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How Bargaining in Marriage Drives Marriage Market Equilibrium*

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ABSTRACT

This paper investigates marriage market equilibrium under the assumption that **B**argaining **I**n **M**arriage (**BIM**) determines allocation within marriage. Prospective spouses, when they meet in the marriage market, are assumed to foresee the outcome of BIM and rank prospective spouses on the basis of the utilities they foresee emerging from BIM. Under these assumptions, the marriage market is the first stage of a multi-stage game -- in the simplest case, a two-stage game -- that must be solved by backwards induction. The marriage market determines both who marries and, among those who marry, who marries whom. Bargaining in the second and any subsequent stages determines allocation within each marriage. When BIM determines allocation within marriage, the appropriate framework for analyzing marriage market equilibrium is the Gale-Shapley matching model.

In contrast, the standard model of marriage market equilibrium assumes that prospective spouses make **B**inding **A**greements in the **M**arriage **M**arket (**BAMM**) that determine allocation within marriage. If we assume BAMM and transferable utility, then the appropriate framework for analyzing marriage market equilibrium is the Koopmans-Beckmann-Shapley-Shubik assignment model. BIM and BAMM have different implications not only for allocation within marriage but also for who marries, who marries whom, the number of marriages, and the Pareto efficiency of marriage market equilibrium.

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1. Introduction

I investigate marriage market equilibrium under the assumption that **B**argaining **I**n **M**arriage (**BIM**) determines allocation within marriage. In contrast, the standard model of marriage market equilibrium assumes that prospective spouses make **B**inding **A**greements in the **M**arriage **M**arket (**BAMM**) that determine allocation within marriage. I show that BIM and BAMM have different implications not only for allocation within marriage, but also for who marries, for who marries whom, for the number of marriages, and for the Pareto efficiency of marriage market equilibrium.

When BIM determines marriage market equilibrium, I assume that when prospective spouses meet in the marriage market they foresee the outcome of future bargaining. Taking account of these outcomes, each man has a ranking of all women, and each woman has a ranking of all men. Under these assumptions, the marriage market is the first stage of a multi-stage game -- in the simplest case, a two-stage game -- that must be solved by backwards induction.

When BIM determines allocation within marriage, a modified version of the Gale and Shapley (1962) matching model is the appropriate framework for analyzing marriage market equilibrium. In the original Gale-Shapley model, each man had a ranking of all women, each woman had a ranking of all men, and these rankings were primitives of the model. I replace the assumption that the rankings are primitives of the model with the assumption that they depend on the outcomes prospective spouses foresee emerging from BIM. With this seemingly trivial modification, BIM and the Gale-Shapley matching model become a credible alternative to the standard marriage market model based on BAMM and the Koopmans-Beckmann-Shapley-Shubik assignment model.[1]

A two-stage example illustrates the relationship between BIM and the marriage market. For definiteness, suppose that Nash bargaining, the workhorse of the family bargaining literature, determines allocation within every possible marriage and that the threat point in every possible marriage is common knowledge to marriage market participants. Then each prospective spouse can foresee the outcome of Nash bargaining in every possible marriage, calculate his or her utility in every possible marriage, and rank every possible marriage partner. The threat point may be divorce or may depend on some measure of control over resources in marriage.

BIM does not require Nash bargaining. Becker's "altruist model," the model underlying the Rotten Kid Theorem, provides a tractable alternative.[2] In the altruist model one spouse, for definiteness, the husband, has the power to impose his preferred allocation subject to his wife's participation constraint. Thus, the wife's utility depends on the couple's resources and on the weight the husband places on the wife's well-being (i.e., how "altruistic" or "caring" he is). As with Nash bargaining, with the altruist model each marriage market participant can calculate his or her utility in every possible marriage and, on the basis of these utilities, rank potential marriage partners. Using these rankings, the Gale-Shapley matching model allows us to analyze marriage market equilibrium.

BIM and the modified Gale-Shapley approach is consistent with all cooperative and noncooperative bargaining models that uniquely determine the utilities of prospective spouses in

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[1] Becker (1973, 1991) was the first to recognize that the assignment model could be used to analyze marriage market equilibrium. For subsequent developments, see Choo and Siow (2006) and Chiappori (2017).

[2] See Becker (1991, p. 9; p. 284). All page citations to Becker's *Treatise on the Family* refer to the 1991 enlarged edition, although virtually all the cited material appeared in the 1981 edition and, before that, much of it in journal articles.

every possible marriage. The original version of Chiappori's "collective model" assumes that allocation within marriage is Pareto efficient and that "distribution factors" that reflect bargaining power within marriage uniquely determine the spouses' utilities (Chiappori, 1988, 1992; Browning et al., 1994). Thus, the original version of the collective model includes as special cases both Nash bargaining and the altruist model. Browning et al., (1994, p. 1072) write that the efficiency assumption "...is particularly attractive in the context of the household since the 'players' have a long-term relationship and are in an environment that does not change much from period to period."[3] Later versions of the collective model such as Chiappori, Iyigun, and Weiss (2009) assume that allocation within marriage is determined by Pareto efficient agreements that prospective spouses make in the marriage market. Pareto efficiency, however, is a less attractive assumption without the Browning et al. rationale that allocation within marriage is the outcome of a repeated game.

The analysis of marriage market equilibrium based on BIM and the Gale-Shapley matching model generalizes from two-stage games to multi-stage games. Because multi-stage games are solved by backwards induction, the continuation values contain all the information that marriage market participants need to rank prospective spouses. The utility each marriage market participant associates with every possible marriage is a sufficient statistic because these utilities determine the rankings that are grist for the Gale-Shapley mill. Specifications as diverse as Nash bargaining, the altruist model, and the original version of the collective model provide suitable starting points for the analysis because the granular structure of bargaining is irrelevant.[4]

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[3] Lundberg and Pollak (2003) argue that major decisions that substantially affect future bargaining power are much less likely to be efficient than minor decisions that allow spouses to split the difference or take turns.

