-u_{ba}-u_{ab}+u_{bb} \equiv \Delta$, so more women choose a when there are more type-a men.

If every woman chooses optimally in period t, that is, if every woman with a cost lower than $C_R(p_t)$ chooses a and every woman with a cost higher than $C_R(p_t)$ chooses b, the proportion of type-a men in period $t+1$ is

$$p_{t+1}(p_t) = F(C_R(p_t)).$$

In each period, whether the proportion of type-a men increases, decreases, or stays the same depends on the sign of $p_{t+1}(p_t)-p_t$.[7]

Let $c_{\min}$ and $c_{\max} > c_{\min}$ denote the two solutions of $f(c)\Delta = 1$. When $C_R(p_t) < c_{\min}$ or

[7] The derivative of $p_{t+1}(p_t)-p_t$ is $f(C_R(p_t))C_R'(p_t)-1 = f(C_R(p_t))\Delta-1$.

$C_R(p_t) > c_{\max}$, $p_{t+1}(p_t) - p_t$ is decreasing. Therefore, in each of these two ranges of c, the dynamic is converging to an equilibrium if there is any. When $c_{\min} < C_R(p_t) < c_{\max}$, $p_{t+1}(p_t) - p_t$ is increasing, implying that the dynamic is diverging. If there is any equilibrium within this range, it must be unstable.

Finally, the equilibrium proportion of type-a men, p^*, satisfies $F(C_R(p^*)) - p^* = 0$ and the equilibrium cost cutoff c^* satisfies

$$B_R(c^*) \equiv C_R(F(c^*)) - c^* = 0.$$

We have the following scenarios.

Proposition 1 (Random Matching). *Suppose $f(\widehat{c})\Delta > 1$ and $B_R(c_{\min}) < 0 < B_R(c_{\max})$. There are two stable equilibria $c_1^* < c_{\min}$ and $c_2^* > c_{\max}$ and one unstable equilibrium $c_0^* \in (c_{\min}, c_{\max})$.*

The case with two stable equilibria and one unstable equilibrium described in Proposition 1 is the generic case we will consider and is depicted in Figure 1. We characterize the other non-generic cases in the appendix (that is, when the condition $B_R(c_{\min}) < 0 < B_R(c_{\max})$ does not hold). In those non-generic cases, there is one stable equilibrium and potentially another partially stable equilibrium.

One may observe that the dynamic incentive structure of our model under random matching is similar to that of an evolutionary model of coordination games. Women are trying to "coordinate" on the action that matches the prevalent type of men, leading to two distinct social conventions: one with type-a men dominating along with most women choosing action a, and another with type-b men dominating along with most women choosing action b.

A sufficiently large transitory shock is needed for the population to escape from the basin of attraction of one equilibrium to the other. More specifically, the transitory shock has to result in at least a fraction of $F(c_0)$ of women choosing action a. Otherwise, the dynamic will revert back to the stable equilibrium in the long run.

A permanent shock on the cost function can shift the entire graph in Figure 1 up or down. The permanent shock can be so big that the function $B_R(c)$ only intersects with the horizontal axis once; then we would have only one stable equilibrium. This would also help the population to transit from one equilibrium to the other as there is only one stable equilibrium left.

3.2 Assortative Matching

Second, suppose men and women are positive assortatively matched to reproduce. When the distributions of types are identical across sexes, the matching would exhibit perfect assortativeness because of homophily, as type-a men and women marry, and type-b men and women marry. When there is an imbalance of types, for example, more type-a women than type-a men, the type-a

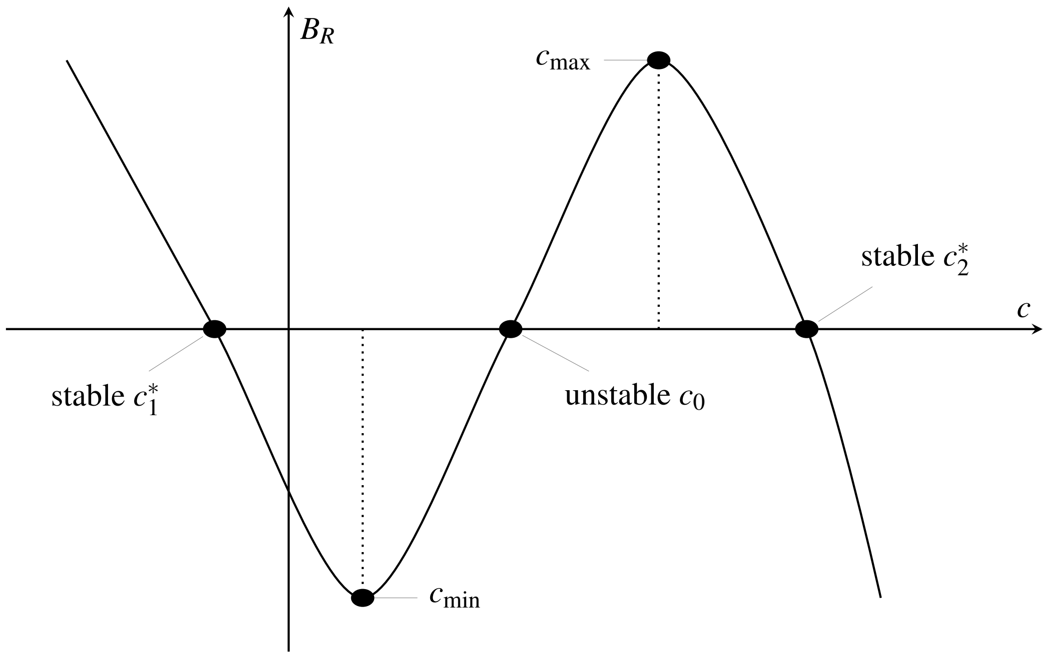

Figure 1: Two stable equilibria c_1^* and c_2^* and one unstable equilibrium c_0 under random matching.

women face competition with one another in marrying a type-a men. This leads to some involuntary cross-type marriages between type-a women and type-b men, while the remaining population are paired according to types.

Let q_t represent the proportion of women who choose action a in period t. Suppose $q_t > p_t$. A type-a woman marries a type-a man with probability p_t/q_t and marries a type-b man with probability $1 - p_t/q_t$, so that a woman's expected payoff from choosing to become type a is $\frac{p_t}{q_t}u_{aa} + (1-\frac{p_t}{q_t})u_{ab} - c$. A type-$b$ woman marries a type-b woman for sure, so that her payoff from choosing to become type b is u_{bb}. Hence, a woman chooses to become type a if and only if

$$\frac{p_t}{q_t}u_{aa} + \left(1 - \frac{p_t}{q_t}\right)u_{ab} - u_{bb} \geq c.$$

We can follow similar logic to derive a woman's optimal decision when $q_t = p_t$ or when $q_t < p_t$. In summary, a woman chooses action a if and only if $c \leq C_A(p_t, q_t)$ where

$$C_A(p_t, q_t) = \begin{cases} \frac{p_t}{q_t}u_{aa} + \left(1 - \frac{p_t}{q_t}\right)u_{ab} - u_{bb} & q_t > p_t \\ u_{aa} - u_{bb} & q_t = p_t \\ u_{aa} - \left(\frac{p_t - q_t}{1-q_t}u_{ba} + \frac{1-p_t}{1-q_t}u_{bb}\right) & q_t < p_t \end{cases}$$

Note that the function C_A is continuous and strictly increasing in p_t, and is continuous and strictly decreasing in q_t.

Recall that under random matching, women's decisions are purely driven by the distribution of men's preferences. However, under assortative matching, *women are instead playing a game with one another because their decisions take into account what other women choose*. Given p_t, the proportion of type-a men in the market, the fraction of women who choose action a in period t is given by $F(c_t)$, where c_t is the unique c that satisfies $C_A(p_t, F(c)) - c = 0$. The uniqueness of the solution follows from the fact that C_A is continuous and strictly decreasing in q_t. Cost c_t is the unique equilibrium cutoff cost simultaneously determined by all women's choices and it in turn determines the fraction of type-a men in period $t+1$, which is $p_{t+1}(p_t) = F(c_t(p_t))$.

In a stationary equilibrium, the distributions of preference types must be identical for the two sexes. Otherwise, the proportion of type-a men will change in the next period.[8] Also, the stationary type-distribution must constitute an equilibrium of the game played by all women. Hence, it satisfies

$$C_A(F(c), F(c)) - c = 0.$$

However, since there is no imbalance in types across sexes, in equilibrium, a type-a woman gets u_{aa} and a type-b woman gets u_{bb}, so the cutoff cost is determined by the difference between the two homophily payoffs, that is, $C_A(F(c), F(c)) = u_{aa} - u_{bb}$. Therefore, the unique equilibrium must satisfy $c^* = u_{aa} - u_{bb}$ and the equilibrium fraction of type-a men is $p^* = F(c^*)$.

In summary, we have the following equilibrium outcomes under assortative matching.

Proposition 2 (Assortative Matching). *There exists a unique equilibrium $c^* = u_{aa} - u_{bb}$, and the equilibrium is stable.*

The rationale for Proposition 2 is as follows. Suppose at period t, $p_t < p^*$. If the fraction of women choosing action a, q_t, equals p_t, then the benefit of choosing action a is $u_{aa} - u_{bb}$. However, the fraction of women whose costs are lower than $u_{aa} - u_{bb}$ equals $F(u_{aa} - u_{bb}) > p_t$. Hence, it is impossible to just have fraction $q_t = p_t$ of women choosing action a; more is needed. This in turn results in an increase in the fraction of type-a men in the next period. In other words, the prospect of marrying a type-a men induces an overflow of women choosing action-a when the fraction of type-a men, p_t, is not larger than p^*. Similarly, the opposite is true when $p_t > p^*$. Interesting, even though more women tend to "coordinate" on an action when more men are of the corresponding type under assortative matching, the evolutionary trajectory in fact resembles that of an anti-coordination game.

To determine the stability of the unique equilibrium, we need to check that (i) $p_{t+1}(p_t) > p_t$ when $p_t < p^*$, (ii) $p_{t+1}(p_t) < p_t$ when $p_t < p^*$, and (iii) $p_{t+1}(p^*) = p^*$. Let us first look at (i). When $q_t > p_t$, $CA(p_t, q_t)$ is less than the equilibrium cut-off cost, $u_{aa} - u_{bb}$, indicating that

[8] We show in section A.2 in the appendix that there does not exist a non-stationary equilibrium.

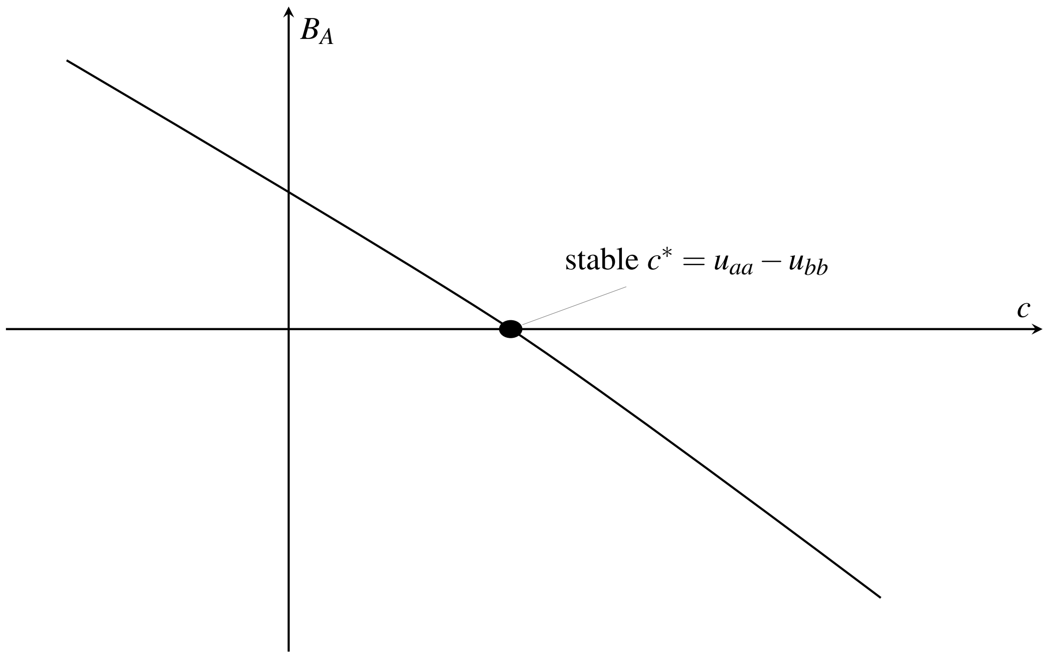

Figure 2: One stable equilibrium c^* and no other equilibrium under assortative matching.

$p_t < q_t = F(CA(p_t, q_t)) < F(c) = p^*$. Hence, $p_{t+1}(p_t) = q_t > p_t$ when $p_t < p^*$. Similarly, one can show that (ii) is satisfied. Finally, (iii) is satisfied because p^* is a stationary equilibrium.[9]

Contrary to the case of random matching, transitory shock no longer has an effect on the dynamic under assortative matching, as the dynamic always moves towards the unique equilibrium. Permanent shocks on the distribution of costs for women can result in a shift of the equilibrium. For example, if the entire graph shifts up, i.e., it is universally more costly to take action a for women, the equilibrium fraction of type-a men will decrease.

It is worth noting that the equilibrium distribution of types is *not necessarily* more balanced under assortative matching than under random matching. Figure 3 shows the possible relationships between the two stable equilibria under random matching and the unique stable equilibrium under assortative matching. In equilibrium, the mass of type-a women under assortative matching can be bigger than, between, and smaller than the two possible masses of type-a women under random matching.

3.3 Mixed Matching

Finally, we combine the two extremes, the random matching and the assortative matching, and consider the intermediate cases. Suppose that each person marries according to random matching

[9] When the cost c is bounded by $[\underline{c}, \overline{c}]$, there may exist two unstable equilibria: (i) $c^* = \overline{c}$ and $p^* = 1$ if $u_{aa} - u_{ba} > \overline{c}$, and (ii) $c^* = \underline{c}$ and $p^* = 0$ if $u_{ab} - u_{bb} > \underline{c}$.

