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ORIGINAL PAPER

United but (un)equal: human capital, probability of divorce, and the marriage contract

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Abstract This paper studies how the risk of divorce affects the human capital decisions of a young couple. We consider a setting where complete specialization is optimal with no divorce risk. Couples can self-insure through savings which offers some protection to the uneducated spouse, but at the expense of a distortion. Alternatively, for large divorce probabilities, symmetry in education, where both spouses receive an equal amount of education, may be optimal. This eliminates the risk associated with the lack of education, but reduces the efficiency of education choices. We show that the symmetric allocation will become more attractive as the probability of divorce increases, if risk aversion is high and/or labor supply elasticity is low. However, it is only a "second-best" solution as insurance protection is achieved at the expense of an efficiency loss. Finally, we study how the (economic) use of marriage is affected by the possibility of divorce.

Keywords Post-marital education · Marriage contract · Divorce

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1 Introduction

Among the most studied topics in family economics are the decisions of marriage and of divorce. Marriage has been justified by a number of reasons, such as the sharing of public goods, division of labor to exploit comparative advantages and increasing returns, extending credit and coordination of investment activities, risk pooling, and coordinating child care. Divorce is most often motivated by adverse "love shocks" or new information on the (mis)match of the marriage partner.[1]

In this paper, we do not examine *why* people get married or divorce; rather, we take marriage as given and view divorce as a random event with a given *probability*. We are interested in how the risk of dissolution affects the human capital decisions of a young married couple. We show that the risk of divorce along with imperfect alimony rights may have a "distortive" impact on the allocation of human and physical capital at the start of the marriage.

There is ample empirical evidence showing that the possibility of divorce has a significant impact on a couple's labor force participation and human capital decisions. The classical reference on divorce is Becker et al. (1977), who try to explain, both theoretically and empirically, the observed acceleration of separation and divorce. In particular, they argue that couples are reluctant to invest in skills "specific" to their marriage if they anticipate dissolution. Investments in marriage-specific capital are only valuable for both spouses when they expect the marriage to stay intact so that they can both reap the rewards. The risk of separation reduces the incentives for such investments. Fernández and Wong (2011) show that an increased divorce risk can, to a large extent, explain the reduction in the education gender gap in the US. Other empirical studies have examined financial investments and savings. Gonzalez and Ozcan (2008) show that a higher risk of divorce increases the propensity of a married couple to save, which reflects an increase in precautionary savings. Stevenson (2007a, 2007b) studies a related issue. She shows that a switch to unilateral divorce law (which weakens the marriage contract) reduces a couples' willingness to make investments early in their marriage. After the policy change, couples were less likely to support each other through school and more likely to have two fulltime workers, implying a greater female labor force participation. The positive effect of divorce risk on labor supply is also found by Johnson and Skinner (1986). More recently, Cigno (2011) has shown from a theoretic point of view that the probability of marriage or divorce depends on marriage legislation, matrimonial property regime, and divorce court sentencing practice.

The relationship between education decisions and marriage has been studied most often under the assumption that education decisions are made *before* marriage. Education is then viewed as affecting the competitive strength of potential spouses and the spousal roles within the marriage.[2] Our paper studies how married couples choose

[1] See Becker (1991), Ermisch (2003), and Browning et al. (2012) for an overview of the forces that draw a couple together and drives them apart.

[2] This is well-summarized in Browning et al. (2012).

the level of (tertiary) education of each spouse. Spouses behave cooperatively,[3] and they both maximize the sum of their lifetime expected utilities.[4] They live for two periods. In the first period, they are married. At the beginning of this period, education choices are made and then both spouses may work earning a wage that results from their education choice. At the end of the first period, they face a given probability of divorce. In case of divorce, they have to rely on their own earnings and on a share of the couple's accumulated wealth. That share depends on the family law currently in place. As is the case in many countries, we assume that assets accumulated during marriage are equally shared between the two (ex-)spouses in case of divorce (see, e.g., §81 EheG for Germany).

Spouses' education choices represent a challenging issue, even when the possibility of divorce is ignored. It has been studied by a number of authors, in particular by Cremer et al. (2011). Their main question is whether there will be specialization (i.e., one of the spouses uses up all the education resources) or symmetry (i.e., both spouses receive an equal amount of education). They show, roughly speaking, that even when spouses are ex ante identical (i.e., they have the same learning ability) specialization is efficient, unless the education technology involves a sufficient degree of decreasing returns.

Our approach is inspired by this model. In particular, both spouses have the same learning skills, and the educational technology involves constant returns to scale. We concentrate on human capital investments made at the start of the marital life. The total amount of human capital investments (i.e., the total education budget) is exogenously given. Within this setting, we can get clear results as to the effects of a potential divorce because complete specialization is optimal when there is no possibility of divorce. This provides us with a simple benchmark.