[4] The Gale-Shapley analysis is consistent with any model that yields unique utilities, regardless of whether allocations within marriages are Pareto efficient.

The standard analysis of marriage market equilibrium assumes that prospective spouses make **B**inding **A**greements in the **M**arriage **M**arket (**BAMM**) that determine allocation within marriage and, hence, the utility each spouse will receive from the marriage. That is, in the standard model, allocation within marriage, implements prior agreements that prospective spouses made in the marriage market.

Given the large and growing literature on bargaining in marriage, a reader might mistakenly assume that the marriage market literature consists of two strands, one corresponding to BIM and the other to BAMM. In fact, the marriage market literature consists of one strand, and that strand is BAMM. Neither bargaining within marriage nor the Gale-Shapley matching model appear in the marriage market literature.[5]

As the word "binding" implies, BAMM assumes that agreements made in the marriage market are enforceable. Although prenuptial agreements appear to provide a way in which BAMM might be enforced, American courts will not enforce contracts about allocation within marriage. In section 6, I discuss enforcement.

With BAMM, the solution concept for marriage market equilibrium is the core. If we assume both BAMM and transferable utility, then the equilibrium assignment (i.e., who marries whom) maximizes the sum of utilities over all possible marriages. With BAMM and transferable utility, the assignment model, introduced by Koopmans and Beckmann (1957) and elaborated by Shapley and Shubik (1971), reduces the task of maximizing the sum of utilities to a linear programming problem.

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[5] I am aware of only two recent marriage market papers that mention Gale-Shapley: Del Boca and Flinn (2014) and Voena (2015). Both follow Becker (1991, p. 126) and assume that all husbands receive the same fraction of output or utility in every marriage. I discuss the same-fraction assumption in section 3.

Thus, the conjunction of BAMM and transferable utility substantially simplifies the analysis of marriage market equilibrium.

Although the standard marriage market model assumes both BAMM and transferable utility, these assumptions are independent. BAMM is an assumption about the contracting opportunities available to prospective spouses in the marriage market, while transferable utility is an assumption about preferences. Although the analysis of marriage market equilibrium with BIM is not simplified by transferability utility, I assume transferable utility to facilitate comparisons between the marriage market implications of BIM and BAMM.

BIM and BAMM have different implications for the Pareto efficiency of marriage market equilibrium. With BAMM, because the solution concept is the core, the equilibrium must be Pareto efficient. With BIM, marriage market equilibrium need not be Pareto efficient even if bargaining in marriage leads to Pareto-efficient allocations within every possible marriage. Examples based on Nash bargaining and altruist model illustrate this possibility: inefficiency can arise if a woman chooses to remain unmarried, rejecting a marriage that would generate a "surplus" -- that is, more total utility than the sum of the utilities she and her prospective husband would receive as unmarried individuals. (With transferable utility, the sum of utilities is well-defined.) A woman would reject such a marriage if she foresaw that her husband would have "too much" bargaining power and would appropriate so much that she would be worse off than if she never married him.[6]

In section 2 I review the literature on bargaining in marriage. In section 3 I discuss marriage market equilibrium with BIM and in section 4 marriage market equilibrium with BAMM. In section

[6] Without the ability to make BAMM, a prospective husband cannot credibly commit himself not to exploit his bargaining power advantage even though he would be better off if he could make such a commitment.

5 I show that BIM and BAMM can have different implications for who marries, for who marries whom, and for the number of marriages; I also show that this is the case in search models as well as in frictionless models in which all marriage market participants meet simultaneously. Section 6 discusses three cases in which, it has been argued, marriage market equilibrium under BIM and BAMM coincide -- costless divorce, prenuptial agreements, and premarital transfers. I argue that none of these cases justify using BAMM rather than BIM to analyze marriage market equilibrium. Section 7 concludes.

2. Bargaining in Marriage: Theory and Evidence

The first theoretical models of bargaining in marriage, those of Manser and Brown (1980) and McElroy and Horney (1981), assumed that cooperative bargaining determined allocation within marriage and that the threat point was divorce. Their principal objective was to challenge the traditional "unitary model" of the household in which spouses "pool" their resources and act as a single "economic agent," maximizing a household utility function subject to household resource constraints. Divorce-threat bargaining models predict that what McElroy (1990) has called "extrahousehold environmental parameters" (EEPs) determine allocation in ongoing marriages. Examples of EEPs include the costs of divorce, the status of divorced individuals, and conditions in the remarriage market.

Although the first theoretical models of bargaining in marriage assumed that divorce was the threat point, more recent work has emphasized control over resources within marriage as a determinant of bargaining power. The recognition of an "internal" as well as an "external" threat point allows for the possibility that bargaining within marriage takes place even in societies in which divorce is not an option as well as in marriages in which divorce is not a credible threat because the participation constraint is not binding.[7]

Evidence that changes in divorce law cause reallocation within existing marriages is consistent with bargaining or rebargaining in marriage.[8] Using US longitudinal data, Voena (2015) investigates the effect of changes in divorce laws on couples that were married before these changes were made. She finds that "when unilateral divorce is introduced in states where property is divided equally, the women who are already married become less likely to work, while no significant change is observed in states that do not impose an equal division of property." This response, as Voena points out, is consistent with divorce-threat bargaining.[9]

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[7] The historian Lawrence Stone writes: "It must never be forgotten that England in the early modern period was neither a separating nor a divorcing society: death was virtually the sole agent for dissolving marriage" (1990, p. 2). Becker (1991, p. 274) cites Rowntree and Carrier for the fact that "There were fewer than two (!) divorces per year in England from 1800 to 1850..." (Becker's exclamation point). The 1857 Divorce Act substantially liberalized the law governing divorce in England and Wales, yet the number of divorces per year remained under 1000 until the First World War (see Stone [1990, Table 13.1]). In the 19th century, divorce rates in the United States were substantially higher than in England; Preston and McDonald (1979) estimate the US divorce rate was between 5 and 6 percent in the late 1860s. Hartog (2000) emphasizes the importance of separation and abandonment as alternatives to divorce in the United States in the 19th century. Predominantly Catholic countries in Europe and Latin America legalized divorce late in the 20th or early 21st centuries -- Italy in 1970, Portugal in 1975, Brazil in 1977, Ireland in 1997, and Chile in 2004.