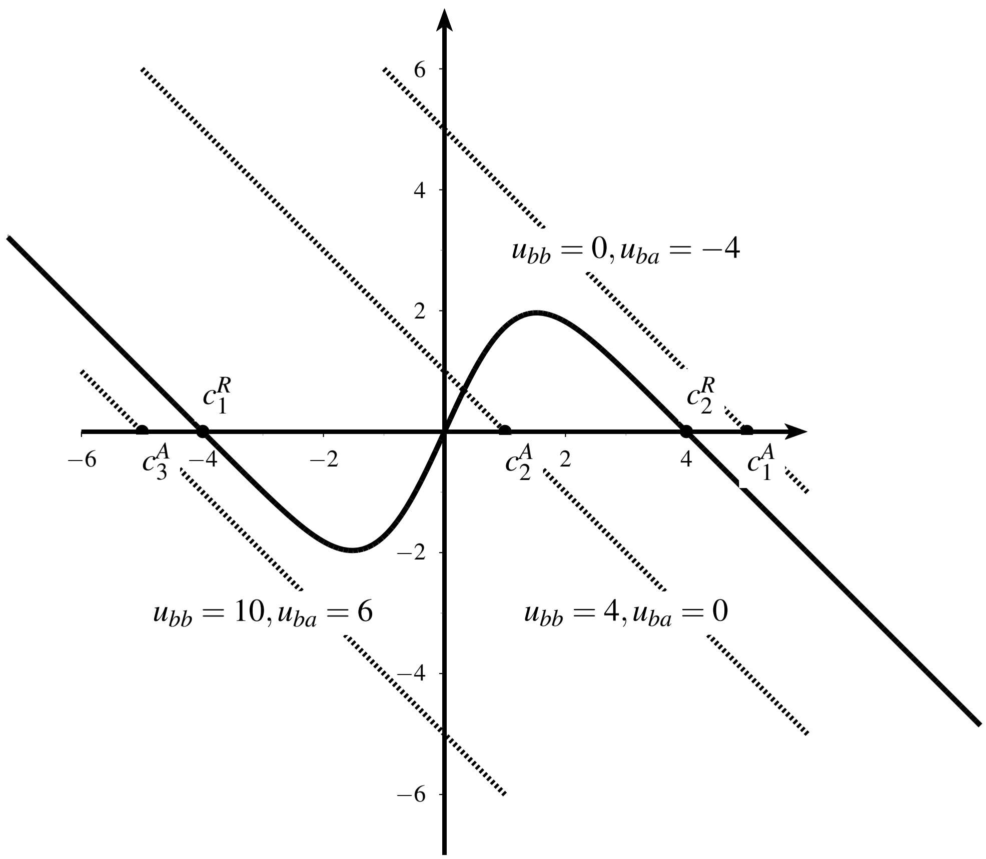

Figure 3: The relationship between the two stable equilibria under random matching and the unique stable equilibrium under assortative matching when $c \sim N(0,1)$, $u_{aa} = 5$, and $u_{ab} = 1$. The two random-matching equilibria $c_1^R = -4$ and $c_2^R = 4$ stay the same for the three groups of values of u_{bb} and u_{ba}. The one assortative-matching equilibrium can be bigger than, between, or small than the two random-matching equilibria: (i) $c_1^A = 5$ when $u_{bb} = 0$ and $u_{ba} = -4$; (ii) $c_2^A = 1$ when $u_{bb} = 4$ and $u_{ba} = 0$; and (iii) $c_3^A = -5$ when $u_{bb} = 10$ and $u_{ba} = 6$.

with probability λ and according to assortative matching with probability $1-\lambda$. Therefore, λ captures the degree of randomness, or, in other words, the level of frictions, in the matching market. The equilibrium cutoff is simply characterized by

$$\lambda C_R(F(c)) + (1-\lambda)C_A(F(c), F(c)) - c = 0.$$

Explicitly, the left-hand side is

$$\lambda F(c)(u_{aa} - u_{ab} + u_{bb} - u_{ba}) + \lambda(u_{ab} - u_{bb}) + (1-\lambda)(u_{aa} - u_{ba}) - c \equiv B(c).$$

It has a slope of

$$\lambda f(c)\Delta - 1.$$

We have the following scenarios.

Proposition 3 (Mixed Matching). *If $\lambda > 1/(f(\hat{c})\Delta)$ and $B(c_{\min}) < 0 < B(c_{\max})$, where $c_{\min}$ and $c_{\max} > c_{\min}$ are the two solutions of $f(c)\Delta = 1/\lambda$, then there are two stable equilibria $c_1^* < c_{\min}$ and $c_2^* > c_{\max}$. Otherwise, there is one stable equilibrium.*

Proposition 3 states that when random matching is prevalent, there may exist two stable equilibria, but when assortative matching is prevalent, there is only one stable equilibrium. Figure 4 demonstrates four different cases: λ takes the value of 0, 0.2, 0.8, and 1, respectively. When $\lambda = 0.2$, there is one stable equilibrium, resembling the equilibrium under assortative matching. When $\lambda = 0.8$, there are two stable equilibria, resembling those under random matching. Moreover, the equilibria in the intermediate mixed matching environment are between the stable equilibria in the extreme cases of random and assortative matching environments. For example, the two stable equilibria when $\lambda = 0.8$, c_1 and c_2 are between c_1^R and c_A and between c_A and c_2^R, respectively.

Furthermore, we can characterize the critical degree of friction in the market that determines the number of stable equilibria in the market. The number of stable equilibria is one if the degree of friction is lower than the critical degree, and is two otherwise.

Proposition 4 (Critical Degree of Frictions). *There exists a critical degree of friction λ^* such that $B(c_{\min}) = 0$ or $B(c_{\max}) = 0$, where $c_{\min}$ and $c_{\max} > c_{\min}$ are the two solutions of $f(c)\Delta = 1/\lambda^*$. There exists one stable equilibrium when $\lambda \leq \lambda^*$, and two stable equilibria otherwise.*

Subsequently, we call a marriage market with $\lambda \leq \lambda^*$ **predominantly assortative** and a marriage market with $\lambda > \lambda^*$ **predominantly random**.

The variation in the number of stable equilibria discussed above suggests that a change to the matching technology can potentially serve as an effective policy instrument. For example,

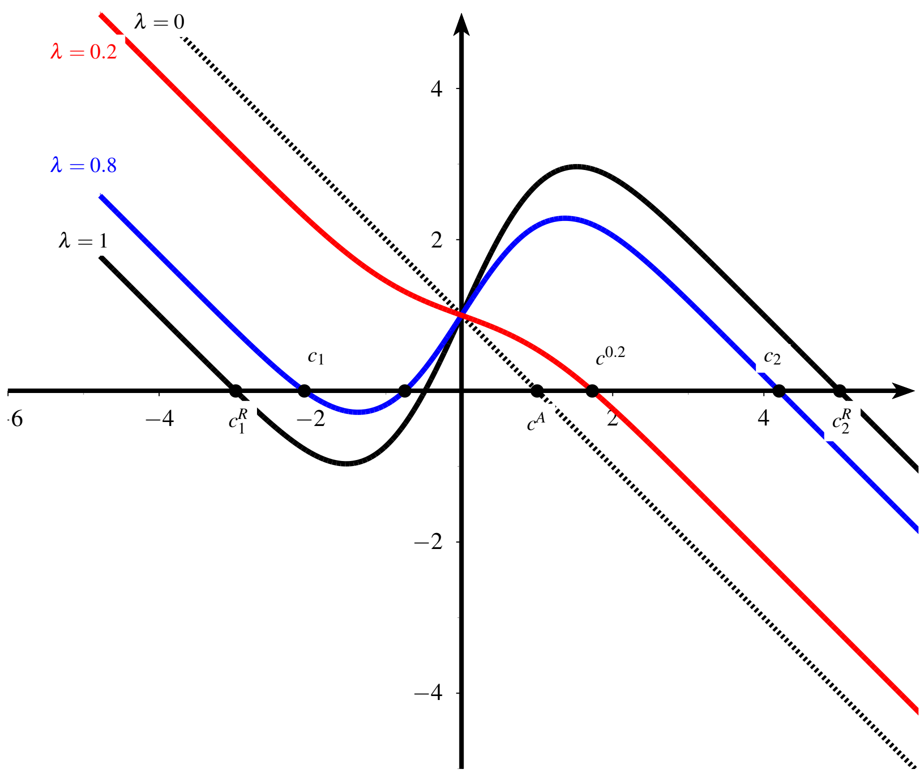

Figure 4: Stable equilibria for different λ when $c \sim N(0,1)$, $u_{aa} = 5$, $u_{ab} = 1$, $u_{bb} = 4$, and $u_{ba} = 0$. (i) When $\lambda = 0$, i.e., under assortative matching, there is a unique stable equilibrium c^A; (ii) When $\lambda = 1$, i.e., under random matching, there are two stable equilibria c_1^R and c_2^R; (iii) When $\lambda = 0.2$, there is a unique stable equilibrium $c^{0.2} \in (c^A, c_2^R)$; (iv) When $\lambda = 0.8$, there are two stable equilibria $c_1 \in (c_1^R, c^A)$ and $c_2 \in (c^A, c_2^R)$.

initially, the matching is random and the population is situated at the stable equilibrium with type-a people dominating. Suppose such an equilibrium is undesirable from a societal perspective. Policy makers can seek to reduce frictions such that the matching technology becomes more assortative and consequently, the population can move to a more balanced state with both types coexisting, provided that the equilibrium distribution of types is more balanced.

4 Evolution of Preferences after a Change

We investigate how a transitory or permanent change affects the equilibrium. The results can be summarized as follows. First, the equilibrium is robust to a transitory change of the environment when the marriages are predominantly assortative, because there is a unique stable equilibrium. Second, the equilibrium may change after a sufficiently large transitory change when the marriages are predominantly random. Third, the equilibrium favors action a when the marriages become more random.

4.1 Transitory Change in Preferences

4.1.1 One Stable Equilibrium under Predominantly Assortative Matching

When assortative matching is sufficiently prevalent, there is only one stable equilibrium. Hence, any transitory change in preferences or in cost does not lead to a persistent change to the equilibrium. Given mass p_t of type-a men, any woman with a cost lower than $c^*(p_t)$ chooses action a, where $c^*(p_t)$ satisfies

$$C_A(p_t, F(c^*(p_t))) - c^*(p_t) = 0,$$

and the mass of type-a men in the next period is $p_{t+1}(p_t) = F(c^*(p_t))$. For any $p_t < p^*$, the mass of type-a men increases and converges to p^*: $p_t < p_{t+1}(p_t) < p^*$; and for any $p_t > p^*$, the mass of type-a men decreases and converges to $p_t > p_{t+1}(p_t) > p^*$. Figure 5 demonstrates the evolution of preferences after a temporary deviation from the stable equilibrium. The equilibrium distribution of preference types reverts back to the unique stable equilibrium after a positive temporary change as well as after a negative temporary change.

4.1.2 Two Stable Equilibria under Predominantly Random Matching

When random matching is sufficiently prevalent, there are two stable equilibria c_1^* and $c_2^* > c_1^*$, so a transitory shock can move the system from one stable equilibrium to the other. Suppose the system is initially at the equilibrium c_1^* with fewer type-a men. There is a shock that results in an increase in the mass of type-a men from $F(c_1^*)$ to $p_0 > F(c_1^*)$. The cutoff cost $c(p_0)$ satisfies the equation

$$\lambda C_R(p_0) + (1-\lambda) C_A(p_0, F(c(p_0))) - c = 0.$$

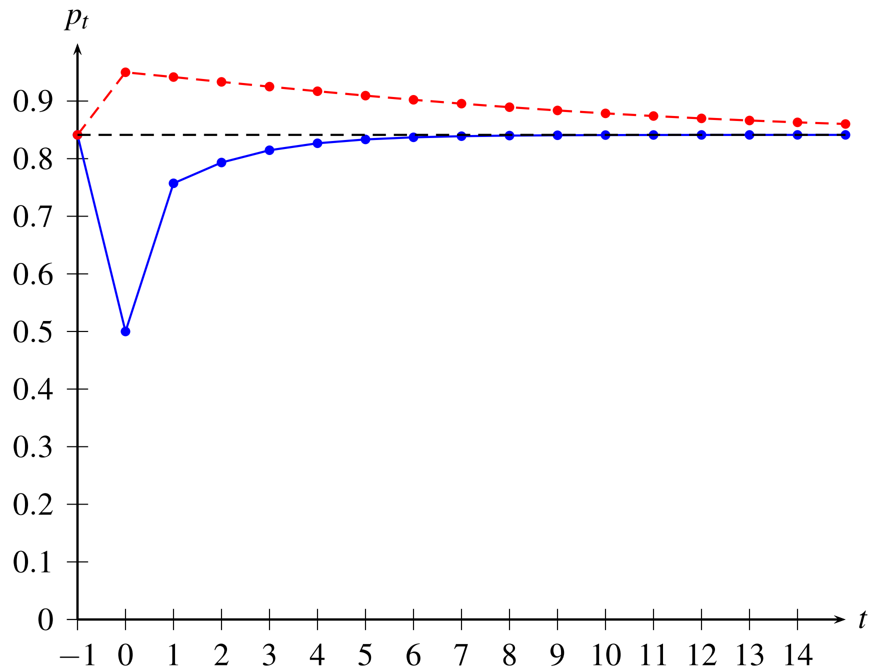

Figure 5: Evolution of preferences after a transitory change under assortative matching when $c \sim N(0,1)$, $u_{aa} = 5$, $u_{bb} = 4$, $u_{ab} = 1$, and $u_{ba} = 0$. No transitory shock has a long-run impact.