In the case of divorce, symmetry in education then acts like an insurance device, particularly when the institutions do not compensate for differences in earnings. But, at the same time, symmetry in education is less efficient, namely it leads to less aggregate surplus (i.e., earnings net of disutility of labor) than the extreme specialization. We show that the symmetric allocation will become more attractive as the probability of divorce increases, if risk aversion is high and/or labor supply elasticity is low. However, it is only a "second-best" solution as the insurance protection is achieved at the expense of an efficiency loss. Furthermore, symmetry may only dominate specialization when the divorce probability is sufficiently large.

These results crucially depend on the assumption that the couple is able to "self-insure" against divorce through savings. In our setting, savings are useful only in

[3]In other words, we have a *cooperative* bargaining solution in which spouses receive equal weight. An alternative would be to study a non-cooperative Nash equilibrium with couples playing a one shot game; see for instance Konrad and Lommerud (1995). Though interesting, this approach cannot be readily combined with ours in a single paper. To achieve a comprehensive understanding of couples' behavior, the two approaches provide insights from different but complementary perspectives.

[4]Besides Becker (1991), see his Treatise on the Family, models of the household do not distinguish between decision-making agents. The alternatives to this unitary model are models assuming that multi-person households include individual decision-makers. Such models have been described as "individual models" (Apps and Rees 2009) or "collective models" (Bourguignon et al. 1995; Browning et al. 2012).

that they may provide (partial) insurance to the less productive spouse. However, this is costly because saving per se is inefficient in our model, and the optimal solution strikes a balance between this distortion and the cost of inefficient education investment.

The interplay of these different distortions implies that the relationship between divorce probability and human capital decision is more complex than one would have expected, even in a simple setting such as ours. For instance, the relationship between a couple's welfare and the education budget devoted to a given spouse is neither monotonic, concave nor convex over the full range. And while an increase in the divorce probability always makes the symmetric solution more attractive (i.e., compared to complete specialization), it may or may not be the optimal outcome, even for divorce probabilities close to one. In some cases (e.g., those with quadratic disutility of labor), the asymmetric solution remains optimal no matter what, even when risk aversion is very high. In other cases, an interior solution may be obtained, and both spouses are educated, albeit to a different degree, in spite of the fact that their learning ability is the same.

Additionally, we study how the (economic) use of marriage is affected by the possibility of divorce. Whenever the educational budget is shared asymmetrically, it is possible that the individual who is less educated finds marriage less attractive than staying single and using his/her own educational budget. The relevant variables are again risk aversion and labor supply elasticity. With a quadratic labor disutility, the surplus generated under specialization is so large that the worse-off spouse enjoys a higher utility with just half of the accumulated assets and no labor income compared to an individual who stays single. If individuals have the possibility of writing a marriage contract which fully compensates the less educated spouse in case of divorce, then the use of a marriage is always positive since the couple is able to generate a higher surplus as compared to a single household.

The closest papers to ours are King (1982), Lommerud (1989), and Cigno (2012). King (1982) studies postmarital education decisions and shows how these are affected by the risk of divorce. He argues that the property rights to human capital are not clearly defined by the courts, and shows that the couple may end up with inefficient low human capital investments because of the divorce risk. His setting is simpler than ours, and labor force participation decisions are ignored. Lommerud (1989) studies how the probability of divorce influences a couple's allocation of time between market and domestic work.[5] In his setting, spouses receive no compensation in case of divorce, and there is no accumulation of assets (i.e., no savings). He shows that specialization becomes less likely for a positive divorce risk.[6]

[5]There is no human capital investment *per se* but the learning-by-doing associated with market work plays a similar role.

[6]Konrad and Lommerud (2000) also study the couple's education, but they do not consider the effect of divorce. Their main finding is that non-cooperation leads to overinvestments in education. Borenstein and Courant (1989) is also somewhat related to our paper. They analyze human capital investments of spouses who can finance these investments either by borrowing on the financial market or from their partner's wealth. They argue that spouses are only willing to extend "credit" to their partners if they can expect to remain married later in life and thereby to profit from their investments. Consequently, investments in human capital are inefficiently low when there is a divorce risk and no marriage contract.

Cigno (2012) also studies divorce but from a different perspective. His approach and ours are both differing and perfectly complementary, as each concentrates on distinct aspects of marriage and divorce. We focus on the human capital dimension with the assumption that there is no value to housework and that divorce is random. Divorce risk makes spouses reluctant to choose the efficient pure specialization outcome. In Cigno (2012), divorce is endogenous and non-market activities are highly valuable. If divorce is not allowed, the non-educated spouse can be left without resources, even though his/her activities are valuable. Divorce allows the spouse specializing in non-market activities to credibly threaten the spouse specializing in market activities.

Our paper is organized as follows. Section 2 sets up the model. Section 3 defines the couple's optimization problem, analyze its first- and second-order conditions, and provides a numerical example. Sections 4 and 5 analyzes the optimal marriage contract and the use of marriage. Section 6 concludes.

