Career Choice, Marriage-Timing, and the Attraction of Unequals

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Abstract: This paper shows that gender differences in fecundity horizons may cause persistent under-representation of women in high-powered professions, unless coordination failures in women's marriage-timing decisions are corrected. To the extent that there is a trade-off between early marriage and investment in a high-powered career, an age-induced decline in women fertility may cause marriage prospects of high-powered women to depend on the marriage-timing decisions of younger, more fertile women. Under these assumptions, women's marriage-timing decisions exhibit strategic complementarities. For the initial cohort of younger women, these complementarities induce a non-cooperative game with two Pareto-ranked, Nash-equilibria. Because of the interdependence of women marriage prospects across age-cohorts, the marriage-timing chosen by the initial cohort of younger women determines that of all subsequent cohorts, leading to steady-state equilibria whereby history repeats itself across all future cohorts of women. Either they all are married women with a high-powered career, or they all are married with a low-powered career. As the former is rather counterfactual, our analysis suggests that persistent professional imbalances between the sexes are caused by a coordination failure in the marriage-timing decisions of the initial cohort of younger women. (JEL: J12; J16; J24)
Keywords: Differential fecundity, career, marriage, Supermodular game, Nash-equilibria.

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I. Introduction

The aim of this paper is to revisit the debate on the sources of persistent under-representation of women in high-powered professions.[1] Our motivation is twofold. First, there has been progress, worldwide, in the fight against all forms of discrimination against women (UN [2004]). However, despite progress in civil rights, access to education and paid work, gender inequality in high-powered professions persists (ILO [2004]). Second, most of the gender gap in pay is due to the different career choices men and women make (Gunderson [1989], Blau and Kahn [2000]). Yet, in most universities' graduate school programs leading to high-powered careers (e.g., programs with a large math and science component), female enrollment continue to be lower than male's (Browne [2002]). It is therefore important to understand why young women have not yet acted to close the gap.

We propose a marriage market-based explanation for the observed persistence of imbalances in high-powered career achievements between men and women. In our model, no forms of social barriers against women's career achievement exist. Career choice and marriage-timing are joint decisions on the part of both men and women. An individual may either delay participation in the marriage in order to invest in a high-education necessary to have a high-powered career (Goldin [2004b]), or participate now in order to achieve a desired family life.[2] Like their male counterparts, women may aspire to have both a high-powered career and a family. But unlike their male counterparts, women who delay participation in the marriage market in order to invest in a high-powered career face a decline in their reproductive capability by the time they complete their career investment. Delaying therefore may impose a penalty in the form of reduced attractiveness in

[1] In this paper, we focus on high-powered occupations, i.e. high profile jobs that require investment in high education. High-powered jobs are a subset of the International Labor Organization (ILO) high profile occupations. The ILO high profile class of jobs includes managerial and professional occupations. Managers include legislators, senior officials and corporate executives. Professional workers include physicists, chemists, mathematicians, architects, engineers and computer scientists. They also include doctors, lawyers and jurists, business professionals and economists, journalists, writers and artists, athletes, college and university teachers.

[2] We assume that all women have access to an adequate technology for delaying participation marriage market, in the form of female-controlled contraceptives and/or safe abortion practices.

the marriage market. This is the only role human biology plays in our model.

Our model rests on the following key assumptions. First, people marry to have children (Becker [1981], Siow [1998]). Second, both career-making and the search for a marriage match take time and cannot be accomplished simultaneously (Goldin and Katz [2000]). Third, the opportunity cost of delaying marriage is higher for women than for men because of women's biological clock (Vella and Collins [1990], Siow [1998], Giolito [2003], Goldin [2004a]). In particular, the marriage prospects of high-powered, relatively less fertile, women may depend on the marriage-timing decisions of younger, more fertile women. In an environment with overlapping cohorts of agents, unless a younger, more fertile, woman can obtain evidence that delaying participation in the marriage market in order to invest in a high-powered career will not compromise her chances at marrying later on when her investment is completed, she may choose a more family-biased lifestyle at the expense of the chance of holding high-powered job. Fourth, young women base their marriage-timing and career decisions on the belief that their marriage prospects, if they choose to delay participation in the marriage market, depend on the success of previous cohorts of high-powered women at matching up. In other words, the higher the matching success of previous cohorts of high-powered women, the higher the belief among young women that delaying will not entail a penalty later on in terms of poor marriage market outcomes. Under these assumptions, we show that the marriage-timing decisions of the initial cohort of young women exhibit strategic complementarities. Because of the interdependance of the marriage prospects for younger and older women, coordination failures in the marriage-timing decisions of the initial cohort of younger, more fertile women emerge as a source of persisting gender differences in career achievements.

In the existing literature on gender, family, and labor supply, there is no consensus on the causes of the persisting professional imbalances between the sexes. On one hand, there is a strand of this literature that views that imbalance as a reflection of human biology at work. It may be due to the "sexes' different biological dispositions" (Polachek [1981], Becker [1985], Browne [2002]). This group of authors stresses the counter-productive consequences of social policy, viewed as an ill-advised interference with a natural process. On the other hand, another strand of this literature views under-representation of women in high-powered positions as a result of socio-economic barriers in the form of either a 'glass ceiling' (Athey, Avery, and Zemsky [2000]; Albrecht, Bjorklund, and Vroman [2003]), a 'social conditioning' (Gneezy, Niederle, and Rustichini [2003]), or lack of insurance against human capital uncertainty (Siow [1998])

Our research is closely related to Siow [1998] and Athey *et al.* [2000]. Siow [1998] develops a model of endogenous family-structure, whereby women are professionally less-accomplished than their spouses, even in absence of gender differences in labor market opportunities, productivities in child rearing, or social norms. Biological differences between men and women with respect to the relative length of the fecundity horizon and lack of insurance against human capital uncertainty are the joint sources of this professional imbalance between the sexes. For young women, marriage acts as insurance against human capital uncertainty. The removal of capital market imperfections reflected in the lack of formal insurance against human capital uncertainty is shown to be a corrective for this imbalance. Furthermore, his model implicitly assumes that all agents, both male and female, have completed their investment in human capital prior to entering the marriage market, so that there is no incentive for strategic behavior among agents. In contrast to Siow [1998], we show that even with no human capital uncertainty, gender imbalances in professional achievements can obtain and persist. The key distinguishing feature responsible for this result is the introduction, in our model, of a trade-off between participation in the marriage market and human capital investment (Goldin and Katz [2000]). This implies that for women, delaying marriage in order to invest in the high-education necessary to hold a high-powered career has an opportunity due to differential fecundity. Because of this trade-off, women's marriage-timing strategies exhibit strategic complementarities, which, unlike in Siow [1998], lead to a multiplicity of steady-state equilibria. If, as its male counterpart, the initial cohort of young women delays marriage to invest in a high-education necessary to hold a high-powered job, then all women in the initial cohort of single, high-powered women, will be able to match up in the marriage market, thereby creating a favorable marriage history for high-powered women. Such history, in turn, creates the belief among future cohort of young women that delaying marriage to invest in a high-powered career is associated with favorable marriage market prospects later on when this investment is completed. To the extend that all young women hold this belief, they will all find it optimal to delay, thus leading to equal professional achievements among married couples, which is counterfactual. Hence, since our model exhibits multiple steady-state equilibria, if a society with these features is stuck in a steady-state equilibrium featuring the attraction of unequals–high-powered men marrying low-powered women– it must be that there are coordination failures in the marriage-timing decisions of the initial cohort of young women.

Athey *et al.* [2000] also develop a multiple-equilibrium model of women's relative representation in top managerial positions within corporate firms. In their model, temporary affirmative action in favor of women can cause equal representation of men and women in top managerial positions to emerge and persists. Their model, however, do not treat career and family plans as joint decisions on the part of individuals. Instead, it focuses solely on career choice as an independent strategy. In our model, marriage and career are joint decisions for both men and women. As a result, unlike in Athey *et al.* [2000] where public policy yields a Pareto-improvement, in our model, the multiplicity of equilibria leads to a gender conflict: men prefer the equilibrium where they are professionally more accomplished than their spouses, whereas women prefer the equilibrium with gender equality in professional achievements. Consequently, a policy-induced social change that selects anyone of these equilibria does not necessarily represents a Pareto-improvement for the society at large. In particular, only policy-induced coordination mechanisms that resolve this conflict will obtain the strongest political support.