Let c_0 denote the unstable equilibrium that satisfies

$$\lambda C_R(F(c_0)) + (1-\lambda)C_A(F(c_0), F(c_0)) - c_0 = 0.$$

If $c(p_0) > c_0$ (or equivalently, $p_0 > F(c_0)$), then this transitory change results in a change in the long-run outcome.

Figure 6 demonstrates the evolution of preferences after a small temporary deviation from the low stable equilibrium as well as a large temporary deviation from the low stable equilibrium. The economy reverts back to the original equilibrium after the small temporary deviation, but moves towards the high stable equilibrium after the large temporary deviation.

4.2 Permanent Change in Matching Technology

Consider a predominantly assortative environment so that there is a unique stable equilibrium. If the marriage market becomes more random and less assortative (i.e., if λ increases), then fewer people will choose action a in equilibrium and there is a lower proportion of type a in equilibrium.

Proposition 5. *Suppose $\lambda < \lambda^*$ so that there is a unique stable equilibrium. Equilibrium cutoff c^* decreases when λ increases. As a result, there is a lower proportion of type a when marriages become less assortative.*

Economically, when women have a lower chance to reap the benefits of marrying to men of the same type, they have a lower incentive to take the necessary actions.

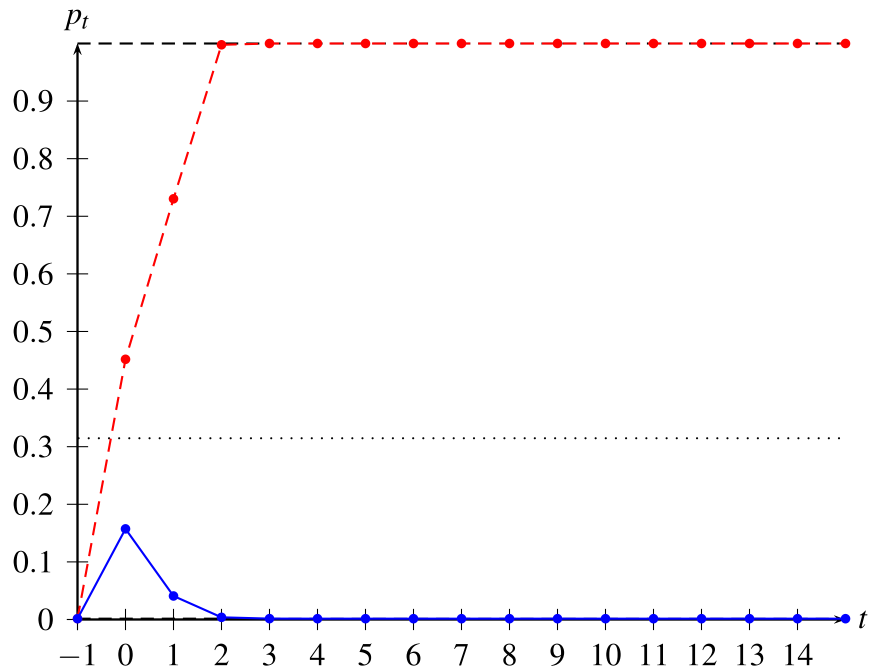

Figure 6: Evolution of preferences after a transitory change under random matching when $c \sim N(0,1)$, $u_{aa} = 5$, $u_{bb} = 4$, $u_{ab} = 1$, and $u_{ba} = 0$. A sufficiently big transitory shock (depicted by the dashed line) can leave a long-run impact. A small transitory shock (depicted by the solid line) cannot leave a long-run impact.

4.3 Permanent Change in Preferences

The equilibrium changes in intuitive ways after a permanent change in preferences.

Proposition 6. *Equilibrium cutoff c^* increases when (i) u_{aa} increases, (ii) u_{ab} increases, (iii) u_{ba} decreases, (iv) u_{bb} decreases, and (v) F decreases first-order stochastically.*

5 The General Model

In this section, we generalize the simple model. We allow both men and women to have types and actions, and an agent's type is determined by both intergenerational transmission and the choice he/she makes.

Consider a unit mass of men and a unit mass of women every period. There are two types available to all agents: a and b. Each agent's life has two periods: childhood and adulthood. During the childhood, an agent adopts an initial type from his/her parents through intergenerational transmission. During the adulthood, an agent chooses either action a or b. The initial type of an agent determines the cost of choosing different actions for him/her when he/she enters the adulthood. For example, suppose type-a represents a preference for hard working, while type-b represents a taste for leisure. Action-a represents an occupation that requires hard work, while action-b is the opposite. then an agent who has a preference for hard working in his/her childhood is likely to have a lower cost to choose an occupation that requires hard work when he/she enters the adulthood than one who has a taste for leisure in his/her childhood.

The action chosen in the adulthood determines the final type for an agent. For example, consider an agent who has a taste for leisure in his/her childhood. Even though he/she is less likely to choose an occupation that requires hard work, as long as he/she chooses it, he/she will eventually develops a preference for hard working. One can see that although the choice made in the adulthood determines the final type of an agent, intergenerational transmission indirectly influences the choice made by the agent through determining his/her initial type.

Let p_t^0 (q_t^0) denote the mass of men (women) whose initial type is a in period t. Let α_t^m (α_t^w) denote the mass of men (women) whose initial type is a choosing action-a in their adulthood in period t. Let β_t^m (β_t^w) denote the mass of men (women) whose initial type is b choosing action-a in their adulthood in period t. Let p_t^1 (q_t^1) denote the mass of men (women) whose final type is a in period t, respectively. We have the following relationships:

$$\begin{aligned} p_t^1 &= p_t^0 \alpha_t^m + (1-p_t^0)\beta_t^m; \\ q_t^1 &= q_t^0 \alpha_t^w + (1-q_t^0)\beta_t^w. \end{aligned}$$

After choosing their actions and forming their final types in the adulthood, all men and women enter the marriage market to find a partner. Assume that all men and women pair up, and each pair reproduces two children, one son and one daughter.

We normalize the cost of action b to 0 and denote the cost of action a by c_ρ^g for an individual whose gender is $g \in \{m, f\}$ and initial type is $\rho \in \{a, b\}$. Assume the cost is distributed according to a differentiable and strictly increasing distribution F_ρ^g with associated single-peaked density f_ρ^g, for $g \in \{m, f\}$ and $\rho \in \{a, b\}$.

Let $u_{t_i t_j}^i$ denote a type-t_i agent's utility from marrying a type-t_j agent of the opposite gender, for $i \neq j$ and $i, j \in \{m, f\}$. Assume homophily in types: $u_{aa}^m > u_{ab}^m$ and $u_{bb}^m > u_{ba}^m$; $u_{aa}^w > u_{ab}^w$ and $u_{bb}^w > u_{ba}^w$.

The intergenerational transmission process is characterized as follows. Suppose that a son has a probability of $h^m \in [0, 1]$ to inherit his father's type and $(1-h^m)$ to inherit his mother's type. A daughter has a probability of $h^w \in [0, 1]$ to inherit her father's type and $(1-h^w)$ to inherit her mother's type. This intergenerational tranmission process gives rise to a dynamical system that characterize the evolution of preferences independent of the matching technology:

$$\begin{aligned}
p_{t+1}^0 &= h^m p_t^1 + (1-h^m) q_t^1 \\
&= h^m (p_t^0 \alpha_t^m + (1-p_t^0)\beta_t^m) + (1-h^m)(q_t^0 \alpha_t^w + (1-q_t^0)\beta_t^w); \\
q_{t+1}^0 &= h^w p_t^1 + (1-h^w) q_t^1. \\
&= h^w (p_t^0 \alpha_t^m + (1-p_t^0)\beta_t^m) + (1-h^w)(q_t^0 \alpha_t^w + (1-q_t^0)\beta_t^w).
\end{aligned}$$

5.1 Random Matching

We first consider random matching. Assume that the agents have the information on the distribution of initial types in the current period (p_t^0 and q_t^0) and they use this information to calculate the expected benefit of choosing an action in the adulthood.[10]

Hence, a man chooses action a if and only if

$$c \leq q_t^0 (u_{aa}^m - u_{ba}^m) + (1-q_t^0)(u_{ab}^m - u_{bb}^m) \equiv c_t^m,$$

where c_t^m denotes the cutoff cost for men. We have $\alpha_t^m = F_a^m(c_t^m)$ and $\beta_t^m = F_b^m(c_t^m)$. Similarly, a woman chooses action a if and only if

$$c \leq p_t^0 (u_{aa}^w - u_{ba}^w) + (1-p_t^0)(u_{ab}^w - u_{bb}^w) \equiv c_t^w,$$

where c_t^w denotes the cutoff cost for women. We have $\alpha_t^w = F_a^w(c_t^w)$ and $\beta_t^w = F_b^w(c_t^w)$. Let $\Delta^m = u_{aa}^m + u_{bb}^m - u_{ab}^m - u_{ba}^m$ and $\Delta^w = u_{aa}^w + u_{bb}^w - u_{ab}^w - u_{ba}^w$.

The dynamic system can thus written as:

$$\begin{aligned}
p_{t+1}^0 &= D_1(p_t^0, q_t^0) \\
&\equiv h^m \big(p_t^0 F_a^m (\Delta^m q_t^0 + u_{ab}^m - u_{bb}^m) + (1-p_t^0) F_b^m (\Delta^m q_t^0 + u_{ab}^m - u_{bb}^m)\big) \\
&\quad + (1-h^m)\big(q_t^0 F_a^w (\Delta^w p_t^0 + u_{ab}^w - u_{bb}^w) + (1-q_t^0) F_b^w (\Delta p_t^0 + u_{ab}^w - u_{bb}^w)\big); \\
q_{t+1}^0 &= D_2(p_t^0, q_{t-1}^0) \\
&\equiv h^w \big(p_t^0 F_a^m (\Delta^m q_t^0 + u_{ab}^m - u_{bb}^m) + (1-p_t^0) F_b^m (\Delta^m q_t^0 + u_{ab}^m - u_{bb}^m)\big) \\
&\quad + (1-h^w)\big(q_{t-1}^0 F_a^w (\Delta^w p_t^0 + u_{ab}^w - u_{bb}^w) + (1-q_t^0) F_b^w (\Delta p_t^0 + u_{ab}^w - u_{bb}^w)\big).
\end{aligned}$$

Now let us determine the number and properties of the stationary equilibria of the dynamic

[10] An alternative assumption is that the agents form expectation on the distribution of final types in the current period (p_t^1 and q_t^1) and use this information to calculate the expected utility of choosing an action in the adulthood. By a standard argument of rational expectation, one should expect that the dynamical systems under different information criteria give rise to the same predictions.

system. Let (p^*, q^*) be a stationary equilibrium. We have $p^* = D_1(p^*, q^*)$ and $q^* = D_2(p^*, q^*)$. Note that $D_2(p,0) - 0 > 0, D_2(p,1) - 1 < 0$. Hence, if $\frac{\partial(D_2(p,q)-q)}{\partial q} - 1 < 0$ for any $p \in (0,1)$, then we have a unique q that satisfies $D_2(p,q) = q$ for any $p \in (0,1)$ and we can thus rewrite q as a function of p, denoted as $S(p)$. Plug $q = S(p)$ into $p = D_1(p,q)$, we have

$$K(p^*) \equiv D_1(p^*, S(p^*)) - p^* = 0. \tag{1}$$

The number of solutions to $K(p) = 0$ determines the number of stationary equilibrium. Let $k(p)$ denote the derivative of $K(p)$. We have the following result:

Proposition 7. *Suppose $\frac{\partial(D_2(p,q)-q)}{\partial q} < 1$ for any $p \in (0,1)$, then there exists at least one stable equilibrium. Further, if $k(p) = 0$ has two solutions, denoted by $p_{min}, p_{max} \in (0,1)$, such that $K(p_{min}) < 0 < K(p_{max})$ then there are two stable equilibria $(p_1^*, S(p_1^*))$ and $(p_2^*, S(p_2^*))$ where $p_1^* < p_{min}$ and $p_2^* > p_{max}$ and one unstable equilibrium $(p_0^*, S(p_0^*))$ where $p_0^* \in (p_{min}, p_{max})$.*

Proposition 7 demonstrates that the main insight of random matching can be obtained in the general model: there exist two social conventions featuring low and high proportion of type-a agents in the population, respectively. A sufficiently large temporary shock on preferences is needed to move the population from one convention to the other. Figure 7 provides a numerical demonstration:

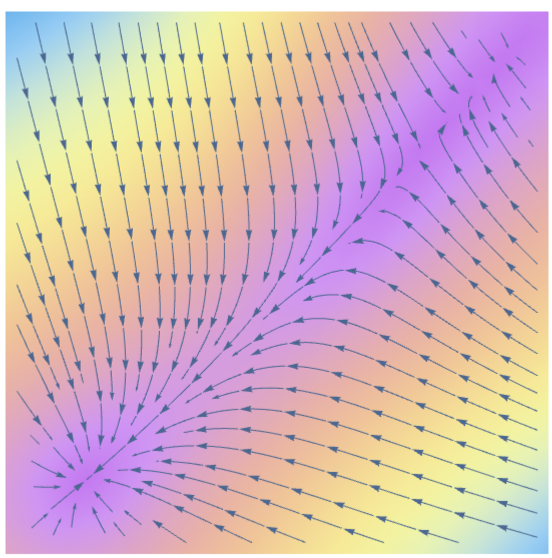

Figure 7: General model with random matching. The horizontal axis represents the proportion of type-a in the men's population. The vertical axis represents the proportion of type-a in the women's population. Let $h^m = 0.6$, $h^w = 0.4$, $\Delta_m = 4$, $u^m_{ab} - u^m_{bb} = -1$, $\Delta_w = 4$, $u^w_{ab} - u^w_{bb} = -2$, $F^m_a = F^w_a \sim N[0,1]$ and $F^m_b = F^w_b \sim N[5,5]$. There are three stationary equilibria: $(p_1^* = 0.13, q_1^* = 0.12)$ and $(p_2^* = 0.93, q_2^* = 0.92)$ are stable, while $(p_0^* = 0.79, q_0^* = 0.77)$ is unstable.