[8] There is strong evidence that both the sex ratio and divorce laws affect allocation within marriage, but many papers fail to investigate the extent to which these factors operate through bargaining in marriage rather than through the marriage market. On divorce laws, see Chiappori, Fortin and, Lacroix (2002), Stevenson (2007), and Roff (2017); on the sex ratio, see Angrist (2002), Chiappori, Fortin, and Lacroix (2002), and Grossbard (2016).

[9] Rangel (2006) investigates the effect of a 1994 legal change in Brazil that made partners in consensual (i.e., cohabiting) unions eligible for "alimony" when the union ended. Rangel finds that women who were in consensual unions when the change was made increased their leisure and decreased both their market work and household work. Rangel attributes these changes to an increase in women's bargaining power.

Schultz (1990) and Thomas (1990) provided early empirical evidence that control over resources within marriage affects allocation within marriage. Their crucial insight was that unitary models imply that couples pool their resources, while bargaining models allow control over resources within marriage to influence allocation within marriage. (Whether the empirical counterpart of control over resources is best interpreted as wealth, income, earnings, or wages is an open question in both the theoretical and the empirical literatures; see Pollak, 2005.) That is, unlike the unitary model, bargaining models allow labor supply, expenditure patterns, and the well-being of children to depend not only on total household resources but also on the proportion of household resources controlled by each spouse. Using Brazilian data, Thomas found that the effect of mothers' unearned income on children's survival probabilities was almost 20 times greater than that of fathers' unearned income. The use of unearned income rather than earnings mitigates the endogeneity problem that arises because unearned income is not exogenous.

The "separate spheres" bargaining model of Lundberg and Pollak (1993) provides a theoretical rationale for the finding that control over resources within marriage affects allocation within marriage. The separate spheres model assumes that in day-to-day marital bargaining the threat point is not divorce but a noncooperative equilibrium within marriage. Bergstrom (1996, p. 1926) memorably characterizes the noncooperative equilibrium as "harsh words and burnt toast," but threats of violence or actual violence are more ominous possibilities. In the separate spheres model, control over resources can affect allocation within marriage even when the participation constraint is not binding (i.e., when neither spouse is sufficiently dissatisfied with the status quo to end the marriage, but at least one is willing to resort to harsh words and burnt toast).

Lundberg, Pollak, and Wales (1997) provides empirical support for the claim that control over resources affects allocation within marriage. The paper avoids the endogeneity problem by using a natural experiment -- a policy change in the United Kingdom in the late 1970s that transferred a substantial child benefit from husbands to wives. This exogenous change in control over resources led to increased expenditures on both women's clothing and children's clothing relative to men's clothing. Corroborating the control-over-resources claim, Ward-Batts (2008) found that the change in the British child benefit affected purchases of tobacco products. Specifically, she found a substantial and statistically significant increase in expenditure on cigarettes and an offsetting decrease in expenditure on cigars and pipe tobacco, which she called "men's tobacco."

Empirical research on the effect of control over resources has often focused on "assignable goods" -- that is, on goods that are assumed to be consumed exclusively by only one member of the household or, more precisely, to enter the utility function of only one member of the household. Examples of assignable goods are men's clothing, women's clothing, and children's clothing and the time husbands and wives allocate to market work, household work, and leisure. Much of the empirical research is motivated by a policy concern with the health or well-being of children. The British decision to transfer resources "from the wallet to the purse" by paying the child benefit to mothers rather than to fathers was based on the belief that "kids do better" when their mothers control a larger fraction of family resources.

Many researchers have investigated the effect of control over resources on expenditure patterns using data from a Mexican conditional cash transfer program, Progresa, and its successor, Oportunidades. Conditional cash transfer programs almost always provide the cash to mothers rather than to fathers. To simplify a bit, Progresa payments were conditioned on children attending school and receiving scheduled immunizations. Progresa and Oportunidades made payments only to mothers but, because some villages were randomly selected to implement Progresa before others, differences in the timing of implementation created a research opportunity.[10] Researchers compared the expenditure patterns of households in the earlier villages with those of households in the later villages. Comparing households with the same level of total expenditure provides a test of the control-over-resources hypothesis. For example, exploiting these timing differences, Attanasio and Lechene (2002) and Rubalcava, Teruel, and Thomas (2009) found persuasive evidence that control over resources affects household expenditure patterns: treated households in villages that implemented Progresa early spent more on food than households with the same level of total expenditure in villages that had not yet implemented Progresa. Using Oportunidades data, Angelucci and Attanasio (2013) also found that control over resources strongly affects expenditure patterns. They conclude that the data are not consistent with the unitary model of the household, and investigate two possible explanations: that the observed differences were due to changes in nutritional knowledge or that they were due to increases in mothers' relative incomes, which they characterize as "a proxy for bargaining power" (p. 150). Angelucci and Attanasio conclude that "The fact that women start to control a sizable proportion of the family income seems to induce a change in the way households allocate total expenditure among different commodities" (p. 176).

Because randomized controlled trials (RCTs) are often regarded as the gold standard for empirical evidence, a powerful test of the control-over-resources hypothesis would be an RCT that made payments to mothers in some families and to fathers in others. Armand, et al. (2016) report the results of such an RCT in Macedonia in which conditional cash transfers were made to mothers in some municipalities and to fathers in others. The Macedonian results strongly support the conclusion that control over resources is an important determinant of household expenditure patterns. Armand,

[10] Behrman and Hoddinott (2005) discuss the randomization.

et al. write: "When provided with an additional source of income, mothers and fathers spend income differently."