The rest of the paper is organized as follows. In the next section, we discuss the extent to which career and family choices are interrelated and motivate some of the crucial hypotheses underlying our model. In the second section, we present our marriage-market based model of gender difference in professional outcomes. In the third section, we discuss the policy implications of the model and offer concluding remarks.

II. Stylized Facts

A. Education and career choices.

A recent publication by the International Labor Organization (ILO, 2004) provides extensive evidence of the under-representation of women in high-powered professions around the world. According to this study, this tendency is higher in developing countries than in developed regions. Yet, even in developed countries, the under-representation of women in high-powered jobs remains high. For instance, in 1999, women only represented 3.4% of the top corporate managers in Canada. In 2000, in the United States, merely 11.7% of the boards of the 500 top companies were women. In the United Kingdom, the women's share of top managerial positions decreased by 20% between 2002 and 2003. In France, only just 124 of 2325 top positions in the largest 200 firms are held by women. One may argue that this professional imbalance between the sexes is merely transitory– as it may take decades for an individual to reach a top position, while women's massive participation in the labor market is only a relatively recent phenomenon. However, since investment in high education is a pre-requisite for high-powered careers, persistent under-representation of women in some business, administration, science and technology majors (Browne [2002]) is an indication that women's career plans continue to differ from men's. Educational choices made by the current cohorts of young women provide us with a reasonably accurate picture of the future. Although equal numbers of men and women hold university degrees in most countries, males and females still make different academic choices. For instance, in 2003, only 21% of students enrolled in Canadian undergraduate computer science programs were female. At the same time, the female average enrolment in the 45 top European business schools was merely 27%. As a result, gender inequality in high-powered professions is likely to be more than a transitory phenomenon.

B. Career choices and gains from marriage.

In the following, we present three stylized facts related to the gains from marriage. First, having children is the main purpose of marriage. Second, people may trade-off the quantity and quality of children. Third, on the marriage market, high-powered professionals are attracted to low profile professionals. Faced with a shortage of low profile professionals, high-powereds increasingly marry high-powereds.

First, the main motive for marriage is to have children (Becker [1981]). Although an increasing number of children are born out-of-wedlock and an increasing number of couples remain childless, trends on marriage and childbearing have not yet reversed. According to the U.S. Census 2002, 82% of married women have at least one child and 77% of never married women are childless.

Second, a trade-off in the quantity and quality of offspring may occur because of income and time constraints (Becker and Tomes [1976], Hanushek [1992]). Although we do not assume that women have a comparative advantage in home production (Becker [1985]), we maintain that gains from marriage are higher when one of the spouses is relatively more specialized in home production than the other spouse. Van Der Klaauw [1996] provides supporting empirical evidence. He finds that higher female wages are associated with lower gains from marriage.

Third, the gains from relative specialization have two implications for the matching on the marriage market. First, we expect the attraction of unequals, i.e. high-powered marrying low-powered, to produce the higher surplus from marriage. Second, as more women pursue careers, we expect the emergence of high-powered couples for which the surplus from marriage is lower. Empirical evidence is consistent with these effects. For instance, a worldwide survey of 1,192 executives in 2000 shows that 75% of married men live with a spouse who does not work. Male executive have in average 2.5 children. [3] Among the female executives who are married, 74% live with a spouse who works full time. Female

[3] Families and work institute, Catalyst and The center for work and family at Boston College, Carroll School of Management (2003).

executive have in average 2.1 children. In addition, 68% of women consider that balancing career and personal life is the most challenging barrier to professional advancement. [4]

C. Career or marriage?

In the following, we argue that there is a trade-off between achieving a high-powered career goals and securing a marriage. We present three stylized facts: (1) when a high-powered career is desirable, men's and women's life sequence imply that they start by investing in their careers and then look for a marriage partner; (2) both men and women fear singlehood; (3) because of differential fecundity, women may want to marry earlier than men.

First, the achievement of a high-powered career involves time-intensive investments in education and early career development. Because of time strains, men and women who attempt to become high-powered professionals may not believe the search for a marriage partner to be compatible with their ambition. Oppenheimer [1988] suggests that starting a family may threaten career goals, as an early commitment to marriage may result in dropping out from university. For this same reason, Goldin and Katz [2000] shows that the availability of contraceptives allowed women to delay marriage and make career investments.

Second, delaying marriage may result in remaining single. There is evidence that, even in the United States, the fear of singlehood remains high among young people (Thornton and Freedman [1982]). The stigma attached to singlehood may vary under different legal, economic and social environments. What are the odds of remaining single for career women? The survey of 1,192 executives shows that 2% of men and 12% of women were never married. In a recent study, Brown and Lewis [2004] find that powerful women are at a disadvantage in the marriage market. Using a laboratory experiment in which men and women are asked to assess an opposite sex person described as a supervisor, a co-worker or an assistant, Brown and Lewis [2004] show that men are more likely to choose the subordinate compared to the high-powered woman for investing in a steady state relationship,

[4] These figures are taken from another survey of 350 female executive in Canada produced by the Women Executive Network (2001).

while women are indifferent between the three categories of men. Another study shows that higher IQ are associated with higher chances to be ever-married for men but lower chances for women (Taylor et al., 2004). The study suggests that higher IQ women are more likely to delay marriage in order to invest in a high-powered career, with some never marrying. This evidence suggests that career women face the risk of staying single because they have delayed marriage. Yet, it remains to understand why it is less the case for career men than for career women. This is our third point.

Men are fertile for a longer period than women. This is the sole gender difference between men and women. As a result, we expect women who delay marriage to incur a higher cost than men because men will find them less attractive as marriage partners than younger and more fertile women. Women may thus want to marry earlier than men (Vella and Collins [1990], Giolito [2003]). According to the United Nations Social Indicators for the period between 1991 and 1997, men do marry at an older age than women in all countries. In the developed regions, men and women are respectively 29 and 26 years old in average at the time of their marriage. Moreover, countries that exhibit the larger gaps in age at first marriage are also the countries that display the lower proportions of women holding high-powered careers.

D. Role of the marriage history of career women.

Our model assumes that the successes and failures of past cohorts of women in having both a high-powered career and family influence the career plans of subsequent cohorts. We draw support for our assumption from the economic history literature.

Goldin [1995] follows career and family choices of women in the past century in the United States. Past experience in the labor market and past fertility rates of working women helps explaining the choices of the subsequent cohorts of young women. As women born in the baby-boom era and graduating from college in the early seventies completes their fertility, they can act as guide to current college women.

In a more recent paper, Goldin [2004*a*] revisits this question. She finds that 88% of the baby-boom women married - a 4% drop compared to their mothers. Among married women, 19% remained childless by age 40 - a 9% rise. Yet, this was the first cohort of women to occupy high-powered professions in the United States. Goldin describes this cohort as having achieved "career then family". "Recognizing the problems with the biological clock" faced by the baby-boom cohort, the most recent cohort who graduated from college in the eighties aims at achieving both "career and family"(Goldin [2004*a*] p.9).

Goldin [2004*b*] focuses more specifically on the career and family achievement of "women at the top". Since the seventies, work plans of young women have remained steady, with close to 90% of them claiming they expect to work by age 35. The number of young woman with professional degrees continues to rise. Yet, since 1980, females in a professional degree programs as a fraction of all college females have remained constant. Similarly, the largest increase in women's share of high-powered professions occurred during the eighties. These facts provide support for our assumption that women's past success at having a high-powered career and a family shows the way to subsequent cohorts of women. Mixed results obtained by the baby boom cohort may have convinced subsequent cohorts that if more young women were to opt for a career, they may too end up single or childless.

III. The Model

This section presents a simple model that highlights differential fecundity and coordination failures in women's marriage-timing decisions as a joint-source of the persisting under-representation of women in high-powered careers. We outline below the features of the socioeconomic environment underlying the persistence of professional imbalances between the sexes.