5.2 Assortative Matching

Next, we consider assortative matching. Assume that the agents have the information on the distribution of initial types in the current period (p_t^0 and q_t^0). To be consistent with the simple model, assume that men take into consideration what other men do. In other words, they form expectation about p_t^1 when calculating their expected utilities. Similarly, women form expectation about q_t^1.[11]

A man chooses action a if and only if $c \leq C_A^m(p_t^1, q_t^0)$ where

$$C_A^m(p_t^1, q_t^0) = \begin{cases} \frac{q_t^0}{p_t^1} u_{aa}^m + \left(1 - \frac{q_t^0}{p_t^1}\right) u_{ab}^m - u_{bb}^m & p_t^1 > q_t^0 \\ u_{aa}^m - u_{bb}^m & p_t^1 = q_t^0 \\ u_{aa}^m - \left(\frac{q_t^0 - p_t^1}{1 - p_t^1} u_{ba}^m + \frac{1 - q_t^0}{1 - p_t^1} u_{bb}^m\right) & p_t^1 < q_t^0 \end{cases}$$

Similarly, woman chooses action a if and only if $c \leq C_A^w(q_t^1, p_t^0)$ where

$$C_A^w(q_t^1, p_t^0) = \begin{cases} \frac{p_t^0}{q_t^1} u_{aa}^w + \left(1 - \frac{p_t^0}{q_t^1}\right) u_{ab}^w - u_{bb}^w & q_t^1 > p_t^0 \\ u_{aa}^w - u_{bb}^w & q_t^1 = p_t^0 \\ u_{aa}^w - \left(\frac{p_t^0 - q_t^1}{1 - q_t^1} u_{ba}^w + \frac{1 - p_t^0}{1 - q_t^1} u_{bb}^w\right) & q_t^1 < p_t^0 \end{cases}$$

Note that the function C_A^m (C_A^w) is continuous and strictly decreasing in p_t^1 (q_t^1), and is continuous and strictly increasing in q_t^0 (p_t^0).

Let c_t^m be the unique c that satisfies $C_A^m(p_t^1, q_t^0) = C_A^m(p_t^0 F_a^m(c) + (1 - p_t^0) F_b^m(c), q_t^0) = c$. The uniqueness of the solution follows from the fact that C_A^m is continuous and strictly decreasing in p_t^1. Let c_t^w be the unique c that satisfies $C_A^w(q_t^1, p_t^0) = C_A^w(q_t^0 F_a^w(c) + (1 - q_t^0) F_b^w(c), p_t^0) = c$. The uniqueness of the solution follows from the fact that C_A^w is continuous and strictly decreasing in q_t^1. We have $\alpha_t^m = F_a^m(c_t^m)$ and $\beta_t^m = F_b^m(c_t^m)$; and $\alpha_t^w = F_a^w(c_t^w)$ and $\beta_t^w = F_b^w(c_t^w)$. The dynamic system is given as follows:

$$\begin{aligned} p_{t+1}^0 &= h^m \big(p_t^0 F_a^m(c_t^m) + (1 - p_t^0) F_b^m(c_t^m)\big) + (1 - h^m) \big(q_t^0 F_a^w(c_t^w) + (1 - q_t^0) F_b^w(c_t^w)\big); \\ q_{t+1}^0 &= h^w \big(p_t^0 F_a^m(c_t^m) + (1 - p_t^0) F_b^m(c_t^m)\big) + (1 - h^w) \big(q_t^0 F_a^w(c_t^w) + (1 - q_t^0) F_b^w(c_t^w)\big). \end{aligned}$$

Because C_A^m and C_A^w are non-differentiable, it is in general difficult to find the stationary equilibria of the dynamical system. Fortunately, we are able to obtain a closed-form analytical result when men and women are symmetric. Let $h = h^g$, $F_a = F_a^g$, $F_b = F_b^g$, $u_{aa} = u_{aa}^g$, $u_{ab} = u_{ab}^g$, $u_{ba} = u_{ba}^g$

[11] The assumption on information implies that men and women are playing two separate simultaneous games. Alternatively, one can assume that men and women are playing a simultaneous game together. Nevertheless, predictions of the dynamical system should not change given a standard argument of rational expectation.

and $u_{bb} = u_{bb}^g$, for $g \in \{m, w\}$, we have the following:

Proposition 8. *Given symmetry across genders, there exists a uniquely stable equilibrium* $p^* = q^* = \frac{F_b(u_{aa}-u_{bb})}{1-F_a(u_{aa}-u_{bb})+F_b(u_{aa}-u_{bb})}$.

The idea behind Proposition 8 is similar to that behind Proposition 2. When the proportion of type-a agents in the population is below p^*, an overflow of both men and women choosing action-a is induced, resulting in an increase of type-a agents in the population. The opposite is true when the proportion of type-a agents in the population is above p^*. Hence, as in the case of the simple model, the incentive structure under assortative matching resembles an anti-coordination game. A single social convention persists which is resilient to temporary shocks. See Figure 8 for an illustration:

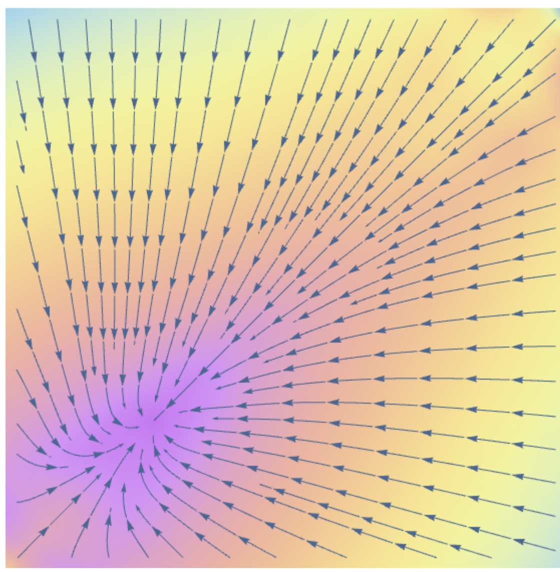

Figure 8: General model with assortative matching given symmetry across genders. The horizontal axis represents the proportion of type-a in the men's population. The vertical axis represents the proportion of type-a in the women's population. Let $h = 0.4$, $u_{aa} = 4$, $u_{ab} = 1$, $u_{ba} = 1$, $u_{bb} = 4$, $F_a \sim N[0,1]$ and $F_b \sim N[5,5]$. $(p^* = 0.24, q^* = 0.24)$ is uniquely stable.

6 Implications of the Model

We provide three examples to demonstrate that different marriage institutions can lead to different patterns of changes in preferences.

6.1 Female Labor Force Participation in Developed Countries

Many empirical studies have shown that the attitude towards gender roles has a profound impact on female labor force participation. Fortin (2005) shows how cultural beliefs about the appropriate role of women influence women's labor market outcomes across the OECD countries.

Fernández and Fogli (2005) show that female labor participation rates in parents' countries of origin predict the labor participation rate of the second-generation American women. Fernández (2007) shows that the attitudes towards working women in parents' countries of origin can explain second-generation American women's work behavior.

Most notably, Fernández, Fogli and Olivetti (2004) empirically show that the men whose mothers worked were more likely to find wives who worked, by using the regional variation in the influence of the World War II as a shock to the female labor force participation.[12] They suggest that an intergenerational transmission mechanism is at work: men with working mothers develop a stronger preference for working wives than the men with non-working mothers.

Our model suggests that such a tremendous transitory event as the World War II could result in a permanent increase in female labor force participation, but only if men and women were sufficiently randomly sorted on the dimension of attitudes towards women working. A transitory positive shock in mothers' work does not always increase labor force participation from future generations' women. When the marriage market is predominantly assortative, a transitory shock does not lead to a permanent change, because there is a unique stable equilibrium. When the marriage market is predominantly random, a transitory shock has to be large enough to overcome the frictions in the marriage market to shift the equilibrium from the one with fewer working women to the one with more working women.

Fernández, Fogli and Olivetti (2004) also provide a theoretical model to support their empirical findings. In what follows, we briefly summarize the key mechanism of their model and point out the key difference between ours and theirs. In their model, men have two types: preferring a working wife and preferring a nonworking wife. A man's type is directly determined by whether his mother works outside the home. Before marriage, each woman chooses an education level that determines her wage distribution, which in turn affects her decision to work or not if she gets married. The marriage market consists of one round of random matching and the marriage decision is made after a pair is matched. Each woman can decide to get married or to stay single. They find that a woman's effort level is always increasing in the proportion of men who like a working wife. However, this does not necessarily result in an increase in the proportion of men who like a working wife across generations because women can stay single. In general, the model generates two distinct dynamic paths depending on the functional forms. First, an upward path leading to a steady state with men who like a working wife being the majority in the population. Second, a downward path leading to a steady state with no man who preferring a working wife. Therefore, there are two possibilities for the population to evolve to the state with most men preferring a working wife (along with high FLFP). First, the evolutionary dynamic is already situated on the

[12] Goldin (1991), Acemoglu and Autor (2004) and Goldin and Olivetti (2013) also study the effect of World War II on female labor supply that persisted for the decades after the war.

upward path, such that the composition of the population is moving to the desired steady state. Second, the evolutionary dynamic is on the downward path and factors such as wars, the expansion of service sectors, labor-saving household technology, decreasing in the importance of marriage bar may shift the curve up to the upward path.

Compared to Fernández, Fogli and Olivetti (2004), our model clearly demonstrates in Section 4.1 that WWII as a transitory shock plays a key role in changing the female labor force participation and the result depends crucially on the matching technology being random. In the model of Fernández, Fogli and Olivetti (2004), however, the dynamic is either on the upward path where transitory shocks play no role, or on the downward path, escaping from which requires permanent shocks on economic fundamentals instead. On the other hand, in a predominantly assortative environment, a transitory shock does not lead to a permanent change, because there is a unique stable equilibrium. Hence, another way to escape from the type-b dominant equilibrium in the random matching environment is to reduce frictions in matching such that the entire society is transformed into a more assortative environment, as Section 4.2 shows.

Compared to the model in Fernández, Fogli and Olivetti (2004), ours incorporates a richer set of matching technologies. Furthermore, how the dynamic operates given different matching technologies depends solely on the incentives created by matching free of any particular functional forms used in the model. Finally, our results suggest that changing the frictions in matching markets may serve as a potential policy tool to achieve desirable social outcomes.[13]

6.2 Gender Norms in Developing Countries

Strong intergenerational correlation in gender norms has been well documented in the literature (Fernández, Fogli and Olivetti, 2004; Farré and Vella, 2013). We can attribute the persistence of gender norms in developing countries to the existence of arranged marriages. While the developed countries have experienced a tremendous transformation towards more equal gender norms and increasing female labor force participation and educational attainment, traditional gender role attitudes such as men's preferences for female chastity and practices including child marriage, purdah and female genital circumcision, still persist in Africa, Middle East and South Asia.

Historically, arranged marriages have been the most common form of marriage. Nowadays, freewill marriages are more prevalent across the globe, although arranged marriages still persist in many regions (Goode, 1970; Cherlin, 2012; Rubio, 2014). Arranged marriages and freewill marriages can lead to different degrees of assortative matching in preferences. Compared with freewill marriages, arranged marriages may result in more assortative matching in certain preferences, for example, preferences for chastity, and for practices including child marriage, purdah and female genital circumcision.

[13] Pande (2018) suggests that raising low rate of female labor force participation will "require behavioural interventions that address social norms."

Arranged marriages result in more assortative matching in certain preferences than freewill marriages do for the following reasons. First, arranged marriages have fewer information/search frictions than freewill marriages. Arranged marriages are usually based on known qualities of the families and the children. Through their social networks, parents usually have a wide access to potential candidates and they may be better at evaluating the candidates' characteristics. Under freewill marriages, however, people need to search for partners on their own with imperfect information about certain characteristics of their potential partners, and long courtship is often required. In addition, arranged marriage is usually organized locally, where naturally the relative small size of the marriage market leads to a higher degree of assortativeness, while freewill marriage features a larger market. Studies have shown a positive correlation between freewill marriage and urbanization/modernization.[14] In the urban area, due to the sheer size of the market, the marriage market is inevitably more random. Second, although freewill marriage can be assortative, it may be assortative along a rich set of preferences because of its complicated nature. As argued by Stone (1979), freewill marriage depends on "personal affection, companionship and friendship, a well-balanced and calculated assessment of the chances of long-term compatibility, based on the fullest possible knowledge of the moral, intellectual and psychological qualities of the prospective spouse, tested by the lengthy period of courtship." As a result, freewill marriage should exhibit relatively more randomness in the few dimensions that families usually care about in arranged marriage. Third, freewill marriage often involves match-specific quality that is idiosyncratic to the couples is not predictable according to observable traits. The match-specific quality can be interpreted as affection or attraction between a couple and it adds randomness to the matching process (Fernandez, Guner and Knowles (2005) and Huang, Jin and Xu (2017)). The match-specific quality, however, is usually out of the picture of arranged marriage as it is not important in the consideration of parents even if parents are altruistic. In certain countries, the practice of blind marriage serves as way to prevent love standing in the way of achieving the goals of parents in arranged marriages.

According to our model, in societies with more frequent arranged marriages, these preferences are more robust to transitory shocks. A temporary shock, such as a campaign to change the preferences of a generation by the government or other social institutions, or a temporary social or political event, may not lead to a permanent change. In contrast, if the society has more freewill marriages, the same temporary shock may be able to shift the social norms permanently.