Uncertainty complicates everything. Prospective spouses may recognize that their feelings for each other may change, that divorce laws may change, and that future wealth, income, earnings, and wages are stochastic. With BIM, uncertainty is a relatively minor complication. If marriage market participants know the underlying distributions of shocks, they can calculate the expected utility in every possible marriage and rank every possible marriage partner on the basis of expected utility. The standard marriage market model assumes "full commitment" -- in the marriage market prospective spouses make binding agreements that completely determine allocation within marriage, leaving no scope for divorce or for rebargaining within marriage. With BAMM, uncertainty is a major complication because it requires substantially more than marriage market participants knowing the distribution of shocks.[11]

"Limited commitment" is an intermediate case, and is the only admissible intermediate version of the collective model between full commitment and no commitment. With limited commitment, utility is reallocated when and only when the participation constraint is binding (i.e., when the sharing rule agreed to in the marriage market would leave one spouse worse off than divorce). When the marriage produces a surplus and the participation constraint is binding, limited commitment allows reallocation but specifies a particular reallocation. The specified reallocation

[11] Transferable utility with uncertainty is highly restrictive; see Chiappori, Costa Dias, and Meghir (2016, pp. 10-11).

increases the utility of the spouse at the participation constraint by just enough to keep that spouse in the marriage.[12]

Limited commitment plays virtually no role in the marriage market literature which either assumes full commitment (i.e., no reallocation, no divorce) or imposes assumptions intended to allow the full commitment analysis to proceed. For example, Chiappori, Costa Dias, and Meghir (2016) use the full commitment version of the collective model to establish the efficiency of the educational choices prospective spouses make before they enter the marriage market. Iyigun and Walsh (2007, p. 510, 515) reach this efficiency conclusion by assuming that divorce is costless. Chiappori, Iyigun, and Weiss (2009, p. 1709) reach it by assuming that prospective spouses make enforceable prenuptial agreements that fully insure against divorce. In section 6 I discuss both costless divorce and prenuptial agreements.

To summarize: Evidence amassed over the past quarter century has established that bargaining in marriage is an important determinant of allocation within marriage. Some studies emphasizes the threat of divorce while others emphasize control over resources within marriage as sources of bargaining power. There is, however, no consensus about the type of bargaining, the empirical counterparts of bargaining power, or whether bargaining takes place only when the participation constraint is binding.

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[12] Thus, limited commitment relies on contingent contracts in which the contingencies are not states but equivalence classes of states specified in terms of utilities. When contracting parties cannot make full commitments, dynamically efficient agreements must take this form; see Ligon, Thomas, and Worrall (2002), Ligon (2002), and Mazzocco (2007). Using Japanese longitudinal data, Lise and Yamada (2015) estimate a dynamic model of allocation within marriage and interpret their results as consistent with the limited commitment version of the collective model.

3. Marriage Market Equilibrium with Bargaining in Marriage (BIM)

Gale and Shapley proposed and analyzed the first matching model in their celebrated 1962 article "College Admission and the Stability of Marriage." They described the marriage problem in three concise sentences: "A certain community consists of n men and n women. Each person ranks those of the opposite sex in accordance with his or her preferences. We seek a satisfactory way of marrying off all members of the community."[13]

I drop the Gale-Shapley assumption that the rankings are primitives of the model and assume instead that individuals' rankings of prospective marriage partners depend on the utilities they foresee emerging from BIM. Becker (1991) started down this road but turned back. Without acknowledging that he was doing so, Becker reinterpreted the Gale-Shapley model by replacing the assumption that individuals' rankings are primitives of the model with the assumption that the rankings depend on the utilities individuals would receive in marriages. Becker, however, imposed an additional assumption that vitiated the power of this reinterpretation to provide the basis for an economic analysis of the marriage market: he assumed that "all men receive the same fraction of output [utility] in all possible matches" (p. 126).[14] Becker recognized that if all men receive the same fraction of output or utility in all marriages, then the analysis of allocation within marriage would be a project for anthropologists

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[13] The Gale-Shapley statement of the problem ("in a certain community") assumes away the issue of marriage market definition. The generalization to unequal numbers of men and women is straightforward. Roth and Sotomayor (1990) provide the definitive exposition and analysis of matching models.

[14] Working within the household production framework, Becker (1973, p. 816) assumed that every marriage produces a single output that must be divided between the spouses, but his analysis also applies with transferable utility. Chiappori (2015) argues that Becker's insistence on output and his rejection of transferable utility was a rare misstep.

or sociologists, not for economists. The Gale-Shapley matching model plays no further role in the *Treatise* and virtually none in the subsequent marriage market literature.[15]

Following Becker, I assume that the rankings depend on the division of output or utility within marriage, but I drop Becker's assumption that all men receive the same fraction of output or utility in all possible matches. Instead I assume that prospective spouses understand that allocation within marriage will be determined by BIM and that they foresee the utilities that will emerge from bargaining. I assume that if man i marries woman j, the sum of the utilities they receive is u_{ij}, while if he never marries he receives utility u_{io} and if she never marries she receives utility u_{oj}. I assume that every possible marriage generates a nonnegative surplus, in the sense that $u_{ij} \geq u_{io} + u_{oj}$. To minimize notational clutter, I assume

$$u_{io} = u_{oj} = 0 \text{ for all i, j.}$$

I assume that the marriage market contains equal numbers of men and women (n) and denote the $n \times n$ "utility surplus matrix," S, by

$$S = \begin{bmatrix} u_{11} & \cdots & u_{1n} \\ \vdots & & \vdots \\ u_{n1} & \cdots & u_{nn} \end{bmatrix}$$

I assume that marriage market participants treat bargaining power and, hence, the division of utility within marriage, as fixed.[16] This implies that agreements made in the marriage market are

[15] I am grateful to Vince Crawford for calling my attention to three papers published in the 1980s that investigate marriage-market models based on Gale-Shapley: Bennett (1988), Crawford and Rochford (1986), and Rochford (1984). These papers have hardly ever been cited in the marriage market literature, but they will be if this paper renews interest in approaches based on Gale-Shapley and BIM.