Time is discrete and extends over an infinite horizon. Initially, the population of single agents consists of three cohorts of respectively aged-3, aged-2 and aged-1 agents. All aged-3 agents are high-powered professionals (e.g., lawyers, physicians, or business executives) who all have a graduate-level education and have one-period left to live. Aged-2 agents are college-educated, and all have two periods left to live. Aged-1 agents are high-school graduates, each with three periods left to live.[5] Let g and j index the gender and the age of the agent respectively, with $g \in \{f, m\}$ and $j \in \{1, 2, 3\}$. An agent of gender f (respectively m) is a female (male respectively).

Let $N_t^{gj} \geq 0$ denote the number of single, aged-j agents of gender g in period t, where $t = 0, 1, \ldots.$. The purpose of this paper is to characterize the infinite sequence, $\left\{N_t^{f3}, N_t^{m3}\right\}_{t=0}^{\infty}$, representing the number of aged-3, high-powered women and men respectively. If in a given period t, $N_t^{f3} < N_t^{m3}$, women will be said to be under-represented in the subset of high-powered professionals in that period. If $N_t^{f3} < N_t^{m3}$ of all $t \geq 1$, this under-representation will be said to persist overtime. Our purpose in this paper is to uncover the root-causes of such persistence.

Assume that in the initial period, there are N men and N women in each of the three age-cohorts.[6] Aged-1 agents' only activity is to invest in a college education. At age 2, agents face a marriage-timing decision.[7] They may decide to participate in the marriage market at that age, and start a low-powered career; or they may elect to delay participation in both the marriage and the labor markets, in order to invest in a graduate education necessary to hold a high-powered career in the next period. An aged-2 agent who chooses this latter option will commit the entire period to completing a graduate program (for example, in a math and science field, business or science) necessary to hold a high-powered job in the next period when he or she becomes aged 3.[8] At age 3, single agents have

[5] Individuals in this age cohort are aged 17-18 at the start of the period, which corresponds to the high-school-leaving age.

[6] We start with initial conditions where there is the same number of high-powered women and high-powered men. This is justified by the fact that both men and women always individually prefer to delay marriage and hold a high profile career, despite gender differential fecundity. Yet, we will show that even with favorable initial conditions, under-representation of women in high-powered occupation may follow and persists.

[7] According to the *World Development Report 2000*, in average, industrialized countries' women have completed 15 years of schooling, which corresponds roughly to an under-graduate university degree. Correspondingly, demographers, in the US for example, place the median age at first marriage for American women at around 22, which is the median age of a college graduate. Therefore, following the marriage and family literature (e.g., Allen and Kalish [1984]), we assume that the normative age for participating in the marriage market is above age-1.

[8] Available evidence indicates that the primary motive for delaying participation in the marriage market is to invest in a high-education (see for example Allen and Kalish [1984], and Houseknecht, Vaughan, and Statham [1987]).

no choice but to participate in the marriage market, as this represents their last chance at gaining a marriage surplus. However, at that age, women, but not men, experience a decline in their reproductive capability, which may put them at a disadvantage in the marriage market, were they to face competition from, more fertile, aged-2 single women. Following Siow [1998], we refer to this biological difference between the sexes as differential fecundity.

Marriage (understood here as a union of individuals of opposite sex) is monogamous. In any period, an agent who finds a match stays married for the rest of his or her life. Likewise, an agent who finds no match after participating in the marriage market stays single his or her entire life, and thus derives a surplus $\delta > 0$ from singlehood. Assume that this surplus is identical for both sexes. Henceforth, the subscript f (respectively m) indexes women's (respectively men's) variables and parameters.

There are two types of careers, low-powered and high-powered respectively. An agent's professional empowerment is measured by the "rewards of money, power, leadership, prestige, and esteem" associated with the position held (Regan and Roland [1985]). Let L and H denote the degree of empowerment achieved by an agent in a low-powered job (denoted L) and a high-powered job (denoted H) respectively, where $H > L$.

All marital matches in this environment feature dual-earner couples.[9] A marital match between two professional agents is denoted as (e_f, e_m). It specifies the degree of professional empowerment, e_g, for the marriage partner of gender g ($g = f, m$). The set of possible combinations of dual-earner couples is given extensively by

$$E = \{(L, L), (L, H), (H, L), (H, H)\},$$

with typical element $e = (e_f, e_m)$. A match between two partners will be said to exhibit negative assortative mating if it is of the form (L, H) or (H, L). Both these types of matches

[9] This assumption can be relaxed without any additional gain in analytical insight. For example one of the spouses could be participating only in home production. He or she will be receiving a transfer L form his or her partner as a reward for this occupation.

correspond to the attraction of unequal professionals. In contrast, a marital match will be said to exhibit positive assortative mating if it is of the form (L, L) or (H, H).

To keep up with the economic literature on marriage and fertility (e.g., Becker [1981]; Edlund and Korn [2002]; Edlund [2004]; Greenwood, Guner and Knowles [2003]), assume that reproduction is the main motive for marriage. In other words, the surplus from a marital match is determined by the couple's reproductive success– understood as the gains from reproduction, including children, their quantity and quality, net of the costs of achieving it. Success in reproduction requires two types of investments from the couple: time, including time necessary to nurture children's emotional and cognitive development, and financial resources including child-rearing costs.

Let $R : E \to \Theta$ be a function describing the relation between a marital match $e \in E$ and the marital surplus (or reproductive success) $\theta \in \Theta$ it generates to each of the partners. In other words, $R(e)$ denotes the reproductive success of a couple with match quality e. Assume that as a reflection of differential fecundity, all marital matches involving a low-powered woman yield each a pair of children (a boy and a girl), while those involving a high-powered woman yield one child, a boy or a girl with equal probability. All new born become high-school graduates by the end of the period in which they were born.

Assumption 1. *The function R satisfies the following properties:*

$$
\begin{array}{lrcl}
(i) & R(L, H) & = & \bar{\theta} \\
(ii) & R(H, L) & \leq & R(H, H) = R(L, L) = \underline{\theta}\ ,
\end{array}
$$

where $\underline{\theta} < \bar{\theta}$.

Assumption 1 reflects the role played by gender differences in fecundity horizons (Siow [1998]; Giolito [2003]). Because aged-3 women experience a decline in their reproductive capability by the time they complete their investment in a high-powered career, they cannot match the fertility rate of younger, low-powered, women. This, combined with the high-demand of child-rearing in terms of time commitment may cause the marital surplus generated by a match of the form (H, H) to be less than the surplus generated by a match of the form (L, H): $\underline{\theta} < \bar{\theta}$. However because reproductive success also depend on quality of offspring, a marital match of the form (L, L) although susceptible to yield a high quantity, may be at a disadvantage when it comes to ensuring high quality to all its offspring. We assume this trade-off between quantity and quality to be reflected by the equality $R(L, L) = R(H, H)$. That $R(H, L) \leq R(H, H)$ reflects gains from quality of offspring associated with a match of the form (H, H), for identical quantity since both (H, L) and (H, H) marital matches yield the same quantity of offspring.

Upon reaching age 2, all agents have preferences over the degree of empowerment, e_g, they derive from their occupation, and over the surplus derived from their chosen lifestyle, i.e. single or married with a high-powered partner, or married with a low profile spouse.[10]

Let λ denote an index operator that takes the value $\lambda = 0$ if the agent ends up in singlehood, and $\lambda = 1$ if married. Let $\widetilde{\theta} = \lambda\theta + (1 - \lambda)\delta$ denote the surplus accrued to an agent of gender g, with marital status λ. As in François [1998] and Fernandez, Fogli, and Olivetti [2004], assume that men and women have identical preferences.[11] Let $\phi : E \times \Theta \rightarrow \Re$ denote the utility function representing these preferences, where $\phi\left(e_g, \widetilde{\theta}\right)$ denotes the level of lifetime utility attained by an agent of gender $g \in \{f, m\}$, who has a career of type e_g, and gains a surplus $\widetilde{\theta}$ from his or her lifestyle.