One distinct feature that distinguishes these regions from the rest of the world is that arranged marriage still constitutes a major form of marriage arrangement and it seems that arranged marriage is deeply interconnected with the above described traditional gender norms. For example, ninety-

[14] Rubio (2014) finds that the transition from arranged marriage to freewill marriage is correlated with increases in urbanization across countries. Cherlin (2012) describes the rise of a "hybrid form" of arranged marriage with daughter's consent in the urban middle class in India. Huang, Jin and Xu (2017) document that in the early 90s, 48% of rural couples and 14.5% of urban couples were married by parent-involved matchmaking in China.

five percent of all marriages are still arranged in South Asia (Rubio, 2014) and there is a universal demand for female chastity. As stated in Desai and Andrist (2010), the value of a daughter cannot be damaged in the marriage market. Even a slight possibility of losing virginity will reduce a bride's desirability.

As a result, parents who benefit from delivering a virgin bride will try their best to prevent their daughter from contacting the opposite sex and searching for potential partners (Edlund and Lagerlöf, 2004). One effective way to preserve a daughter's virginity for parents is to marry her at a young age. Wahhaj (2018) quotes the following paragraph from Rozario (1992) on the case of Bangladesh to support his argument that child marriage results from the fact that age signals poor quality of women in societies with predominantly arranged marriages:

> "Many ... parents prefer to have their daughters marry as young as possible. About 15-16 years old is seen as ideal, while 18 years is considered too old, particularly if a girl begins to visit friends and neighbours outside the household and thereby cast doubt on her purity." (Rozario, 1992)

Men's preferences for female purity also result in the practice of purdah, which is adopted in certain Muslim and Hindu societies to segregate women from men and it seems that the practice is transmitted across generations:

> "[Women who practice purdah] look forward to being able to arrange their children's marriages and exert an element of power in that important decision. They certainly expect their sons to marry girls who have been carefully shielded by purdah from temptation." (White, 1977)

Traditional gender role attitudes and practices in regions where marriage are mostly arranged severely limit women's mobility and reduce their chances to receive education and to work. As shown in Rubio (2014), there is a negative correlation between arranged marriage and female participation in the formal labor market and a negative correlation between arranged marriage and women's educational attainment.

So the question is, why traditional gender norms persist under arranged marriage while transformation towards gender equality is observed in many parts in the rest of world especially the developed countries where freewill marriages prevail? We believe that the assortativeness of the marriage market affects the transmission of preferences as we demonstrate in our model can explain at least partially the variations.

Consider the simplified version of our model. Men have two types: type-a represent preferences for a working or educated wife and type-b represent preferences for a modest and domestic wife or preferences for female chastity. Assume men do not have actions to choose. Women do not have types, but they have two actions to choose from: action-a is the decision to participate in the labor force or to receive formal education and and action-b is the opposite. Naturally, homophily arises as type-a men prefer women choosing action-a and type-b men prefer women choosing action-b. As we have argued, arranged marriage results in a relatively high degree of assortativeness in the marriage market along the dimension of gender norms. Hence, our model predicts that there is a uniquely stable equilibrium. If the cost of choosing action-a for women is sufficiently high, which is true in the regions we consider, then the unique equilibrium should feature strong traditional gender norms and low female labor participation rate.[15] Moreover, the equilibrium is resilient to temporary shocks which means that there is still a long way ahead for globalization and interventions by international agencies to change the situation.

On the other hand, in societies with predominantly freewill marriages, matching is relatively random and our model predicts that there are two stable equilibria: (1) a type-a dominant equilibrium with majority of men preferring a working wife along with high female labor force participation rate that fits the description of most modern developed countries; (2) a type-b dominant equilibrium with majority of men disliking a working wife along with low female labor force participation rate that matches what happened a century ago in almost all societies. The dynamic can be trapped in the basin of attraction of the type-b dominant equilibrium but a significant transitory shock can enable the dynamic to escape from it. Fernández, Fogli and Olivetti (2004), as discussed above, provides a perfect example that WWII served as a significant transitory shock on the female labor force participation which successfully transformed the gender norms in the United States through cultural transmission and lead to a steady increase in the female labor force participation rate.

It is worth mentioning that the same effects may also distinguish the evolution of preferences in urban and rural areas. In the urban area, the larger size of the market determines that the marriage market is relatively more random. In the rural area, the relative small size of the marriage market naturally leads to more frequent assortative marriages. As a result, the same temporary shock to behavior may move the social norm in cities more likely than in villages.

6.3 Capitalistic Spirit in Preindustrial England

Doepke and Zilibotti (2006) provide evidence that, in preindustrial England, the middle class including craftsman, artisans and merchants developed preference traits featuring a good work ethic and patience, while the landed upper class instead cultivated a refined taste for leisure. When the Industrial Revolution arrived, the patient and hardworking middle class members seized the

[15] In the rural and less developed areas, the high cost of choosing action-a can be attributed to the lack of government support for the elderly and the missing market for household services, These factors raise the opportunity cost of working or receiving higher education for women and raise the value that parents place on a submissive and home-oriented daughter-in-law. See Huang, Jin and Xu (2017) for a discussion.

opportunities of economic advancement through entrepreneurship and investment and rose up in the social hierarchy, but the landed elites failed to do so.

Doepke and Zilibotti (2006) convincingly argue that the stratification in preferences and occupational choices across the two classes is deeply rooted in the economic incentives faced by them. However, they do not consider the potential effects of the different marriage institutions of the two classes. As we argue in this paper, different two-sided matching technologies can lead to distinct trajectories of preference evolution and the mechanisms can further support the observed transmission of capitalistic preferences in early modern England.

To see this, we need to provide a picture of the marriage arrangements that took place in England prior to the Industrial Revolution. Goody (1983) documents that the rise of the Catholic Church started the transformation from arranged marriages to freewill marriages across Europe, except among the landed upper class, whose members continued to arrange marriages for their children until the arrival of the Industrial Revolution. For the specific case of England, we refer to Stone (1979), which perhaps is the most important sociological work on marriage study in preindustrial England. The book points out several important properties of the class specific marriage arrangements in that era:

First, in the landed class, arranged marriage prevailed. People married at a young age and families' considerations are heavily involved in determining the matches.

> "Authoritarian control by parents over the marriages of their children inevitably lasted longest in the richest and most aristocratic circles, where the property, power and status stakes were highest." (Stone, 1979)

Second, among the lower classes, freewill marriage instead was the most common form of marriage. There are several reasons behind this phenomenon and they are summarized as follows:

> "In the first place, their parents had little economic leverage over them since they had little or nothing to give or bequeath them. In the second place, most of the children left home at the age of ten to fourteen in order to become apprentices, domestic servants, or living-on labourers in other people's houses. This very large floating population of adolescents living away from home were thus free from parental supervision and could, therefore, make their own choice of marriage partners as soon as they were out of apprenticeship." (Stone, 1979)

Members of these classes generally married late because of the need to accumulate sufficient capital to set up house and to start a shop or trade. Given the high mortality rates in the pre-modern society, parents were probably dead when their children reached their late twenties, which further freed them from patriarchal control.

Third, marriages across classes were rare. The marriage markets in the upper class and the lower classes were essentially segregated:

> "Freedom of choice can most easily be conceded by parents in closely integrated groups with internalized norms, where there is little chance that the children will come into close contact with members of the lower social class." (Stone, 1979)

Fourth, the marriage market for the landed class was organized relatively more locally compared with the lower classes. Here is an example for the landed class:

> "To give but one example, ninety percent of the known marriages of Lancashire gentry in the early seventeenth century were with other gentry families." (Stone, 1979)

The local marriage market for the landed class members possibly allowed families to arrange their children's marriages along some preference dimensions other than wealth, status, and power. For example, a wealthy man with a refined taste for leisure activities such as shooting, fox-hunting, and cricket must want to find a fine groom with the same taste for his daughter instead of someone who developed an usual enthusiasm in non-aristocratic business.

For the members in the lower classes, especially the craftsmen, artisans and merchants that Doepke and Zilibotti (2006) argue as the main force to become the early industrialists during the Industrial revolution, the marriage market was much larger and exhibited a higher degree of randomness. Farr (2000) provides a comprehensive documentary of people associated with these occupations in pre-modern Europe. He showed that craftsmen, artisans and merchants constituted a substantial percentage of the stable urban population and in major European cities, the number of trades was usually very large. For example, Late medieval London had an estimated 180 different trades and crafts. More importantly, he points out that guild endogamy is low:

> "The children of the great majority of guildsmen did not marry spouses who were, or whose fathers were, in the same guild as themselves or their fathers. That is, guild endogamy was far from the norm." (Farr, 2000)

Note that he also argued that artisanal endogamy was high. Artisans tended to find spouses in the broader social world beyond the guild but within the artisanry. However, given that they represented a significant portion of the urban population and there were a large number of different trades within artisanry in each city, we can conclude that the marriage market for them must be relatively random.

To summarize, the marriage markets in different social classes were operated independently in pre-modern England. Arranged marriage persisted in the upper landed class and the marriage market was usually organized locally and relatively assortative. Freewill marriage was popular among the lower classes. For middle class involving craftsmen, artisans and merchants, the marriage market took place in large urban areas and was relatively random.

Now we attempt to apply our model to the context of preindustrial England. Let type-a represent a taste for diligence and type-b represent a taste for leisure. Action-a represents work in occupations that require hard work such as craftsmanship, artisanry and commerce action-b represents a choice refraining from entering these businesses. Assume homophily in types. Our model predicts the following. For members in the upper landed class, the (physical and opportunity) cost of working hard was universally larger because people already had sufficient land income. Moreover, because the marriage market for them was relatively assortative, there will be a uniquely stable equilibrium in which type-b dominates. For members in the middle class, the cost of choosing action-a was much lower for type-a agents than type-b agents because those occupations associated with action-a favored the hardworking people and there was no land income at stake. Given that the marriage market for them was less assortative, there will be two stable equilibria, a type-a dominating equilibrium and a type-b dominating one.

A large transitory shock is needed to move the middle class population from the type-b dominating equilibrium to the type-a one, while such a shock has no effect on the upper landed class. The Protestant Reformation represented such a shock. As mentioned in Doepke and Zilibotti (2006), Protestant ethic of Max Weber, and in particular Puritanism, which featured frugality, thrift and diligence, spread through the urban middle classes, while the landed elites were still cultivating their taste for leisure. Therefore, our model presents a novel mechanism to explain the relation between the Protestant Reformation and the spirit of capitalism: the difference in the structure of their marriage markets between the landed upper class and the middle class determined that the Protestant values only had a chance to spread in the middle class through intergenerational transmission, which enabled its members to rise up during the Industrial Revolution and changed the economic landscape of the entire society.

6.4 Long-term Cultural Persistence

A recent literature has documented the historical roots of today's gender role attitudes. For example, Alberto Alesina and Nunn (2013), Hensen, Jensen and Skovsgaard (2015), Teso (2018), Xue (2018) and Grosjean and Khattar (2019). The idea is that the short-run outcome of a certain historical incident may imprint into people's preferences and beliefs, which are transmitted through generations until today even though the circumstances that caused the incident have long been changed.[16]

Grosjean and Khattar (2019) show that the male-biased sex ratio caused by the British policy of sending convicts to Australia has a persistent effect on men having a more traditional gender

[16] See Bisin and Verdier (2011) for a literature review on long-term persistence beyond the topic of gender roles.

attitude towards women even until today although the gender balance was quickly restored after the importation of convicts stopped. They argue that the male-biased sex ratio changed the bargaining position between men and women, leading to women enjoying more leisure in the short run. This in turn became part of the preferences and persist through cultural transmission. Moreover, they argue that homogamy marriage reinforces the persistence. They find that in areas with high homogamy marriage, male-biased sex ratio leads to a more traditional gender view, while it is not the case in areas with low homogamy marriage. We believe that our model can account for this observed pattern.

Consider the simple model with type-a referring to a man's preference for a two-income household, type-b referring to the opposite. Action-a represents a woman's participation in the work force, action-b is the opposite. Let the male-biased sex ratio be a shock that fundamentally changes people's utility in marriage. In particular, it leads to an increase in u_{bb}, the utility of a women who chooses to stay home marrying a man who prefers a single-income household.

Under assortative marriage, an increase in u_{bb} will shift the uniquely stable equilibrium to the left where there are more type-b male and women choosing action-b because the uniquely stable equilibrium cutoff cost $c^* = u_{aa} - u_{bb}$ is decreasing in u_{bb}.

Under random matching, an increase in u_{bb} will shift the two stable equilibria to the left as well because the two stable equilibrium cutoff costs c_1^*, c_2^* under random matching satisfy

$$B_R(c^*) \equiv C_R(F(c^*)) - c^* = \Delta F(c^*) + u_{ab} - u_{bb} - c^* = 0.$$

Take derivative with respect to u_{bb}, we have

$$\begin{aligned} & \Delta f(c^*)\frac{\partial c^*}{\partial u_{bb}} + F(c^*) - 1 - \frac{\partial c^*}{\partial u_{bb}} = 0 \\ \Rightarrow \quad & \frac{\partial c^*}{\partial u_{bb}} = \frac{1 - F(c^*)}{\Delta f(c^*) - 1} < 0 \text{ (because } \Delta f(c^*) - 1 < 0 \text{ for both stable equilibria).} \end{aligned}$$

Moreover, it has a much larger negative impact on the type-b dominant stable equilibrium c_1^* than on the type-a dominant stable equilibrium c_2^*. The rationale is that under random matching, in the type-a dominant equilibrium, a woman's probability of matching with a type-b man is low, so an increase in u_{bb} won't significantly increase her incentive to switch to action-b. However, in the type-b dominant equilibrium, a woman's probability of matching with a type-b man is high, so an increase in u_{bb} will lead to many women switching to action-b. To see the intuition clearer, let's look at the derivative of the cutoff cost function $C_R(p_t)$ with respect to u_{bb}: $\frac{\partial C_R(p_t)}{\partial u_{bb}} = p_t - 1$, which is decreasing in p_t. Hence, the impact of an increase in u_{bb} on the cutoff function is decreasing in the proportion of type-a men in the population. Since the proportion of type-a men in the type-a dominant equilibrium is larger than that in the type-b dominant equilibrium, the impact of an increase in u_{bb} on women's incentive to choose action-b is smaller in the former than the latter. Figure 9 provides an illustration:

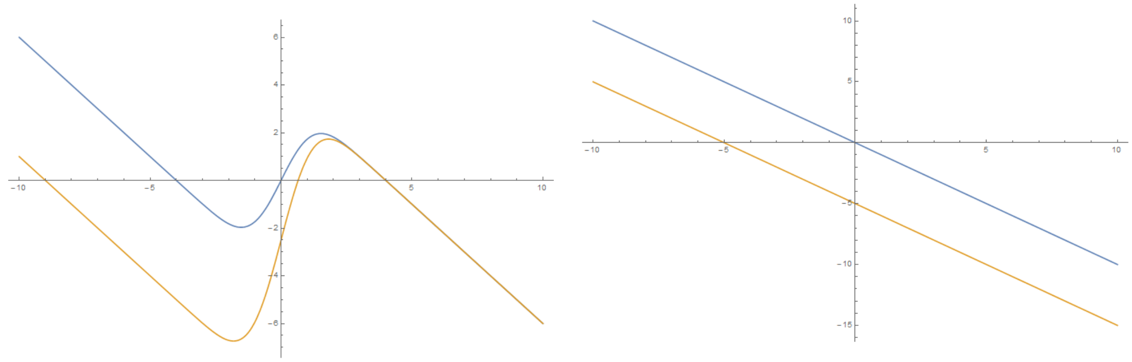

Figure 9: The impact of a change in u_{bb} on equilibria under random versus assortative marriage.