[16] Prenuptial agreements and premarital transfers can alter bargaining power within marriage and, hence, the division of utility. I discuss these possibilities in section 6.

cheap talk. If man i marries women j, I denote the expected division of utilities between them by ($\tilde{u}_{ij}^{h}$, $\tilde{u}_{ij}^{w}$) and the n × n the "utility division matrix," D, by

$$D = \begin{bmatrix} (\tilde{u}_{11}^{h}, \tilde{u}_{11}^{w}) & \cdots & (\tilde{u}_{1n}^{h}, \tilde{u}_{1n}^{w}) \\ \vdots & & \vdots \\ (\tilde{u}_{n1}^{h}, \tilde{u}_{n1}^{w}) & \cdots & (\tilde{u}_{nn}^{h}, \tilde{u}_{nn}^{w}) \end{bmatrix}$$

To facilitate comparisons between BIM and BAMM, I assume that utility divisions are Pareto efficient so that

$$\tilde{u}_{ij}^{h} + \tilde{u}_{ij}^{w} = u_{ij},$$

although the BIM analysis of marriage market equilibrium does not require Pareto efficiency.[17] The marriage market implications of BIM follow from the division matrix and the assumption that the utilities of unmarried men and unmarried women are 0.[18] I do not assume

$$\tilde{u}_{ij}^{h} \geq 0 \text{ or } \tilde{u}_{ij}^{w} \geq 0.$$

Instead, I distinguish between two participation constraints: the "marriage market participation constraint" (i.e., the constraint facing an unmarried individual considering whether to enter a particular marriage) and the “ongoing marriage participation constraint" (i.e., the constraint facing a married individual considering whether to leave a particular marriage).[19] The ongoing marriage participation constraint depends on McElroy's EEPs as well as on the individual's wage rate and other characteristics. The possibility that a woman might choose to remain unmarried rather than

[17] BIM does not require prospective spouses to have identical expectations about the division of utility that will emerge from marital bargaining. Divergent expectations may increase the probability of divorce, but economists have done little to investigate spouses' expectations at the time they enter marriage.

[18] The assumption of equal numbers of men and women and the assumption that the utilities of unmarried men and unmarried women are 0 simplify the notation and the exposition, but most of the analysis does not require these assumptions.

[19] This distinction disappears if we assume costless divorce.

marry a man who would have "too much" bargaining power depends on the distinction between the marriage market participation constraint and the ongoing marriage participation constraint.

If each man associates a utility with every possible marriage, he can rank the women in the marriage market. Similarly, if each woman associates a utility with every possible marriage, she can rank the men in the marriage market. Under these assumptions, the Gale-Shapley matching model applies directly to the marriage market.

Gale and Shapley proposed an intuitively appealing equilibrium concept for matching models, a “stable matching.”[20] They define a stable matching as an assignment of women to men (or, equivalently, of men to women) that satisfies two properties:

(i) no married individual prefers being unmarried to his or her current assignment,

(ii) no two individuals of opposite sexes prefer being married to each other to their current assignments.

This definition covers both the case in which the current assignment is being unmarried and the case in which it is being married to a particular individual. Gale and Shapley proved that if each individual's ranking is an ordering, as it must be under our assumption that rankings are based on the utilities individuals expect to emerge from BIM, then a stable matching exists. I denote a stable matching corresponding to BIM by the mapping $\tilde{F}(i) = j$ from the set of men, $\{1,...,n\}$, into the set $\{0,1,...,n\}$. If $\tilde{F}(i) = j$, $j \neq 0$, then man i marries woman j; if $\tilde{F}(i) = 0$, then man i remains unmarried. I denote the number of marriages by $\tilde{\imath}$.

The analysis of marriage market equilibrium with BIM does not depend on a particular bargaining model, but it does assume that, for every possible marriage, bargaining implies a utility or

[20] Gale and Shapley also introduced the "deferred acceptance" algorithms for finding stable matchings; see Roth (2008).

expected utility corresponding to every prospective spouse. Hence, bargaining models with probabilistic outcomes are admissible, but a solution concept such as the core that specifies a set of outcomes without specifying the corresponding probabilities is inadmissible.

Three additional points about the marriage market equilibrium with BIM deserve mention. First, with BIM the analysis of marriage market equilibrium neither requires nor is substantially simplified by assuming transferable utility. Second, with BIM the analysis of marriage market equilibrium is not substantially simplified by assuming equal numbers of men and women. Third, although the utility or expected utility of each individual in every possible marriage is determined, the equilibrium assignment of women to men need not be unique.[21]

4. Marriage Market Equilibrium with Binding Agreements in the Marriage Market (BAMM)

The standard economic analysis of marriage market equilibrium assumes that prospective spouses, when they meet in the marriage market, make binding agreements that determine the division of utility in marriage. With BAMM, these utilities must satisfy conditions that relate the utilities of married individuals to the utilities they would receive in other marriages and to the utilities they would receive as unmarried individuals. The comparison with their utilities as unmarried individuals is an individual rationality condition: individuals will not voluntarily enter a marriage unless they receive at least the utility they would receive as unmarried individuals. The comparison with the utilities they would receive in other marriages implies two conditions: (1) no one is willing to offer an unmarried

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[21] If individuals' preference rankings are strict (i.e., no ties), then the number of marriages and the set of individuals who marry are the same at every stable matching; see Roth and Sotomayor (1990, p. 42, Theorem 2.22). Furthermore, if individuals' rankings are strict, the utility payoffs associated with different stable matchings have a lattice structure, and the best stable matching for men (women) is the worst for women (men); see Roth and Sotomayor (1990, p. 36, Theorem 2.16; p. 33, Theorem 2.13). Eeckhout (2000) establishes a sufficient condition for uniqueness.

individual enough to induce that individual to marry and (2) no one is willing to offer a married individual enough to bid that individual away from his or her assigned spouse.

With BAMM, agreements made in the marriage market are assumed to be binding contracts although enforcement is seldom discussed. Framing their discussion in terms of output rather than utility, Becker and Murphy (2000, p. 31) provide an explicit statement of the role of bids and offers: "...the marriage market allows [the men and women in the marriage market] to bid for different spouses by offering a larger or smaller share of the output they would produce together."