Assumption 2. *The function ϕ is strictly increasing in each of its arguments:*

$$\begin{array}{lllll} (i) & \text{for all } e'_g & > & e_g, & \phi\left(e'_g, \widetilde{\theta}\right) - \phi\left(e_g, \widetilde{\theta}\right) > 0, \quad \text{for each } \widetilde{\theta} \text{ fixed} \\ (ii) & \text{for all } \widetilde{\theta}' & > & \widetilde{\theta}, & \phi\left(e_g, \widetilde{\theta}'\right) - \phi\left(e_g, \widetilde{\theta}\right) > 0, \quad \text{for each } e_g \text{ fixed.} \end{array}$$

[10] As in Lundberg and Pollak [1993], households are composed of individual decision-makers. The interdependence between marriage partners in our model therefore operates solely through consumption of the surplus, which is the only household public good.

[11] In a recent survey of leaders of in the global economy, the *Families and Work Institute* [2004] finds no real support for the common wisdom that men are more ambitious than women when it comes to career preferences. Although this survey does find that in average more men than women aspire to be CEO, it does also find that these observed gender differences rather than reflecting gender differences in preferences, are more likely to be consequences of social factors that give different shapes to women's and men's respective choice sets.

Part (i) of assumption 2 implies that given the surplus associated with his or her lifestyle, any agent in this environment is always better off having a high-powered career than a low-powered one. Assumption 2 is consistent with findings from the literature on gender and family that both men and women show a desire for high-powered professional careers (Regan and Roland [1985]; Goldin and Katz [2002]). Part (ii) implies that given his or her career choice, any agent in this environment is always better off having a lifestyle that yield the highest surplus.

Assumption 3. *The function ϕ has strictly increasing differences in $\left(e_g, \widetilde{\theta}\right)$ on $E \times \Theta$: for all $e'_g > e_g$ and $\widetilde{\theta}' > \widetilde{\theta}$,*

$$\phi\left(e'_g, \widetilde{\theta}'\right) - \phi\left(e_g, \widetilde{\theta}'\right) > \phi\left(e'_g, \widetilde{\theta}\right) - \phi\left(e_g, \widetilde{\theta}\right).$$

Assumption 3 states that for a typical agent in this environment, the incremental return to having a high-powered career is greater, when combined with a lifestyle that yields the highest surplus. Alternatively, one can easily check that this assumption also states that the incremental return to having a high-surplus lifestyle is greater, when combined with a career that yields the highest degree of professional empowerment:

$$\phi\left(e'_g, \widetilde{\theta}'\right) - \phi\left(e'_g, \widetilde{\theta}\right) > \phi\left(e_g, \widetilde{\theta}'\right) - \phi\left(e_g, \widetilde{\theta}\right).$$

To the extent that the surplus generated by any marital match is higher than the surplus derived from singlehood (i.e., $\delta < \underline{\theta}$), Assumption 3 implies that all agents (male and female) are better off combining a high-powered career and a marriage life. In other words, higher career achievement complements higher marriage surplus in any agent utility function. We will therefore show that an agent's failure to combine a high-powered career and a marriage life reflects the environment constraining his or her family and career plans, more so than her preferences.

A. The Marriage Market

In this environment, participation in the marriage market takes the form of single men and women sending and/or soliciting marriage offers. Agents who elect to participate in the marriage market compete by revealing the type of career (low-powered or high-powered) they have and the age-group (i.e., age-2 or age-3) they expect their marriage partner to fall into. There are no direct transfer payments involved between two marriage partners.

Assumption 4. *The parameters L, H, $\bar{\theta}$, $\underline{\theta}$, and δ satisfy the following conditions:*

$$\phi(H,\underline{\theta}) > \phi\left(L,\bar{\theta}\right) > \phi(H,\delta) > \phi(L,\underline{\theta}).$$

Assumption 4 contains three main statements. The first statement (i.e., $\phi(H,\underline{\theta}) > \phi\left(L,\bar{\theta}\right)$) implies that in making their family and career plans, all individuals are willing to trade off a high-surplus marriage for a high-powered career, provided they can still marry. The second statement (i.e., $\phi\left(L,\bar{\theta}\right) > \phi(H,\delta)$) implies that all agents would trade off a high-powered career for a high-surplus marriage in order to avoid singlehood. The third and last statement (i.e., $\phi(H,\delta) > \phi(L,\underline{\theta})$) implies that all agents would trade off a low-surplus marriage for singlehood to avoid being a low-powered professional. Assumption 4 is consistent with the common view that although marriage has been losing its importance, particularly in advanced industrialized countries, it remains the most preferred lifestyle for both men and women.

Together, assumptions 1-4 imply that marriage-timing is not a trivial decision in this environment. In particular, because of differential fecundity, a woman may have a better chance of finding a marital match when aged 2 than when aged 3. Therefore an aged-2 single woman must carefully evaluate her options before deciding what timing to select. At age 3, single agents face their last chance of finding a match. For a single man aged 3, the search for a match proceeds as follows:

Step 1. First post a marriage offer in the age-2 segment of women's end of the marriage market. If the offer is picked up by an aged-2 single woman, marriage occurs and the successful aged-3 man has a lifetime utility, $\phi\left(H,\bar{\theta}\right)$, while his low-powered, younger partner has lifetime utility level, $\phi\left(L,\bar{\theta}\right)$. This type of marriage profile corresponds to what we refer to as the attraction of unequals.

Step 2. If no aged-2 single woman picks up the offer, next posts an offer in the age-3 segment of the women's end of the market. If the offer is picked up by an aged-3 single woman, marriage occurs, and both partners attain an identical lifetime utility level, $\phi\left(H,\underline{\theta}\right)$. This marriage between two high-profile individuals exhibits gender equality in professional achievements. An aged-3 man whose second offer is not picked up stays single for the rest of his life, in which case he will have a lifetime utility, $\phi\left(H,\delta\right) < \phi\left(H,\underline{\theta}\right)$, by assumption 4.

All aged-2 single agents must choose the timing of their participation as it determines whether or not they will invest in a high-powered career. For aged-2 single men, their optimal marriage-timing is characterized by the following proposition:

Proposition 1. *Under assumptions 1-4, delaying participation in the marriage market until age 3 is always a dominant strategy for all aged-2 men.*

Proposition 1 implies that no man elects to marry at age-2. This result is a direct implication of Assumptions 1-4. This proposition implies that in this environment, all men will be high-powered professionals. In other words, the infinite sequence, $\{N_t^{m3}\}_{t=0}^{\infty}$, of high-powered men satisfies $N_t^{m3} = N_{t-1}^{m2} = N_{t-2}^{m1}$, for all $t \geq 3$, with $N_0^{m3} = N_1^{m3} = N_2^{m3} = N$. Proposition 1 therefore rules out all marital matches of the form (H, L), where the man is professionally less-accomplished than his spouse. It implies that any single, aged-3 woman can only receive marriage offers from aged-3 single men, if any.

If a single woman participates in the marriage market at age-2, she is guaranteed to find a spouse, if the size of the population of single, aged-2 women is at most as high as the size of the population of participating single men. This is because participating men first post marriage offers in the aged-2 segment of the women's end of the market. This, however, means that a woman who elects to marry at age 2 will settle for a lifetime utility level $\phi\left(L,\bar{\theta}\right)$ less than the maximum, $\phi\left(H,\underline{\theta}\right)$, she can attain under assumptions 1-4, were she to delay instead. But if she chooses to delay, there is a risk that she will have to settle for singlehood as a lifestyle, in which case she obtains a payoff $\phi(H, \delta) < \phi\left(L, \bar{\theta}\right)$. In other words, for aged-2 single women, choosing one marriage-timing strategy over the other entails a trade-off. So, how do these women choose the timing of their participation in the marriage market? In the next subsection, we take the first step in addressing this question.

B. The Expected Payoff from Delaying Participation in The Marriage Market

In every period t, an aged-2 woman has two marriage-timing strategies to choose from. She may elect to participate in the marriage market at age 2 so as to take advantage of her competitive edge at reproduction over older, aged-3 women, or she may elect to delay participation until period $t+1$, in order to invest in a high-powered career in the meantime. Denote the former as strategy $s = 0$ and the latter as strategy $s = 1$. Choosing either strategy has an opportunity cost, however. Participating early (i.e., $s = 0$) means giving up on a high-powered career for sure, while delaying participation (i.e., $s = 1$) exposes a woman to the risk of having singlehood as a lifestyle. When a woman delays, she knows she might not find a marital match next period because her success at reproduction will be lower than that of any potential aged-2 competitor. Because the option to delay yields an uncertain outcome, an aged-2 woman will not know which of the two marriage-timing strategies to choose, unless she knows the expected outcome associated with the option to delay participation. In this subsection therefore, we explain how a typical aged-2 single woman computes the odds of finding a marital match in the next period if she chooses to delay participation in the marriage market.