The above discussion demonstrates that an increase in u_{bb} caused by the male-biased sex ratio has a significant impact on people's gender role attitudes under assortative matching (high homgamy marriage). Moreover, such a shift in gender role attitudes is resilient to cultural shocks promoting more equal gender norms that the Australians possible experienced in the 20th century. Under random matching (low homgamy marriage), although an increase in u_{bb} caused by the male-biased sex ratio severely impacts the type-b dominant equilibrium, its impact on the type-a dominant equilibrium is negligible. Also, according to our model, a sufficiently large cultural shock can shift the entire population to the type-a dominant equilibrium. Hence, if the cultural shocks promoting equal gender norms that took place in Australia were significant, they could have shifted the men in the regions with low homgamy marriage to have more progressive gender role attitudes. This explains Grosjean and Khattar (2019)'s observation on the variations in gender role attitudes across regions characterized by different marriage markets.

7 Related Literature

In this section, we discuss the modelling differences between ours and influential models in the literature that concern the role of marriage market in the evolution of preferences.

7.1 Cultural Transmission

Bisin and Verdier (2000) proposed an overlapping generational cultural transmission model with a marriage market. In their model, agents in the population have two types and they prefer their children to have their own types, an assumption called the "imperfect empathy." Agents need to enter a frictional marriage market to get married so as to produce offsprings. The marriage market consists of two restricted matching pools exclusive for the two types respectively and a common matching pool. Entering a restricted matching pool is costly. The paper assumes that the same-type parents enjoy a more efficient socialization technology for their shared type than the mixed-type parents. As a result, agents prefer to marry with their own types (homogamy marriage). The authors show that when the proportion of a type of agents decreases in the population, agents of such type have a stronger incentive to enter the restricted marriage pool and to exert a higher effort to socialize their type to their children. The dynamic generated by this cultural transmission process will eventually lead to cultural heterogeneity, a stable equilibrium in which both types coexist.

Although their model considers marriage and sexual reproduction, agents in the population are not distinguished by sexes and consequently the marriage market is not two-sided as in our model. In addition, as they show in their subsequent paper (Bisin and Verdier, 2001), imperfect empathy alone can generate the key prediction of cultural heterogeneity without marriage and sexual reproduction as long as the socialization technology is not perfect, i.e., children have a possibility to be influenced by role models in the population at large. In our model, the socialization technology is perfect as the children are influenced either by their father or their mother. Interestingly, we are able to obtain an equilibrium in which both types coexist with each constituting a significant proportion of the population, demonstrating that cultural heterogeneity in preferences can be attributed to the incentives that arise in an assortative two-sided marriage market.

7.2 Marriage Incentives and Risk Taking

A notable study of an evolution model with a two-sided matching structure is Robson (1996*b*), who points out that competing for mates may lead to risk taking. His model proceeds in two stages. At the first stage, each man decides whether to take a risky gamble. At the second stage, each woman decides which man to marry to. The marriage system allows polygyny and it is assumed that the wealthier a man is and the more wives he has, and consequently the more offspring he can produce. If the gamble results in a large gain and a small loss, then taking it becomes the dominant strategy for each man as it gives him a chance to get a sufficiently large relative wealth to attract more wives.

The model of Robson (1996*b*) provides a reproductive mechanism to explain risk-taking behavior. However, he assumes that all men (women) are identical and the model is not of a dynamic nature as there is nothing really evolving. Our model instead allows heterogeneity in the population and we consider how two-sided matching influences the evolution of preferences in the long run.

Now consider a variation of our model applied in a similar context. Suppose women have two types, a type (type-a) that attracts and is attracted to wealthier men, and an opposite type (type-b). Men can choose to take a risky gamble and their types are defined by their wealth. Suppose the transmission channel operates through father to daughter. That is, the wealthier a father is, the more likely his daughter is type-a. In a random matching environment, the prediction would be that either women are mostly type-b with almost no men taking risk or women are mostly type-a with most man taking risk. In an assortative environment, a mixture of both types of women with a moderate proportion of men taking risk would be the prediction. Compared to Robson (1996*b*), our model is able to discuss the implications of different matching technologies on the evolution of attitudes towards risk.

8 Conclusion

This paper examines the intergenerational transmission of preferences under different organizations of the marriage market. We find that different organizations of the marriage market influence the evolution of preferences. Namely, there are multiple stable equilibria, like in coordination games, when the degree of frictions in matching is large, and there is one stable equilibrium, like in anti-coordination games, when the degree of frictions is small. The model can be applied to study the effect of transitory shocks to preferences. To be able to explain how the equilibrium permanently shifts due to a transitory shock to individual choices or preferences (for example, more women work today due to the transitory increase in World War II), we must be working under a sufficiently frictional matching market.

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A Apppendix

A.1 Non-generic cases of equilibria under random matching

The appendix includes the characterization of equilibria under random matching when the condition $0 < B_R(c_{\min}) < B_R(c_{\max})$ does not hold. We will exhaustively consider three other cases: (1) $0 = B_R(c_{\min}) < B_R(c_{\max})$, (2) $B_R(c_{\min}) < B_R(c_{\max}) = 0$, and (3) $B_R(c_{\min}) < B_R(c_{\max}) < 0$.

A.1.1 One type-a dominant stable equilibrium

If $0 < B_R(c_{\min}) < B_R(c_{\max})$, then there is one stable equilibrium $c^* > c_{\max}$ and no other equilibrium. Figure A.1 illustrates this scenario.

A.1.2 One stable equilibrium and one negative-stable equilibrium

If $0 = B_R(c_{\min}) < B_R(c_{\max})$, then there is one stable equilibrium $c^* > c_{\max}$ and one negative-stable but positive-unstable equilibrium $c_{\min}$. Figure A.2 illustrates this scenario.

A.1.3 One stable equilibrium and one positive-stable equilibrium

If $B_R(c_{\min}) < B_R(c_{\max}) = 0$, then there is one stable equilibrium $c^* < c_{\min}$ and one positive-stable but negative-unstable equilibrium $c_{\max}$. Figure A.3 illustrates this scenario.

A.1.4 One type-b dominant stable equilibrium and no other equilibrium

If $B_R(c_{\min}) < B_R(c_{\max}) < 0$, then there is on stable equilibrium $c^* < c_{\min}$ and no other equilibrium. Figure A.4 illustrates this scenario.

A.2 Nonexistence of a non-stationary equilibrium

Proposition. *There does not exist a non-stationary equilibrium under assortative matching.*

Proof. We prove the nonexistence of a non-stationary equilibrium by contradiction. Let c^* denote the unique stable stationary equilibrium.

Suppose there exists a non-stationary equilibrium in which the cutoff is $c_t > c^*$ in period t. The equilibrium fraction of type-a men in the next period, period $t+1$, must be $F(c_t) > F(c^*)$. Facing fraction $F(c_t)$ of men, the fraction of women choosing action a in period $t+1$ is $p_{t+1} = F(c_{t+1})$, where c_{t+1} satisfies $C_A(F(c_t), F(c_{t+1})) - c_{t+1} = 0$. Because $C_A(F(c_t), F(c)) - c > C_A(F(c), F(c)) - c$ as $C_A(p_t, q_t)$ is strictly increasing in p_t, and because $C_A(F(c'), F(c)) - c$ is strictly decreasing in c, $c_{t+1} > c^*$ when $c_t > c^*$. We know that $C_A(F(c_t), F(c_{t+1})) - c_{t+1} = 0$, and that $C_A(F(c_{t+1}), F(c_{t+1})) - c_{t+1} < 0$ because $c_{t+1} > c^*$. The fact that $C_A(F(c_t), F(c_{t+1})) - c_{t+1} = 0 > C_A(F(c_{t+1}), F(c_{t+1})) - c_{t+1}$ implies that $c_{t+1} < c_t$, because $C_A(p_t, q_t)$ is strictly increasing in p_t. Therefore, $c^* < c_{t+1} < c_t$. This is true for any $c_t > c^*$, so in equilibrium we must have a monotonic sequence of cutoffs that converges to c^* (rather than sequence of cutoffs that oscillate in a non-stationary equilibrium).

Following the similar logic, we can show that there does not exist a non-stationary equilibrium

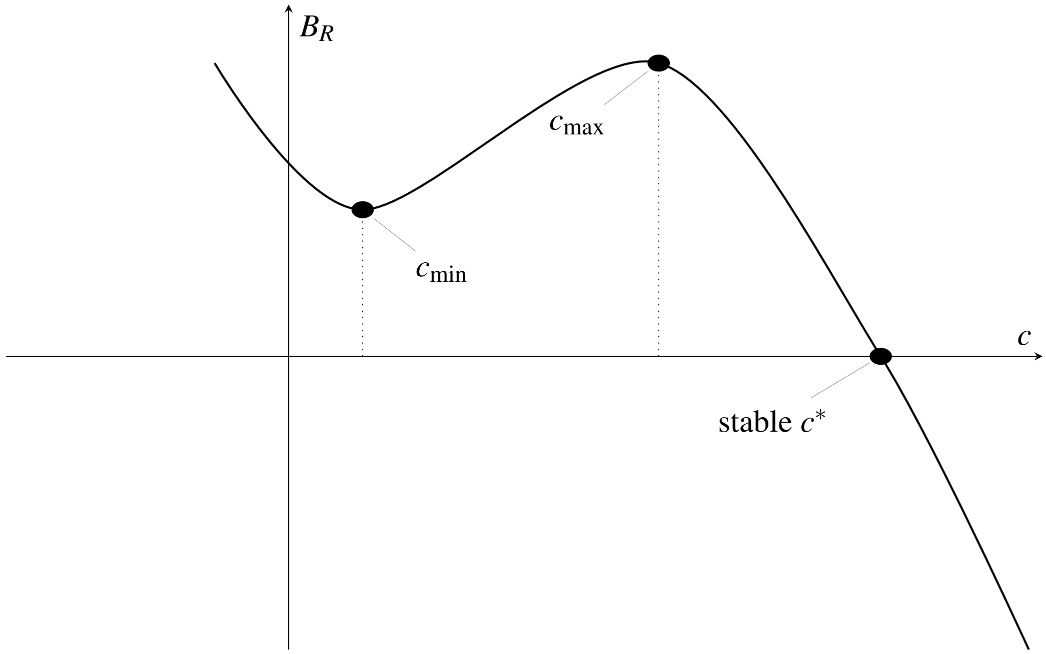

Figure A.1: One stable equilibrium $c^* > c_{\max}$ and no other equilibrium when $0 = B_R(c_{\min}) < B_R(c_{\max})$.

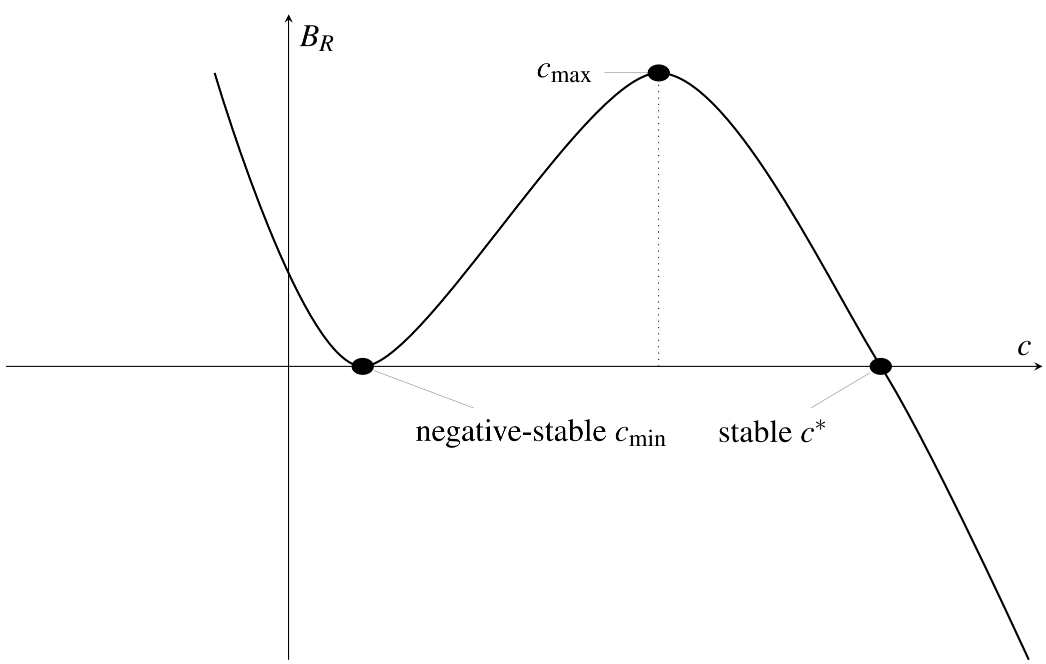

Figure A.2: One stable equilibrium c^* and one negative-stable but positive-unstable equilibrium $c_{\min}$ when $0 = B_R(c_{\min}) < B_R(c_{\max})$.