The Koopmans-Beckmann-Shapley-Shubik assignment model is the mathematical foundation of the standard analysis of marriage market equilibrium. With BAMM and transferable utility, the core of the marriage market game maximizes the sum of utilities over all possible marriages. Hence, under these assumptions, the assignment model reduces the problem of finding marriage market equilibrium to a linear programming problem.

We denote the BAMM equilibrium marriage market assignment by the mapping $\hat{F}(i) = j$ from the set of men, $\{1,...,n\}$, into the set $\{0,1,..,n\}$. If $\hat{F}(i) = j$, $j \neq 0$, then man i marries woman j; if $\hat{F}(i) = 0$, then man i remains unmarried. (I leave open the possibility of nonmarriage in order to drop the nonnegative surplus assumption and discuss nonmarriage in section 5.) Under our assumptions, the utility surplus matrix, S, which shows the total utility each possible couple produce together, contains all the information required to calculate the equilibrium assignment. Unless two marriages produce the same surpluses, the equilibrium assignment is unique but the "imputations" (i.e., the utilities received by each individual) are not.

The dual of the social planner's maximization problem leads to a set of imputation vectors that show the utility divisions consistent with the equilibrium assignment. Because our assumptions imply that all men and all women marry, the vectors in this set are of the form $V = [(\hat{u}^h_{11}, \hat{u}^w_{11}), ...,$

$(\hat{u}^{h}_{nn}, \hat{u}^{w}_{nn})$] where each vector shows a division of utility in every marriage. I denote the set of imputation vectors by $\mathcal{V}$: V ∈ $\mathcal{V}$.[22]

The literature is silent about the contents of agreements made in the marriage market. One interpretation is that agreements are state-contingent contracts specifying allocations within marriage in every state of the world.[23] An alternative interpretation is that prospective spouses make prenuptial agreements or premarital transfers that alter bargaining power within marriage, so that bargaining in marriage results in a pattern of utility divisions, V*, that clears the marriage market (i.e., V* ∈ $\mathcal{V}$). Under this interpretation, allocation within marriage is determined by bargaining in marriage, where agreements or transfers made in the marriage market determine bargaining power in marriage. In section 6 I argue that neither prenuptial agreements nor premarital transfers provide a plausible way for prospective spouses to redistribute bargaining power within marriage.

5. Implications of BIM and BAMM for Who Marries Whom and the Number of Marriages

Using the machinery introduced in sections 3 and 4, in this section I investigate the implications of BIM and BAMM for who marries whom and for the number of marriages. I first construct a class of cases in which BIM and BAMM can lead to different marriage market assignments, and then a class of cases in which BIM and BAMM must lead to identical marriage market assignments. I then compare the number of marriages under BIM and BAMM. I show that if every possible marriage produces a nonnegative surplus, then BAMM implies at least as many marriages as BIM. I then show that if some marriages fail to produce a nonnegative surplus, then BIM

[22] As the number of marriage-market participants increases, the requirements of marriage-market equilibrium may imply increasingly tight bounds on imputations. In the limit, the set of imputation vectors may converge to a singleton.

[23] In the introduction to the Enlarged Edition of the *Treatise*, Becker (1991, p. 14-15) rejects the state-contingent contracts interpretation.

can imply more marriages than BAMM. Finally, I show that the distinction between BIM and BAMM is crucial not only in frictionless models in which all marriage market participants meet simultaneously but also in search models.

A special case of the altruist model provides a transparent example in which BIM and BAMM lead to different marriage market assignments. Suppose that each man, if he had the power to allocate resources within marriage, would divide the utility surplus in the same proportion as every other man. Formally, this implies that the elements of the BIM utility division matrix are of the form

$$\tilde{u}^h_{ij} = \sigma u_{ij} \text{ for all } i, j \text{ and } \quad \tilde{u}^w_{ij} = (1-\sigma) u_{ij} \text{ for all } i, j.$$

Hence, in every marriage, husbands receive the same fraction of the surplus. If preferences are strict, the following simple algorithm leads to the BIM marriage market equilibrium. First form the marriage that produces the greatest total utility. (The same-fraction assumption implies that this marriage provides greater utility to the husband and the greater utility to the wife than any other marriage.) Next reduce the set of marriages by eliminating all marriages involving individuals matched in previous rounds. From the subset of marriages that remain, form the marriage that provides the greatest total utility. Repeat this procedure until everyone is matched. (This algorithm also implies that, with the same-fraction assumption and strict preferences, the BIM marriage market equilibrium is unique.)

With this same-fraction specification, BIM and BAMM lead to different marriage market equilibria unless the BAMM equilibrium happens to be one that includes the marriage that corresponds to the greatest utility:

$$\tilde{F}(i) \neq \hat{F}(i), \text{ for some } i, i = 1,...,n.$$

Becker (1991, p. 111) showed that BAMM maximizes the sum of utilities over all possible marriages but, as he showed, it does not necessarily choose the marriage that corresponds to the greatest utility.

I next construct a class of cases in which BIM and BAMM imply identical marriage market assignments by formalizing the intuition that if the BIM utility divisions and the BAMM imputations are identical, then BIM and BAMM imply the same marriage market assignments:

$\tilde{F}(i) = \hat{F}(i), \; i = 1,...,n.$

There are two potential problems, both related to nonuniqueness. First, although the BAMM imputations are not unique, their nonuniqueness poses no problem because we can use any BAMM imputation vector. Second, the BIM stable matching corresponding to a given utility division matrix need not be unique. Here nonuniqueness requires us to interpret the claim that the BIM and BAMM assignments are "identical" to mean that the BAMM assignment belongs to the set of BIM stable matching -- that is, there exists a BIM stable matching identical to the BAMM assignment.