Denote as λ_{t+1} be the marital status, at period $t+1$, of a woman aged-2 in period t who elects to delay participation in the marriage market until $t+1$. By convention, $\lambda_{t+1} = 1$ means she marries at $t+1$, while $\lambda_{t+1} = 0$ means she does not.

Let $P(\lambda_{t+1}/s = 1)$ denotes the conditional probability that a single woman aged 2 in period t ends up with a marital status λ_{t+1} in period $t+1$ if, in period t, she elects to delay participation in the marriage market (i.e., $s = 1$) in order to invest in a high-powered career. Additional notations are necessary to characterize this conditional probability.

Denotes as $N_{t-1}^{f3} \geq 0$ be the number of aged-3 women who were high-powered professional in period $t-1$. Observe that unlike their counterparts from period t, single, high-powered women, from the $t-1$-cohort have already completed their participation in the marriage market by the time the economy reaches period t. This implies that their success rate at matching up in the marriage market is known at t. Let $n_{t-1}^{f3} \in \left[0, N_{t-1}^{f3}\right]$ denote the number of single, high-powered women from the $t-1$ cohort who where successful at matching up in period $t-1$.

Assumption 5. *The conditional probability, $P(\lambda_{t+1}/s = 1)$, that a woman aged 2 in period t will find a marital match in period $t+1$ if she delays participation in the marriage market until period $t+1$ is defined as follows:*

$$P(\lambda_{t+1} = 1/s = 1) = \begin{cases} n_{t-1}^{f3}/N_{t-1}^{f3} & \text{if } N_{t-1}^{f3} > 0, \\ \rho\left(n_t^{f3}/N_t^{f3}\right) & \text{if } N_{t-1}^{f3} = 0 \text{ and } N_t^{f3} > 0 \\ 0 & \text{if } N_{t-1}^{f3} = 0 \text{ and } N_t^{f3} = 0 \end{cases}$$

where $P(\lambda_{t+1} = 0/s = 1) = 1 - P(\lambda_{t+1} = 1/s = 1)$, and $n_t^{f3} \in \left\{0, 1, ..., N_t^{f3}\right\}$ denotes the number of single women aged 3 in period t who marry in that period.

Assumption 5 states that at any period t, the matching success rate of past cohorts of high-powered women influences the beliefs of currently aged-2 single women about their marriage prospects if they choose to delay participation in the marriage market in order to invest in a high-powered career. In particular, to the extent that $N_{t-1}^{f3} > 0$, the matching success rate, $n_{t-1}^{f3}/N_{t-1}^{f3}$, of the $t-1$-cohort of aged-3 high-powered women provides young single women aged 2 in period t with a measure of the likelihood that they will marry next period if, in the current period, they choose to delay marriage in order to invest in a high-powered career in the meantime.[12] In other words, whenever $N_{t-1}^{f3} > 0$, all women

[12] As noted in the previous section, Goldin [1995] and Goldin [2004a] document, in the case of the US,

aged 2 in period t know that the conditional probability they each will marry in the next period (i.e., in $t+1$), if they delay, is given by the proportion, $n_{t-1}^{f3}/N_{t-1}^{f3}$, of married women from the $t-1$-cohort of high-powered women–i.e., those who completed their participation in the marriage market by the end of $t-1$.

However, if $N_{t-1}^{f3}=0$, then, provided $N_t^{f3}>0$, all single women aged 2 in period t will evaluate their future marriage prospects, if they delay, on the basis of their anticipations about the matching success rate of currently single, high-powered. This is because they all know that this matching success rate, n_t^{f3}/N_t^{f3}, will influence the marriage-timing decision of the $t+1$-cohort of aged-2 single women, which, in turn, will influence the likelihood that a currently aged-2 single woman will find a marital match in period $t+1$ if she delays today. In other words, if $N_t^{f3}>0$, the conditional probability, $P(\lambda_{t+1}/s=1)$, that a woman aged 2 in period t will marry in period $t+1$ if she elects to delay participation in the marriage market by one period depends on $P(\lambda_{t+2}=1/s=1)=n_t^{f3}/N_t^{f3}$, i.e., the conditional probability that a woman aged 2 in period $t+1$ marries in period $t+2$ if, at $t+1$, she delays participation in the marriage market. Hence the relation $P(\lambda_{t+1}=1/s=1)=\rho\left(n_t^{f3}/N_t^{f3}\right)$, with $\rho(0)=0$ and $\rho(1)=1$.

If in contrast, $N_{t-1}^{3}=N_t^{3}=0$, then $P(\lambda_{t+1}/s=1)=0$, because no past representation of women in high-powered professions conveys the belief that for single young women, delaying participation in order to invest in a high-powered career is not optimal. In our next step, we formally define $\rho\left(n_t^{f3}/N_t^{f3}\right)$.

Letting N_t^{f2} denote the number of aged-2 single women in period t, and denotes as $\widetilde{N}_t^{f2}\in\left\{0,1,...,N_t^{f2}\right\}$ the number of those who elect to delay participation in the marriage market until the next period. Then, the number of single, high-powered women in period t is given by

$$N_t^{f3}=\widetilde{N}_{t-1}^{f2} \text{ for } t\geq 1,$$

with $N_0^{f3}=N$ given. Therefore, in order to determine $\left\{N_t^{f3}\right\}_{t=0}^{\infty}$,it suffices to characterize

the tendency of college-educated women to look to the family and career achievements of previous cohorts, in order to inform their own family and career choices.

the infinite sequence $\left\{\widetilde{N}_t^{f2}\right\}_{t=0}^{\infty}$ of single women aged 2 in period t who elect to delay participation in the marriage market until period $t+1$. This objective sketches the outline for the remainder of this section.

Observe that since $N_0^{f3} > 0$, for any period $t \geq 1$, assumption 5 implies that each single woman aged 2 in period t has expected payoff

$$\frac{n_{t-1}^{f3}}{N_{t-1}^{f3}} \phi\left(H, \underline{\theta}\right) + \left(1 - \frac{n_{t-1}^{f3}}{N_{t-1}^{f3}}\right) \phi\left(H, \delta\right),$$

from delaying participation in the marriage market until period $t+1$. Not delaying yields a payoff, $\phi\left(L, \bar{\theta}\right)$. Thus, for each member of the t-cohort of aged-2 single women, the decision to delay is optimal if and only if the following inequality holds:

$$\frac{n_{t-1}^{f3}}{N_{t-1}^{f3}} > \frac{\phi\left(L, \bar{\theta}\right) - \phi\left(H, \delta\right)}{\phi\left(H, \underline{\theta}\right) - \phi\left(H, \delta\right)}, \tag{III.1}$$

all $t \geq 1$. In other words, delaying participation is optimal whenever there is a sufficiently high marriage success rate for the $t-1$-cohort of high-powered women who already completed their participation in the marriage market. When condition (III.1) does not hold, delaying is not optimal. Therefore, since all agents are identical within each age-cohort, for $t \geq 1$, the sequence $\left\{\widetilde{N}_t^{f2}\right\}_{t=1}^{\infty}$ is given by

$$\widetilde{N}_t^{f2} = \begin{cases} N_t^{f2} & \text{if inequality (III.1) holds at } t, \\ 0 & \text{otherwise.} \end{cases}$$

A key feature of this environment is that in period 0, there is no marriage history of high-powered women. However, each of them anticipates that the period-1 cohort of age-2 single women will base their decision on how successful the period-0 cohort of aged-3 high-powered women is at matching up in the marriage market in period 0. But, the success of aged-3 women in period 0 entirely depends on the decisions of the period-0 cohort of aged-2 single women. In other words, if $\widetilde{N}_0^{f2}$ members of the period-0 cohort of aged-2 single women decide to delay marriage, then $N - \widetilde{N}_0^{f2}$ of them are on the marriage market in period 0. Under assumptions 1-4 and proposition 1, all of them will match up with high-powered men. Given our normalization of the population size in period 0, this will leave only $\widetilde{N}_0^{f2}$ single aged-3 bachelor men available for period-0's aged-3 women. Thus, among N_0^{f3} high-powered women in period 0, only $n_0^{f3} = \widetilde{N}_0^{f2}$ of them are able to find a marital match in that period. This has three implications.