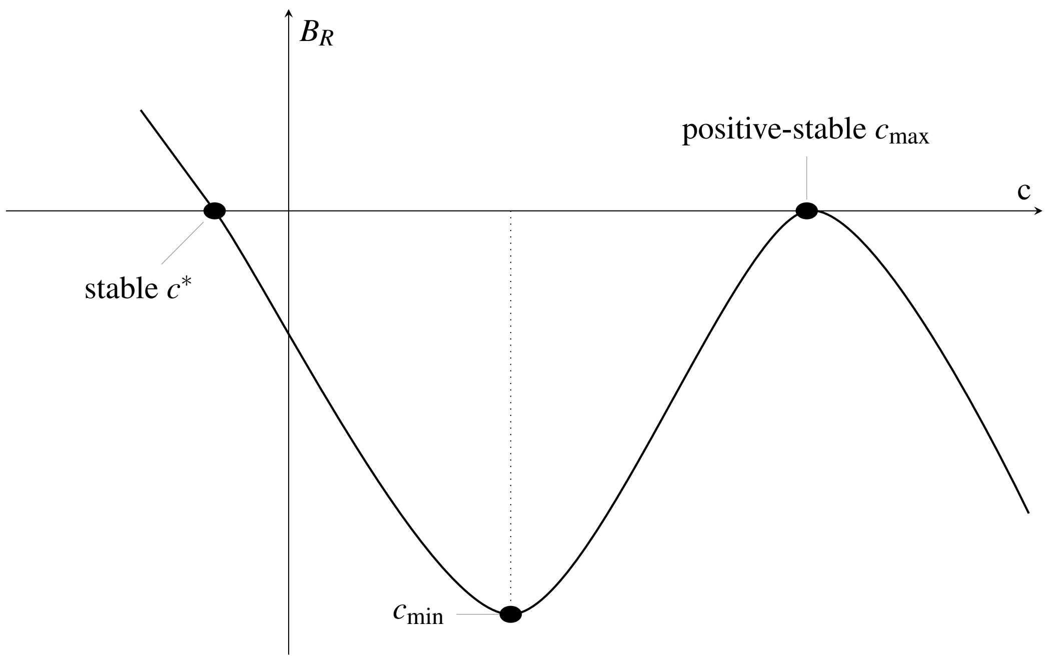

Figure A.3: One stable equilibrium $c^* < c_{\min}$ and one positive-stable but negative-unstable equilibrium $c_{\max}$ when $B_R(c_{\min}) < B_R(c_{\max}) = 0$.

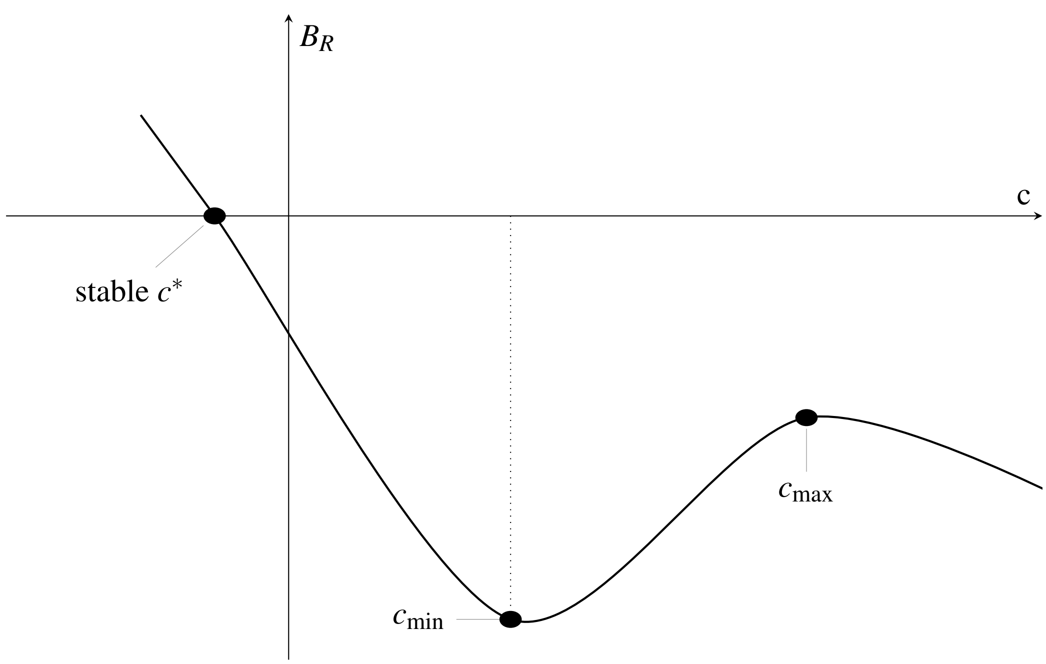

Figure A.4: One stable equilibrium c^* and no other equilibrium when $B_R(c_{\min}) < B_R(c_{\max}) < 0$.

in which the cutoff in equilibrium is $c_t < c^*$. $\square$

Proposition. *There does not exist a non-stationary equilibrium under any matching technology.*

Proof of Proposition 5. Consider the equation characterizing the equilibrium cutoff.

$$\lambda F(c^*)(u_{aa} - u_{ab} + u_{bb} - u_{ba}) + \lambda(u_{ab} - u_{bb}) + (1-\lambda)(u_{aa} - u_{ba}) - c^* = 0$$

Applying the implicit function theorem and taking the derivative of the equation, we get

$$(F(c^*) - 1)\Delta - c'(\lambda) + \lambda f(c^*)\Delta c'(\lambda) = 0.$$

Rearranging, we have

$$c'(\lambda) = \frac{1 - F(c^*)}{\lambda f(c^*)\Delta - 1}\Delta.$$

Since $\lambda f(c^*)\Delta - 1$ is the slope of the left hand side of the equation, it is negative. Therefore, $c'(\lambda) < 0$. $\square$

Proof of Proposition 7. Observe that $K(0) > 0$ and $K(1) < 0$. There must exist at least one stationary equilibrium, $(p^*, S(p^*))$, such that $K(p^*) = 0$ and $k(p^*) < 0$, implying that the equilibrium is stable.

Suppose $k(p) = 0$ has two solutions, denoted by p_{min}, p_{max}, then we must have $k(p) < 0$ for $p \in (0, p_{min}) \cup (p_{max}, 1)$ and $k(p) > 0$ for $p \in (p_{min}, p_{max})$. Furthermore, if $K(p_{min}) < 0 < K(p_{max})$, then $K(0) > 0$, $K(p_{min}) < 0$, together with $k(p) < 0$ for $p \in (0, p_{min})$, imply that there must exist a stable stationary equilibrium in which the p value lies in $(0, p_{min})$. Similarly, since $K(p_{max}) > 0$, $K(1) < 0$ and $k(p) < 0$ for $p \in (p_{max}, 1)$, there must exist a stable stationary equilibrium in which the p value lies in $(p_{max}, 1)$. Finally, $K(p_{min}) < 0 < K(p_{max})$, together with $k(p) > 0$ for $p \in (p_{min}, p_{max})$, implies that there exists an unstable equilibrium whose p value lies in (p_{min}, p_{max}). $\square$

Proof of Proposition 8. Since $h^m = h^w$, we must always have $p_t^0 = q_t^0$, for $t > 0$. Also, symmetry implies $c_t^m = c_t^w$. Hence, $p_t^1 = q_t^1$. This further implies that $c_t^m = c_t^w = u_{aa} - u_{bb}$. Hence, the dynamical system can be simplified as $p_{t+1}^0 = p_t^1 = p_t^0 F_a(u_{aa} - u_{bb}) + (1 - p_t^0)F_b(u_{aa} - u_{bb}))$.

A stationary equilibrium (p^*, q^*) thus satisfies $p^* = q^* = p^* F_a(u_{aa} - u_{bb}) + (1 - p^*)F_b(u_{aa} - u_{bb})$. This gives us a unique solution: $p^* = q^* = \frac{F_b(u_{aa} - u_{bb})}{1 + F_b(u_{aa} - u_{bb}) - F_a(u_{aa} - u_{bb})}$.

Differentiate $p_t^0 F_a(u_{aa} - u_{bb}) + (1 - p_t^0)F_b(u_{aa} - u_{bb})) - p_t^0$ with respect to p_t^0, we obtain a negative derivative $F_a(u_{aa} - u_{bb}) - F_b(u_{aa} - u_{bb}) - 1$, implying that the dynamical system always converges to the stationary equilibrium (p^*, q^*). $\square$

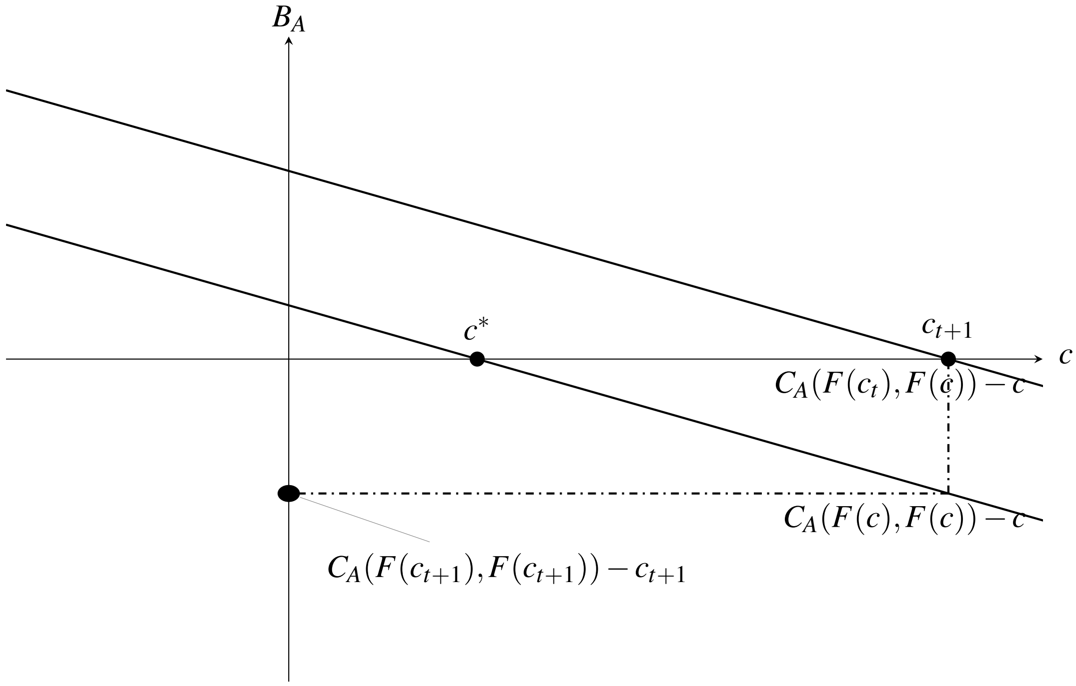

Figure A.5: One stable equilibrium c^* and no other equilibrium under assortative matching.

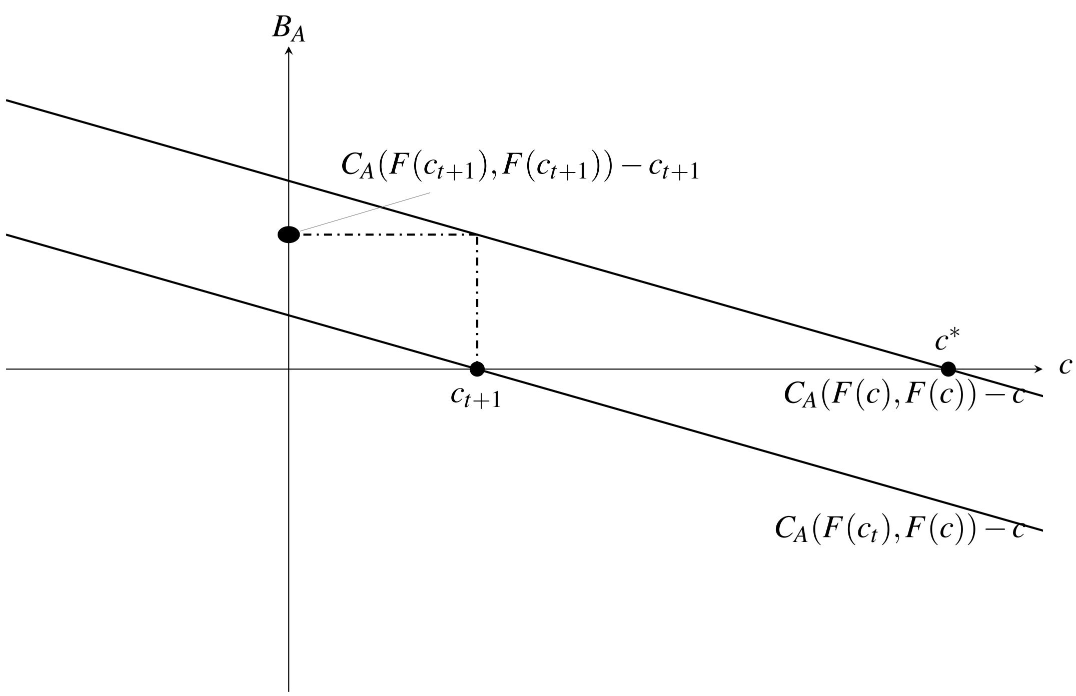

Figure A.6: One stable equilibrium c^* and no other equilibrium under assortative matching.