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Except when discussing polygyny or unequal numbers of men and women, economists have virtually ignored nonmarriage. But even with monogamy and equal numbers of men and women, some men and some women may remain unmarried.[24]

If every possible marriage produces a nonnegative surplus, at least as many marriages form with BAMM as with BIM. Indeed, if every possible marriage produces a nonnegative surplus, with BAMM there cannot be both unmarried men and unmarried women in equilibrium. I call this property "universal marriage." The universal marriage conclusion reflects both the nonnegative surplus assumption and the assumption that, if there is a mutually advantageous agreement to be made, individuals will make it. With BAMM and a nonnegative surplus in every possible marriage, if there were an unmarried man and an unmarried women, both would receive greater utility if they married

[24] Search frictions, which I have thus far ignored, provide an alternative explanation of nonmarriage.

each other; hence, the maximum number of (monogamous) marriages will form and this implies universal marriage.[25]

With BIM the number of marriages depends not only on whether marriages produce a nonnegative surplus but also on the division of that surplus, that is, on the outcomes prospective spouses foresee emerging from bargaining in marriage: unless both prospective spouses foresee that the utilities they would receive from bargaining are greater than the utilities they would receive as unmarried individuals, they will not marry each other.[26] With BIM, if every possible marriage produces at least as much utility for each spouse as nonmarriage,

$$\tilde{u}_{ij}^{h} \geq 0 \text{ for all i,j and } \tilde{u}_{ij}^{w} \geq 0 \text{ for all i,j}$$

then BIM implies universal marriage.

When we drop the assumption that every possible marriage produces a nonnegative surplus, more marriages may form with BIM than with BAMM. For example, suppose there are two men and two women, and that unmarried individuals receive 0 utility. Consider the utility surplus matrix:

$$S = \begin{bmatrix} 12 & 4 \\ 4 & -2 \end{bmatrix}$$

With BAMM there is one marriage: man 1 marries woman 1. With BIM, the number of marriages depends on the utilities that individuals foresee emerging from bargaining. Suppose the utility division matrix is

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[25] The universal marriage conclusion continues to hold when we redefine "surplus" in a way that does not presuppose transferable utility: if, for every possible couple, there exists an allocation within marriage that would make both prospective spouses better off than never marrying, then BAMM implies universal marriage.

[26] Indeed, even if every possible marriage produces a nonnegative surplus, BIM might nevertheless lead to a marriage market equilibrium in which no one marries. This would occur, for example, if husbands would have "too much" bargaining power in every possible marriage so that women refuse to marry.

$$D = \begin{bmatrix} (11, 1) & (2, 2) \\ (2, 2) & (-1, -1) \end{bmatrix}$$

Then with BIM, man 1 marries woman 2 and man 2 marries woman 1. Hence, with this division matrix, BIM leads to more marriages than BAMM.

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In search models, as in frictionless models in which all marriage market participants meet simultaneously, the distinction between BIM and BAMM is crucial.[27] The "one draw" search protocol of Konrad and Lommerud (2010) provides a transparent and tractable illustration because it assumes away most of the complications of search, allowing us to focus on the contracting opportunities available to prospective spouses when they meet in the marriage market. In the one-draw protocol, a man and a woman are drawn at random from the marriage market and offered a take-it-or-leave-it choice: marry each other or never marry. With BAMM, if every possible marriage produces a nonnegative surplus and if bargaining is assumed to lead to Pareto efficient agreements, then every randomly selected couple will agree on a utility division that both prefer to remaining unmarried. With BIM, the allocations that some randomly selected couples foresee emerging from bargaining may be worse for one of them than never marrying. In this case, even if every possible marriage produces a nonnegative surplus, some of the randomly selected couples may not marry. Hence, the BIM-BAMM distinction is crucial with search frictions.

6. Enforcement: Costless Divorce, Prenuptial Agreements, and Premarital Transfers

Browning, Chiappori, and Weiss (2014, pp. 311-314) argue that costless divorce allows prospective couples to enforce agreements made in the marriage market because divorce-threat bargaining will lead to BIM utilities that mimic BAMM imputations. They also argue that prenuptial

[27] Chade, Eeckhout, and Smith (2017) provide a recent survey of search and matching models.

agreements and premarital transfers enable prospective spouses to enforce agreements made in the marriage market by fine-tuning the BIM utilities to replicate the BAMM imputations. In this section I show that these claims are misleading.

Commitment is the essential feature that distinguishes marriage from cohabitation, and Becker (1991, p. 30/31) posits that marriage itself is defined by long-term commitment. Marriage functions as a commitment device precisely because divorce is costly. Costless divorce, because it negates commitment, is an oxymoron.[28]

Prenuptial agreements are unlikely to lead to a pattern of BIM utilities that mimic BAMM imputations and, hence, provide no support for the use of BAMM to analyze marriage market equilibrium in a BIM world. There are three reasons. The first is empirical. Few couples make prenuptial agreements. The conventional wisdom is that in first marriages about 5 percent of couples make prenuptial agreements, and that in second and higher order marriages this rises to about 20 percent.[29] The second is theoretical. Because each prospective spouse has multiple objectives, the provisions of prenuptial agreements are likely to differ from those individuals would agree to if they were solely concerned with influencing allocation within marriage. Anecdotal evidence suggests that prenuptial agreements are used primarily by wealthy prospective spouses seeking to protect their own interests in the event of divorce or to protect the inheritance interests of their children from previous relationships. Of course agreements designed primarily for these purposes affect allocation within

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[28] If divorced individuals are allowed to remarry, to replicate the BAMM imputations requires both costless divorce and "costless reentry" into the marriage market. Costless reentry presumably implies that prospective spouses do not distinguish between parents and nonparents and, among parents, between custodial and noncustodial parents.

[29] These figures, which are usually cited to Marston (1997), an article in the *Stanford Law Review*, are suspect. They are based on two articles published in *Money Magazine* neither of which cites a source; see Pollak (2016) for details.

marriage, but we would not expect prenuptial agreements acceptable to both prospective spouses, each with multiple objectives, to replicate the utilities corresponding to BAMM. The third is legal. American courts will not enforce provisions of prenuptial agreements that specify allocation within marriage.[30] American courts will oversee the dissolution of marriages, but they will not supervise ongoing marriages. The legal scholar Saul Levmore (1995) characterizes this rule as "love it or leave it."