First, how many single women aged 2 in period 0 delay marriage will determine whether or not delaying marriage will be optimal (in an expected value sense) for the next cohort of aged-2 single women.

Second, in period 1, all single women aged 2 will elect to delay if and only if the proportion, $n_0^{f3}/N_0^{f3} = \widetilde{N}_0^{f2}/N$, of period 0 high-powered women who were successful at matching up satisfies the following condition:

$$\frac{\widetilde{N}_0^{f2}}{N} > \frac{\phi\left(L, \bar{\theta}\right) - \phi\left(H, \delta\right)}{\phi\left(H, \underline{\theta}\right) - \phi\left(H, \delta\right)} = \gamma. \tag{III.2}$$

Third, when condition (III.2) holds, all single women aged 2 in period-0 know that if they delay, they will not face competition in the marriage market from the next cohort of aged-2 single women (since all of them will elect to delay under condition III.2). Given that from proposition 1 there will be N high-powered bachelor men ready to participate in the marriage market in period 1, this implies that any woman aged 2 in period-0 who elects to delay will marry in period 1 with probability $\rho\left(\widetilde{N}_0^{f2}/N\right) = 1$. However, if condition (III.2) is violated, then this probability is $\rho\left(\widetilde{N}_0^{f2}/N\right) = 0$. Thus, in period 0, the function ρ is defined as follows:

$$\rho\left(\widetilde{N}_0^{f2}/N\right) = \begin{cases} 1 & \text{if } \widetilde{N}_0^{f2} > \gamma N \\ 0 & \text{if } \widetilde{N}_0^{f2} < \gamma N \end{cases} \tag{III.3}$$

where $\gamma \in (0,1)$ is as defined in (III.2), and

$$\widetilde{N}_0^{f2} = \sum_{j=1}^{N} s_j \tag{III.4}$$

denotes the total number of women aged 2 in period 0 who elect to delay participation in the marriage market until period ($s_j = 1$).

Expressions (III.2), (III.3), and (III.4) imply that the marriage-timing strategies of members of the period-0 cohort of aged-2 single women are complements. The higher the number, $\widetilde{N}_0^{f2}$, of women aged 2 in period 0 who elect to delay participation in the marriage market, the higher the conditional probability that each of them will marry in period 1, and thus the higher the individual payoff from delaying marriage. Since all agents are anonymous in this environment, each member of the initial cohort of aged-2 single women will behave strategically with respect to other members of her cohort. This strategic behavior creates a non-cooperative game situation between women in the initial age-2 cohort, the outcome of which determines the structure of the infinite sequence $\left\{N_t^{f3}\right\}_{t=0}^{\infty}$, of high-powered women in this economy. In what follows, we describe the marriage-timing game aged-2 women from the initial cohort play in this environment.

C. The Marriage-Timing Game.

The game takes place in period 0, and involves all women aged-2 in that period. We are interested in this game because its outcome creates a marriage history for high-powered women upon which future cohorts of aged-2 single women will based their marriage-timing decision.

Let i index a member of the initial cohort of aged-2 single women, where $i \in I$ and $I = \{1, .., N\}$. Hereafter, we refer to a member of that cohort as simply woman i. Denote as $S_i = \{0, 1\}$ the finite strategy set of woman i, with typical element $s_i \in S_i$. $s_i = 0$ means woman i elects to participate in the marriage market when aged 2, while $s_i = 1$ means she elects to delay participation in order to invest in a high education necessary to have a high-powered career in the next period (period t).

We will also need the following definitions. Let $S = S_1 \times ..., \times S_N$ denote the set of feasible joint strategies, with typical element $s = (s_1, ..., s_N)$. Observe that since S_i is finite for all i, S is also finite and contains a total of 2^N elements. Let $S_{-i} = S_1 \times .. \times S_{i-1} \times S_{i+1} ... \times S_N$ denote the set of feasible joint strategies for woman i's competitors, with typical element $s_{-i} \in S_{-i}$.

Continuing our description of the normal-form of the women's marriage-timing game, we now turn our attention to the players' utility payoff functions. Denote woman i's payoff function as $u_i : S \to \Re$, defined by

$$u_i(s) = s_i \psi(s) + (1 - s_i) \phi\left(L, \bar{\theta}\right), \tag{III.5}$$

where

$$\psi(s) = \rho\left(\widetilde{N}_0^{f2}/N\right) \phi(H, \underline{\theta}) + \left[1 - \rho\left(\widetilde{N}_0^{f2}/N\right)\right] \phi(H, \delta) \tag{III.6}$$

is obtained using assumption 4. In other words, if woman i plays the strategy $s_i = 0$ in period 0, when her opponents play the strategy profile s_{-i}, Equation (III.5) implies that she will receive a payoff

$$u_i(0, s_{-i}) = \phi\left(L, \bar{\theta}\right), \tag{III.7}$$

as an immediate implication of assumptions 1-4; she will receive a payoff

$$u_i(1, s_{-i}) = \psi(s), \tag{III.8}$$

if she selects the strategy $s_i = 1$, when her opponents select the profile s_{-i}.

A *noncooperative game of marriage-timing* between members of the initial cohort of aged-2 single women is a triple $\Gamma = \langle I, S, \{u_i : i \in I\} \rangle$, consisting of a non-empty set of players I, a set S of feasible joint marriage-timing strategies, and a collection of payoff function $\{u_i : i \in I\}$ where u_i is a real-valued function defined on S such that for any feasible joint strategy s woman i receives a payoff $u_i(s)$ given in (III.5) for all $i \in I$.

Observe that since the players have identical strategy sets (i.e., $S_1 = S_2, ... = S_N$) and for all $i, j \in I$, $u_i(s) = u_j(s)$, therefore Γ is a symmetric game. In what follows, we look for the Nash-equilibria of this game.

D. Symmetric Nash-Equilibria

Given that the initial cohort of aged-2 women operates in a symmetric environment, and women in that cohort are involved in a one-shot interaction, this provides us with the opportunity to take full advantage of the computational simplicity associated with symmetric, one-shot, games. In particular, since we are only interested in making gender comparisons regarding the level of professional achievement, comparisons between same-gender agents are irrelevant, implying that we can restrict attention to symmetric equilibria. To show that restriction to symmetric Nash-equilibria of the marriage-timing game, Γ, is made at no qualitative cost, we will show that these are indeed the only stable equilibria of Γ. This is because, as we show below, Γ is a supermodular game, also known as a game with strategic complementarities (Milgrom and Roberts [1990]).

Definition 1. *(Milgrom and Roberts [1990])* Γ *is a supermodular game if for all* i,

(i) S_i *is a compact subset of* $\Re$;

(ii) u_i *is upper semi-continuous in* s_i, *for each* s_{-i};

(iii) u_i *is continuous in* s_{-i}, *for each* s_i;

(iv) u_i *has a finite upper bound;*

(v) u_i *has increasing differences in* (s_i, s_{-i}) *on* $S_i \times S_{-i}$.

Therefore to show that the marriage-timing game Γ is supermodular, it suffices to show that it satisfies conditions $(i) - (v)$. We prove the following proposition in Appendix B.

Proposition 2. *Under assumptions 1-5, the symmetric game of marriage timing,* Γ, *is supermodular.*

Proposition 2 essentially states that the game Γ exhibits strategic complementarities at the level of players' actions.

Corollary 1. (*Topkis* [1968]) *Woman i's best response is a function $B_i : S_{-i} \to S_i$ defined by*

$$B_i\left(s_{-i}\right) = \arg\max_{s_i} u_i\left(s_i, s_{-i}\right)$$

such that, for all i, and for all $s'_{-i} > s_{-i}$, $B_i\left(s'_{-i}\right) > B_i\left(s_{-i}\right)$.

Corollary 1 of proposition 2 states that the game Γ has increasing best-responses. In other words, players' strategies are complements, implying that Γ may have multiple pure-strategy equilibria (Cooper and John [1988]).