Proof of Equilibrium Uniqueness. Let p and q represent p^1 and q^1, respectively. Equilibrium p and q satisfy

$$(h^m p + (1-h^m)q)F_a^m(k_m(p,q)) + (1-h^m p-(1-h^m)q)F_b^m(k_m(p,q)) - p = 0 \tag{1}$$

$$(h^w p + (1-h^w)q)F_a^w(k_w(p,q)) + (1-h^w p-(1-h^w)q)F_b^w(k_w(p,q)) - q = 0 \tag{2}$$

where

$$k_m(p,q) = \begin{cases} \frac{q}{p}u_{aa}^m + (1-\frac{q}{p})u_{ab}^m - u_{bb}^m & p \geq q \\ u_{aa}^m - \left(\frac{q-p}{1-p}u_{ba}^m + \frac{1-q}{1-p}u_{bb}^m\right) & p < q \end{cases}$$

$$k_w(q,p) = \begin{cases} \frac{p}{q}u_{aa}^w + (1-\frac{p}{q})u_{ab}^w - u_{bb}^w & p < q \\ u_{aa}^w - (\frac{p-q}{1-q}u_{ba}^w + \frac{1-p}{1-q}u_{bb}^w) & p \geq q \end{cases}$$

Since for any p, there is a q that satisfies equation (2), we have that

$$(h^w p + (1-h^w)q(p))F_a^w(k_w(p,q(p))) + (1-h^w p-(1-h^w)q(p))F_b^w(k_w(p,q)) - q(p) = 0.$$

By implicit function theorem,

$$\begin{aligned} & (h^w + (1-h^w)q')F_a^w + (-h^w - (1-h^w)q')F_b^w - q' \\ + & (h^w p + (1-h^w)q)f_a^w \cdot (k_{wp} + k_{wq}q') + (1-h^w p - (1-h^w)q)f_b^w \cdot (k_{wp} + k_{wq}q') \quad = \quad 0, \end{aligned}$$

where $k_{wp} > 0$ and $k_{wq} < 0$

$$k_{wp} = \begin{cases} \frac{1}{q}\left(u_{aa}^w - u_{ab}^w\right) & p < q \\ \frac{1}{1-q}\left(u_{bb}^w - u_{ba}^w\right) & p \geq q \end{cases}, \quad k_{wq} = \begin{cases} -\frac{p}{q}\frac{1}{q}\left(u_{aa}^w - u_{ab}^w\right) & p < q \\ -\frac{1-p}{1-q}\frac{1}{1-q}\left(u_{bb}^w - u_{ba}^w\right) & p \geq q \end{cases}.$$

Simplify the expression above, we get

$$q' = \frac{h^w(F_a^w - F_b^w) + f^w k_{wp}}{1-(1-h^w)(F_a^w - F_b^w) - f^w k_{wq}} > 0$$

where

$$f^w = (h^w p + (1-h^w)q)f_a^w + (1-h^w p - (1-h^w)q)f_b^w \in (\min\{f_a^w, f_b^w\}, \max\{f_a^w, f_b^w\}).$$

The denominator minus the numerator of q' is

$$1-(F_a^w-F_b^w)-f^w(k_{wq}+k_{wp})=1-(F_a^w-F_b^w)-f^w\times\begin{cases}(1-\frac{p}{q})\frac{1}{q}(u_{aa}^w-u_{ab}^w) & p<q\\ (1-\frac{1-p}{1-q})\frac{1}{1-q}(u_{bb}^w-u_{ba}^w) & p\geq q\end{cases}\tag{3}$$

As long as this expression is non-negative, q' is weakly smaller than 1. Let's investigate the slope of the LHS of equation (1), given $q(p)$. It is

$$(h^m+(1-h^m)q')(F_a^m-F_b^m)+f^m\cdot(k_{mp}+k_{mq}q')-1$$

where

$$f^m=(h^mp+(1-h^m)q)f_a^m+(1-h^mp-(1-h^m)q)f_b^m\in(\min\{f_a^m,f_b^m\},\max\{f_a^m,f_b^m\}),$$

and $k_{mp}<0$ and $k_{mq}>0$ represent

$$k_{mp}=\begin{cases}-\frac{q}{p}\frac{1}{p}(u_{aa}^m-u_{ab}^m) & p\geq q\\ -\frac{1-q}{1-p}\frac{1}{1-p}(u_{bb}^m-u_{ba}^m) & p<q\end{cases},\quad k_{mq}=\begin{cases}\frac{1}{p}(u_{aa}^m-u_{ab}^m) & p\geq q\\ \frac{1}{1-p}(u_{bb}^m-u_{ba}^m) & p<q\end{cases}$$

Plugging in q', we can show that the LHS has the same sign as the following expression:

$$\left[\frac{(1-h^m)(F_a^m-F_b^m)+f^mk_{mq}}{1-h^m(F_a^m-F_b^m)+f^mk_{mq}r^m}\right]\cdot\left[\frac{h^w(F_a^w-F_b^w)+f^wk_{wp}}{1-(1-h^w)(F_a^w-F_b^w)+f^wk_{wp}r^w}\right]-1$$

where $r_m\leq 1$ and $r_w\leq 1$ represent

$$r^m=\begin{cases}\frac{q}{p} & p\geq q\\ \frac{1-q}{1-p} & p<q\end{cases},\quad r^w=\begin{cases}\frac{1-p}{1-q} & p\geq q\\ \frac{p}{q} & p<q\end{cases}$$

The numerator minus the denominator of the first term is simplified as

$$1-(F_a^m-F_b^m)-f^mk_{mq}(1-r^m)=1-(F_a^m-F_b^m)-f^m\times\begin{cases}(1-\frac{q}{p})\frac{1}{p}(u_{aa}^m-u_{ab}^m) & p\geq q\\ (1-\frac{1-q}{1-p})\frac{1}{1-p}(u_{bb}^m-u_{ba}^m) & p<q\end{cases}\tag{4}$$

As long as this expression is nonnegative, the first term is weakly smaller than 1. Coupled with q' smaller than 1, the LHS must be decreasing and we have a unique equilibrium. Furthermore, since the LHS is nonnegative when $p=0$ and is nonpositive when $p=1$, even if the LHS is upward-sloping for small p (or for big p), there is still a unique equilibrium. □

A.3 Evidence from Arranged Marriages in India

We use India Human Development Survey-II (IHDS-II), 2011-2012, to verify our assumptions that arranged marriages are more assortative in marital preferences and characteristics, as well as our predictions that (the more assortative) arranged marriages are associated with more backwards (male-dominated) norms in marriage and work, and in fertility preferences and actualization.

Arranged marriages are defined as those marriages in which parents/relatives alone choose a husband (MH4A=3) and a woman does not have a say in the choice (MH4B=0). Non-arranged marriages are those marriages in which (i) a woman chooses on her own (MH4A=1), (ii) the woman and parents/relatives jointly choose together (MH4A=2), or (iii) parents/relatives choose alone (MH4A=3) but a woman has a say in the choice (MH4B=1).[17]

Table A.1 shows summary statistics of arranged marriages: 5 percent of women choose husband alone, 21.9 percent of women choose jointly with parents, 30.6 percent of women have a say in parents' choice, and 42.5 percent of women do not have a say in parents' choices.

Table A.1: **marriage type**

Item	Number	Per cent
Woman chooses	1968.0	5.0
Woman and parents/relatives jointly choose	8605.0	21.9
Parents/relatives choose, woman has a say	11991.0	30.6
Parents/relatives choose, woman has no say	16672.0	42.5
Total	39236.0	100.0

Source: data.dta

Subsequently, we show how arranged marriages are associated with more homophily in preferences, more homophily in social and economic status, more backwards norms in work and marriages, preferences for more children and sons, and actually having more children (but not ending up with more sons).

First, arranged marriages are associated with more assortative matching in preferences. Table A.2 shows that arranged marriages are associated with 1.1 percent more chance in having the same preference for whether women want to work and 10.5 percent more chance of having the same preference for having more kids as well as more homophily in preferences for when to have next kid and how many more kids to have.

Second, arranged marriages are associated with more assortative matching in social and economic status. Table A.3 shows that arranged marriages are associated with 1.4 percent more chance of marrying in the same caste, 1.4 percent more chance of marrying to the same or better economic status, 3.4 percent more chance of marrying to the same college level, and 3.1 percent more chance

[17] Jacob (2016) defined arranged marriages in exactly the same way. In contrast to our paper that focuses on the associations of arranged marriages with marital preferences and with alignment of husband's and wife's preferences, she investigated the effects of arranged marriages on marital life and child development.

Table A.2: preference homophily in arranged marriages

	sameworkpref	samemorekidspref	samewhennextkidpref	samenmorekidspref
	b/t	b/t	b/t	b/t
arranged=1	0.011***	0.105***	0.003	0.001
	(4.07)	(13.43)	(0.65)	(0.08)
Constant	0.945***	0.533***	0.969***	0.956***
	(512.02)	(105.92)	(367.87)	(196.44)
Observations	26677	16179	6505	2769

of speaking English.

Table A.3: social and economic status homophily in arranged marriages

	samecaste	sameeconstatus	samecollege	sameEnglish
	b/t	b/t	b/t	b/t
arranged=1	0.014***	0.014***	0.034***	0.031***
	(6.58)	(3.75)	(8.41)	(7.15)
Constant	0.944***	0.159***	0.785***	0.781***
	(613.35)	(65.13)	(287.29)	(267.60)
Observations	39077	39143	39236	34401

Finally, arranged marriages are associated with more male-dominated norms in marital preferences and behavior. Table A.4 shows that arranged marriages are associated with 29.7 percent more chance of practicing purdah, 26.2 percent more chance of being illiterate, 1.1 percent more chance that husband decides whether wife can work, and 3.5 percent more chance husband decides to whom children marry.

Table A.4: backwards norms in arranged marriages

	purdah	illiterate	husbdecideswork	husbdecideskidmarr
	b/t	b/t	b/t	b/t
arranged=1	0.297***	0.262***	0.011*	0.035***
	(62.84)	(53.76)	(2.15)	(7.52)
Constant	0.452***	0.279***	0.422***	0.672***
	(136.48)	(93.42)	(128.42)	(214.87)
Observations	39236	39233	39236	39236

Figure A.7 confirms the positive correlation between percent of male-dominated norms and percent of arranged in different Indian states.

Arranged marriages are associated with more kids and higher percent of sons desired. Table A.5 shows that women in arranged marriages want 0.345 more children, 0.263 more sons, 0.083 more daughters, and 2.3 percent more sons.

Arranged marriages are associated with more actual kids but not more actual sons. Table A.6 shows that women in arranged marriages have 1.207 more children, 0.598 more sons, 0.598 more daughters, but virtually the same percent of sons as those in non-arranged marriages despite of preference for a higher composition of sons.

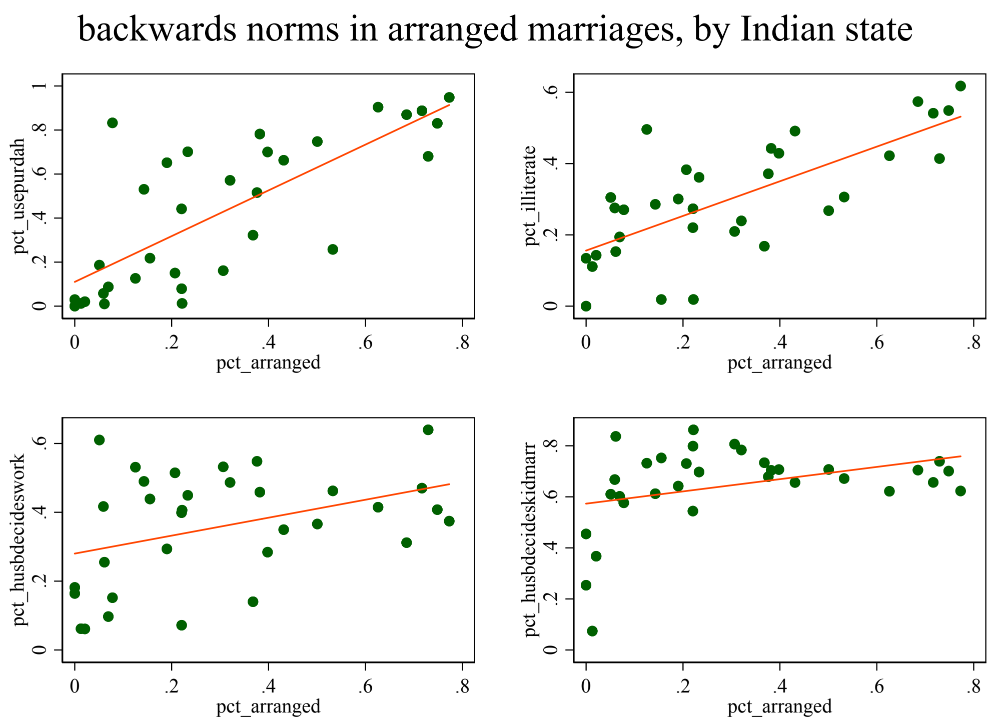

Figure A.7: Correlation between percent of backwards norms and percent of arranged marriages in different Indian states.

Table A.5: kids desired in arranged marriages

	nkidswanted	nsonswanted	ndaughterswanted	psonswanted
	b/t	b/t	b/t	b/t
arranged=1	0.345***	0.263***	0.083***	0.023***
	(35.07)	(40.65)	(16.32)	(14.35)
Constant	2.261***	1.238***	1.097***	0.541***
	(376.60)	(330.05)	(338.58)	(524.53)
Observations	37430	34567	34246	34505

Table A.6: kids realized in arranged marriages

	nkids	nsons	ndaughters	psons
	b/t	b/t	b/t	b/t
arranged=1	1.207***	0.609***	0.598***	-0.003
	(47.23)	(38.24)	(33.49)	(-0.66)
Constant	2.422***	1.259***	1.163***	0.540***
	(169.35)	(136.33)	(115.37)	(175.92)
Observations	24452	24452	24452	22695