At first glance, economic theory seems to suggest that individuals would be better off if, in the marriage market, they could make binding commitments not to divorce and binding agreements about allocation within marriage. Yet over the last two hundred years, most countries and all American states have made divorce quicker and easier. Furthermore, marrying couples, when offered a choice between the "standard marriage" contract and "covenant marriage," overwhelmingly choose the standard marriage contract which allows easier divorce.[31]

At second glance, it is not surprising that prospective spouses, recognizing that their feelings for each other may change and that future health, wealth, income, earnings, and wages are stochastic, might prefer greater flexibility to stronger commitment. Transaction cost considerations suggest that even if courts were willing to enforce contracts specifying allocation within marriage, such contracts would necessarily be incomplete -- bounded rationality implies that contracts could take account of only a small fraction of future contingencies and enforcement requires that both contingencies and

[30] Before the 1960s, the only legally enforceable provisions of prenuptial agreements were those specifying the disposition of assets following the death of a spouse. In the 1960s and 1970s, the enforceable provisions of prenuptial agreements expanded to include the division of income and assets following divorce. See Hasday (2014), Case (2011), and Pollak (2011).

[31] Covenant marriage requires premarital counseling and makes ending marriage more difficult by limiting how quickly and easily couples can divorce. Cherlin (2009, p. 4) writes: "Less than 2 percent opted for [covenant marriage] in Louisiana and in Arkansas which introduced [covenant marriage] in 2001."

performance are amenable to third-party verification. For these reasons, drawing on transaction cost analysis, Scott and Scott (1998) describe marriage as a "relational contract."

With premarital transfers the threshold difficulty is again empirical. Although we can build models in which prospective spouses use premarital transfers to influence allocation in marriage, there is no evidence that prospective spouses actually do so.[32] Nevertheless, because premarital transfers operate through both the outside option and bargaining power within marriage, they raise more interesting theoretical issues than prenuptial agreements. I sketch these in Pollak (2016), distinguishing between the case in which prospective spouses have sufficient initial assets to make the transfers needed to replicate the BAMM imputations and the case in which they do not. Furthermore, prospective spouses contemplating premarital transfers might be concerned about the possibility that the marriage will fail to take place or, if it does take place, that it will last only briefly. Those with such concerns might seek to protect themselves with contracts similar in content and complexity to prenuptial agreements. Finally, unlike transfers between spouses, premarital transfers can have tax consequences.

7. Conclusion

Before concluding, cohabitation deserves further comment. Virtually all marriage market models ignore cohabitation.[33] Yet as Stevenson and Wolfers point out, "cohabitation has emerged as an important institution, as a precursor to and sometimes as a substitute for marriage." In the

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[32] Dowry and bride price fit awkwardly into individualistic models of the marriage market because they are not usually transfers between prospective spouses. Anderson (2007, 150-151) characterizes these transfers as "payments between families..." and writes, "Such payments typically go hand-in-hand with marriages arranged by the parents of the respective spouses."

[33] Indeed, virtually all economic discussions of marriage ignore cohabitation. Exceptions include Brien, Lillard, and Stern (2006), Stevenson and Wolfers (2007), Lundberg and Pollak (2014, 2015) and Lundberg, Pollak, and Stearns (2016).

United States, most marriages are preceded by cohabitation and cohabitation is usually short-term, but long-term cohabitation is more common in Northern Europe than in the US.

If we view cohabitation as a precursor to marriage, then we cannot analyze it using a full information model in which all prospective spouses meet simultaneously in the marriage market. We need a search model. Alternatively, if we view cohabitation as a substitute for marriage, then we can retain the full information-simultaneous meeting framework. We must, however, drop the assumption that there are only two possible living arrangements, marriage and living alone, and recognize cohabitation as a third alternative. In Pollak (2016) I sketch a generalization of the dichotomous matching model to a trichotomous model. The existence of equilibrium in the trichotomous model follows from essentially the same argument used in the dichotomous framework. We can reinterpret the trichotomous framework as one in which couples choose between living alone and two forms of marriage. This is the situation in France and in Italy where marrying couples must choose between two marital property regimes: common (i.e., community) property and separate property.[34]

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The standard analysis of marriage market equilibrium assumes that prospective spouses make binding agreements in the marriage market and that these agreements determine allocation within marriage. With BAMM and transferable utility, the appropriate framework for analyzing marriage market equilibrium is the Koopmans-Beckmann-Shapley-Shubik assignment model. Pareto efficiency follows immediately because marriage market assignments and the utilities received by the spouses are determined by a cooperative game in which the solution concept is the core.

[34] For France, see Laferrère (2001); for Italy, Bayot and Voena (2015).

With bargaining in marriage, the marriage market is the first stage of a multi-stage game that must be solved by backwards induction. The second and subsequent stages determine allocation within each marriage. The first stage, the marriage market, determines who marries and, for those who marry, who marries whom. The original Gale-Shapley matching model does not provide a basis for an economic model of the marriage market because it treats marriage market participants' rankings of prospective spouses as primitives of the model. I modify the Gale-Shapley model by assuming that the rankings depend on the allocations that individuals foresee emerging from BIM. With this modification, BIM and the Gale-Shapley model provide a credible alternative to BAMM and the Koopmans-Beckmann-Shapley-Shubik assignment model as a framework for analyzing the marriage market. I show that BIM and BAMM can have different implications not only for allocation within marriage but also for who marries, who marries whom, the number of marriages, and the Pareto efficiency of marriage market equilibrium.

An obvious advantage of basing the analysis of marriage market equilibrium on BIM is that doing so recognizes bargaining in marriage and connects marriage market equilibrium with the theoretical and empirical literatures on family bargaining. The alternative, to ignore or deny that spouses bargain within marriage and base the analysis of marriage market equilibrium on BAMM, flies in the face of both casual empiricism and econometric evidence.

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