Our interest in supermodular games rests on four essential properties these games have. First, a supermodular game dispenses with the reliance on mixed-strategies to ensure existence of a Nash equilibrium, as such game always has an equilibrium in pure strategies, by virtue of Tarski's fixed-point theorem[13]. Indeed, Corollary 1 implies that conditions underlying Tarski's fixed-point theorem apply in this case, meaning that a Nash-equilibrium in pure strategies does exist. Second, even though the game may have mixed-strategy Nash-equilibria, such equilibria are always unstable (Echenique and Edlin [2004]). Third, for a symmetric game, all pure-strategies Nash equilibria are symmetric because of strategic complementarities. Therefore, without loss of generality, we can restrict attention to symmetric Nash equilibria (SNE) in pure strategies.[14] Fourth, when Γ is a supermodular game with positive spillover, the SNE where all players choose their highest action, when it exists, is always *Pareto-preferred* (Cooper and John, [1988]; Levin [2003]). We prove the following Lemma in Appendix C.

Lemma 1. *Under assumptions 1-5,the function u_i is increasing in s_{-i}, for each s_i fixed: $\forall\left(s_{-i}, s'_{-i}\right)$ such that $s'_{-i} > s_{-i}$, $u_i\left(s_i, s'_{-i}\right) - u_i\left(s_i, s_{-i}\right) \geq 0$.*

[13]**Tarski's Fixed-Point Theorem:** Suppose that $f : \{0,1\} \to \{0,1\}$ is a nondecreasing function, that is, $f(x') \geq f(x)$ whenever $x' \geq x$. Then f has a fixed point: $\exists x \in \{0,1\}$ such that $x = f\left(x\right)$.

[14]At a SNE if all players select a strategy s^*, it is optimal for player i to select $s_i = s^*$, as well.

Lemma 1 states that the supermodular game Γ has positive spillover. In other words, when woman i's competitors take their highest respective actions, her payoff is either unchanged or it increases.

We define a pure-strategy Nash equilibrium in terms of the payoffs players receive from various strategy profiles:

Definition 2. *A pure-strategy profile s^* is a strict SNE of Γ if and only if $u_i(s^*) > u_i(s_i, s^*_{-i})$ for each $s_i \in S_i$ and each player $i \in I$.*

Since Γ is a symmetric game, in any pure-strategy Nash-equilibrium all women will choose to play the same strategy. Thus a pure-strategy profile s^* is a SNE of Γ if and only if $s^*_i = s^*_j$, for all $i \neq j$, $i, j \in I$, and s^* is a Nash-equilibrium.

In what follows, we characterize the set of symmetric Nash equilibria when all women make their marriage-timing decision simultaneously. The following proposition proved in Appendix D establishes our main result:

Proposition 3. *Suppose*

$$\underline{\rho} < \frac{\phi\left(L, \bar{\theta}\right) - \phi\left(H, \delta\right)}{\phi\left(H, \underline{\theta}\right) - \phi\left(H, \delta\right)}. \tag{III.9}$$

where $\underline{\rho} = \rho(1/N)$. Then, under assumptions 1-5, there exists two pure-strategy SNE: one where all members of the initial cohort of aged-2 single women delay, and another where none of them does.

The left-hand side of condition (III.9) states that the probability, $\underline{\rho}$, that a woman aged 2 in the period 0 who chooses to delay participation in the marriage market finds a spouse in the next period, when all same-age women choose not to delay, is sufficiently low. Notice that the right-hand side of (III.9) is what we previously defined as γ. We know from (III.3) that $\underline{\rho}$ can only take one of two values, 0 or 1. Yet, for N sufficiently large, $1/N$ is always smaller that γ. Thus, $\underline{\rho}$ is likely to be equal to zero and the SNE where no women delay always exists.

Thus, when condition (III.9) holds, there are two possible equilibrium sequences for the population of high-powered women: either $N^{f3}_t = 0$ all $t \geq 1$, $N^{f3}_0 = N$ given, or

$N_t^{f3} = N_t^{m3} = (1/2)\,N$, for all $t \geq 3$, and $N_t^{f3} = N_t^{m3} = N$, for $t = 0, 1, 2$. When the first sequence obtains as a steady state equilibrium, women's under-representation in the subset of high-powered professionals emerges from period 1 and persists throughout time. When the second obtains instead, equal representation will persist over time. Because the equal-representation steady state equilibrium involves late marriage for all agents, the total population size of each cohort is lower than its level in the under-representation equilibrium due to differential fecundity. In order words, a move from the under-representation equilibrium to the equal-representation one, lead to a drop in the population size of each cohort from $2N$ to N. Any temporary action that can successfully coordinate the actions of the initial cohort of young women towards delay of marriage, will have a steady state effect on the relative professional status of both genders.While such a move is preferred by all women on the basis of assumption 4, it will represent a Pareto-improvement for the society at large, only if men's utility is not negativitely affected.

IV. Summary and Discussion

In this paper, we illustrate a mechanism which can cause a society to experience the emergence and persistence of imbalances in professional career achievements between men and women. In our model society, men and women only differ on the basis of the length of their fecundity horizons. Individuals' career and family plans reflect the interplay between their desire to have both a family and a rewarding career and gender differences in the length of the fecundity horizon. As a result of this interplay, agents have to choose between two strategies for their marriage timing. One is to delay marriage in order to invest in a high-powered career, and the other is to participate early in order to invest more in one's family life instead. While the interplay between individuals' life ambitions and human biology lead to all men having 'marriage delay' as a dominant strategy, it leads to strategic complementarities in women marriage-timing decisions. For the initial cohort of young (aged-2) single women, the non-cooperative game induced by these strategic complementarities leads to a multiplicity of equilibrium marriage-timing profiles. Overtime, this multiplicity of marriage-timing equilibria leads to two different steady state equilibrium sequences representing the number of high-powered women in each period t. One of these two equilibrium sequences implies equal representation of men and women in the subset of high-powered professionals, which is counterfactual. Therefore, our model suggests that in societies where the only difference between men and women is the length of their respective fecundity horizons, the persistence of under-representation of women in high-powered careers is caused by a coordination failure in the marriage-timing decisions of the initial cohort of young women that rules out equal representation as a steady state equilibrium.

All women prefer the equal-representation steady state equilibrium. In that equilibrium, each woman attains a level of utility $\phi(H, \underline{\theta})$, whereas she attains a level $\phi\left(L, \bar{\theta}\right) < \phi(H, \underline{\theta})$ under the under-representation steady state equilibrium. Women, as a group, are therefore likely to support social changes that coordinate their marriage-timing decisions towards delaying participation in the marriage market in order to invest in a high-powered career. Whenever the equal-representation steady state equilibrium obtains, our analysis shows that it will lead to a decline in the total population, due to late marriage and differential fecundity.

Our model also reveals that while women strictly prefer the steady state equilibrium with persisting equal representation of men and women in high-powered careers, men, in contrast, are better off in the steady state equilibrium where they are more professionally accomplished than their respective spouses. In the latter, each man attains a level of utility $\phi\left(H, \bar{\theta}\right)$, whereas he attains only $\phi(H, \underline{\theta}) < \phi\left(H, \bar{\theta}\right)$ in the former. This situation creates a gender conflict regarding which of the two steady state equilibria should be selected. In particular, men may oppose all social changes aimed at jolting the economy into an equilibrium with equal-representation of both genders in high-powered careers, as such changes will take them out of their preferred state. One may therefore find it less surprising the fact that in some countries, men are increasingly turning to the international marriage market to find high-surplus brides, as has been recently documented in the case of some industrialized countries, including the United States.[15]

However, a gender conflict is not inevitable. Indeed, all coordination mechanisms that cause assumption 1 to become violated have a better chance of achieving a Pareto-improvement in the society at large. Such coordination devices would ensure that the inequality, $R(H,H) \geq R(L,H) = \bar{\theta}$, always obtains. This inequality, unlike assumption 1, states that the marital surplus achieved by a dual-earner family in which both partners are high-powered professionals is at least as high as one where the woman is less-accomplished than her high-powered partner. A public policy actions likely to establish that inequality is one that mandates insurance coverage of fertility treatments for women over 35 (Buckles 2005).[16] Alternatively, women may take time off after college in order to start a family, then return to graduate school, when their fertility is completed (Gilbert [2005]). Special scholarship program that target women returning to graduate school may therefore help achieve gender equality in career achievements, and thus help reduce the gender gap in pay.

Appendix

A. Proof of Proposition 1.

Regardless of what other agents do, an aged-2 single man who elects to delay participation in the marriage market in order to invest in a high-education will face one of the probable three following events: (i) he will marry a low-powered, younger woman; (ii) he will marry a high-powered woman; or (iii) he will remain single. If the first of these events occurs, he will achieve his highest possible lifetime utility level, which is $\phi\left(H,\bar{\theta}\right)$. He will achieve a lifetime utility level $\phi\left(H,\underline{\theta}\right) < \phi\left(H,\bar{\theta}\right)$ if the second event occurs, and a lifetime utility level $\phi\left(H,\delta\right)$ if the third occurs instead. However, if he elects not to delay, he will face

[15] A 1999 report to the Congress by the United States Citizenship and Immigration Services (USCIS) reveals a rapid growth in the number of international matchmaking organizations assisting American men in their search for marriage-partners from foreign countries, including Asian countries and the former Soviet Union. The USCIS estimates that these organizations bring approximately 4,000 to 6,000 foreign brides a year into the United States.

[16] Buckles [2005] provides evidence that access to fertility therapies significantly increases women's wages at all ages.

one of two possible events. (i) he will marry an aged-3, high-powered woman, or (ii) stay single for the rest of his life. The first event is associated with a payoff $\phi(L, \underline{\theta})$, while the second is associated with a payoff $\phi(L, \delta)$. The result then follows from assumption 4.

B. Proof of Proposition 2.

To prove proposition 2, first, observe that for all i, $S_i = \{0, 1\}$, which is clearly a closed and bounded subset of $\Re$. Therefore property (i) of a supermodular game is trivially satisfied. Second, to establish property (ii) and (iii), it suffices to prove the following claim:

Claim 1. *For all $i \in I$, $u_i : S \to \Re$ is continuous on S, where $S = S_1 \times ... \times S_N$.*

Proof. Since S_i is finite for all i, therefore S is also finite, as the Cartesian product of a finite number of finite sets. Indeed, S has cardinal number 2^N, which is finite since N is a finite number. Therefore, by theorem[17], u_i is continuous on S. This establishes property (ii) and (iii) of a supermodular game ■

Third, to establish property (iv), it suffices to prove the following claim:

Claim 2. *For all $i \in I$, $u_i : S \to \Re$ attains a maximum on S.*

Proof. Since S is a finite set, we also have that $u_i(S) \subset \Re$ is a finite set. And finite subsets of $\Re$ always contain their upper and lower bounds. It therefore follows that u_i has a finite upper bound on S. This completes the proof of the claim ■

Fourth, the following claim establishes property (vi):

Claim 3. *Let assumptions 1-5 hold. Then for all $i \in I$, $u_i : S \to \Re$ has strictly increasing differences in (s_i, s_{-i}) on $S_i \times S_{-i}$: for all $i \in I$, for all $s'_i > s_i$ and $s'_{-i} > s_{-i}$,*

$$u_i\left(s'_i, s'_{-i}\right) - u_i\left(s_i, s'_{-i}\right) \geq u_i\left(s'_i, s_{-i}\right) - u_i\left(s_i, s_{-i}\right) \quad \text{(IV.1)}$$

Proof. Suppose that for all $i \in I$, $s'_i > s_i$ and $s'_{-i} > s_{-i}$, but

$$u_i\left(s'_i, s'_{-i}\right) - u_i\left(s_i, s'_{-i}\right) < u_i\left(s'_i, s_{-i}\right) - u_i\left(s_i, s_{-i}\right). \quad \text{(IV.2)}$$

[17]**Theorem** (Topology). Any function defined on a finite set is continuous.

We will show that, since the function ρ is monotone increasing by assumption, inequality (IV.2) leads to a contradiction.

Observe that inequality (IV.2) can also be written as follows:

$$u_i\left(s_i', s_{-i}'\right) - u_i\left(s_i', s_{-i}\right) < u_i\left(s_i, s_{-i}'\right) - u_i\left(s_i, s_{-i}\right) \tag{IV.3}$$

all $i \in I$. Since $S_i = \{0, 1\}$, for all i, take $s_i' = 1$ and $s_i = 0$. Then, using (III.5), it can be shown that (IV.3) reduces to

$$\psi\left(s'\right) - \psi\left(s_i', s_{-i}\right) < 0. \tag{IV.4}$$

Define

$$\begin{aligned} N_2' &= s_i' + \sum_{j \neq 1}^{N} s_j' \\ \widetilde{N}_2 &= s_i' + \sum_{j \neq 1}^{N} s_j \end{aligned}$$

Since $s_j' > s_j$ for all $j \neq i$, therefore $N_2' > \widetilde{N}_2$. From (III.6), inequality (IV.4) leads to

$$\left[\rho\left(N_2'\right) - \rho\left(\widetilde{N}_2\right)\right]\left[\phi\left(H, \underline{\theta}\right) - \phi\left(H, \delta\right)\right] < 0.$$

Clearly, this is a contradiction since $\phi\left(H, \underline{\theta}\right) - \phi\left(H, \delta\right) > 0$, by assumption 2, and ρ is an increasing function. Hence the result ■

The strict inequality in (IV.1) implies that for player i, the incremental gain from taking a higher action is higher, when her opponents also play their highest action. Condition (IV.1) can easily be shown to imply the following: for all i,

$$u_i\left(s_i', s_{-i}'\right) - u_i\left(s_i', s_{-i}\right) \geq u_i\left(s, s_{-i}'\right) - u_i\left(s_i, s_{-i}\right).$$

In other words, when player i's opponents take their highest action, the incremental gain to player i is highest if she herself takes her highest action.

C. Proof of Lemma 1.

Let $\Delta_i \equiv u_i\left(s_i, s'_{-i}\right) - u_i\left(s_i, s_{-i}\right)$. From (III.5), the difference Δ_i reduces to

$$\Delta_i = \left[\psi\left(s_i, s'_{-i}\right) - \psi\left(s_i, s_i\right)\right] s_i,$$

for all $s_i \in S_i$ and all $i \in I$. We want to show that $\Delta_i \geq 0$, for all $i \in I$.

Now, suppose instead that for some i, and for all $s'_{-i} > s_{-i}$, $\Delta_i < 0$. Then from (III.6)), it can be shown that inequality $\Delta_i < 0$, reduces to

$$\left[\rho\left(\widehat{N}_2\right) - \rho\left(N_2\right)\right]\left[\phi\left(H, \underline{\theta}\right) - \phi\left(H, \delta\right)\right] s_i < 0,$$

where

$$\begin{aligned} \widehat{N}_2 &= s_i + \sum_{j \neq i} s'_j \\ N_2 &= s_i + \sum_{j \neq i} s_j. \end{aligned}$$

Since $s'_{-i} > s_{-i}$, it follows that $\widehat{N}_2 > N_2$ by construction, implying that $\rho\left(\widehat{N}_2\right) - \rho\left(N_2\right) \geq 0$. Clearly, we reach a contradiction, since, by assumption 2, the function ϕ is strictly increasing in both its arguments, and $s_i \in \{0, 1\}$. This completes the proof.

D. Proof of Proposition 3.

The proof is divided in two claims:

Claim 1. *The strategy profile s^0 such $\forall i$, $s_i^0 = 0$, is a SNE of Γ.*

Proof. Using (III.7) and (III.8), it follows from definition 2 that the profile s^0, is a strict pure-strategy SNE of Γ if and only the following condition is always satisfied for all i:

$$\phi\left(L, \bar{\theta}\right) > \phi\left(H, \underline{\theta}\right) \underline{\rho} + \left(1 - \underline{\rho}\right) \phi\left(H, \delta\right).$$

The result then clearly follows from (III.9) ■

Claim 2. *The strategy profile s^1 such $\forall i$, $s_i^1 = 1$, is a SNE of Γ.*

Proof. The proof follows in the same manner as in Claim 1. Hence the result. ■

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