2 The model

Consider a male (subscript 'm') and a female (subscript 'f') who live for two periods $t = 1, 2$.[7] In the first period, the two are married; while in the second period, they face a probability π of getting divorced. Divorce occurs for reasons exogenous to the analysis. For the time being, we also assume that the reasons to enter into the marriage are exogenous. In Section 5, we relax this assumption and analyze the individual's economic use of the marriage. In both periods, the two spouses cooperatively decide about labor supply ℓ and consumption c. While married, the two share a common budget, whereas when divorced each individual has to finance his/her own living expenses. In the first period, the couple can save part of their income for the next period. Both the interest rate and time preferences are equal to zero. We consider an institutional framework such that in the case of divorce, savings s—or, more generally, wealth accumulated during marriage—are equally divided between the male and the female.[8] Per period utility of each individual depends on consumption of a numeraire commodity c and on labor disutility $v(\ell)$. Specifically, utility is given by $u(c - v(\ell))$ with $u' > 0$, $v' > 0$, and $u'' < 0$, $v'' > 0$. This quasi-linear specification is adopted for the ease of exposition.

Productivities or wages are endogenous. That is, at the beginning of the first period, the couple cooperatively decides about the human capital investments they each make. We are only concerned by human capital investments that are made at the start of marital life. One can think of such investments, for example, the tertiary education choice, as resources invested for job-specific skills like learning foreign languages, or going abroad in order to get a better paying job. At the time of their marriage, each spouse already has some human capital or educational level $\bar{w}$ which

[7] Throughout this paper, we assume that the couple consists of one women and one man. We make this assumption only for expositional convenience.

[8] This presumes that a judge is able to observe the couple's accumulated wealth.

without loss of generality is normalized to zero. A couple's feasible human capital choices are described by the following technology [9]

$$\Gamma = \{(w_m, w_f) | w_m + w_f = 2\}. \tag{1}$$

This amounts to assuming that wages are determined by educational expenditures through a linear technology and that the total budget for human capital investments is fixed.[10] The linear technology implies that productivities can be transferred between spouses on a one-to-one basis, implying that both spouses have the same learning skills and that there are no decreasing returns to education. This technology incorporates two extreme scenarios as follows: (i) complete equalization of wages between both spouses, $w_m = w_f = 1$ and (ii) maximum wage inequality, $w_i = 2$ and $w_{-i} = 0$ for $i = m, f$. In the latter case, all educational resources are concentrated on a single spouse.

The decisions of the couple are made cooperatively. More precisely, the couple maximizes a common welfare function which is given by the sum of first- and second-period (expected) utility of both the male and female; see also Lommerud (1989). The two spouses' utilities are weighted equally and the couple's welfare function is thus given as follows:

$$\begin{aligned} \mathcal{W} = {} & u\left(c_m^{1c} - v\left(\ell_m^{1c}\right)\right) + u\left(c_f^{1c} - v\left(\ell_f^{1c}\right)\right) + \pi\left[u\left(c_m^{2s} - v\left(\ell_m^{2s}\right)\right) + u\left(c_f^{2s} - v\left(\ell_f^{2s}\right)\right)\right] \\ & + (1-\pi)\left[u\left(c_m^{2c} - v\left(\ell_m^{2c}\right)\right) + u\left(c_f^{2c} - v\left(\ell_f^{2c}\right)\right)\right], \end{aligned} \tag{2}$$

where the first superscript denotes the period and the second superscript indicates the marital status of the individuals in the second period ('c' for couple and 's' for single). Recall that a divorce occurs with probability π in which case the (ex-)spouses are single in the second period. The budget constraints of a couple who do not divorce (and thus pools resources in both periods) are given as follows:

$$c_m^{1c} + c_f^{1c} = w_m \ell_m^{1c} + w_f \ell_f^{1c} - s, \tag{3}$$

$$c_m^{2c} + c_f^{2c} = w_m \ell_m^{2c} + w_f \ell_f^{2c} + s. \tag{4}$$

In case of divorce, the two ex-spouses face separate budget constraints in the second period. They consume their own labor income plus half of the couple's first period saving. Formally, we have

$$c_m^{2s} = w_m \ell_m^{2s} + \frac{s}{2}, \tag{5}$$

$$c_f^{2s} = w_f \ell_f^{2s} + \frac{s}{2}. \tag{6}$$

[9] See Cremer et al. (2011).

[10] The assumption that the education budget is fixed is made for simplicity but has no impact on the results. This follows directly from Cremer et al. (2011) who show that the specialization result continues to apply with an endogenous budget as long as the education technology does not exhibit a significant degree of decreasing returns.

3 The couple's optimization problem

3.1 Statement and first-order conditions

The couple maximizes (2) subject to the budget constraints, Eqs. (3)–(6) and the education technology (1). For expositional convenience, we decompose this problem into two stages. First, the couple chooses the education levels w_m and w_f. Second, the couple chooses savings as well as labor supplies and consumption levels of each of the spouses in both periods and states of nature (divorce or not). This specific timing is of no relevance to our results.[11]

Let us first consider the second stage optimization problem, that is, the determination of savings, consumption, and labor supply for a given educational decision. Solving Eqs. (3) and (4) for c_m^{1c} and c_m^{2c} and substituting into the objective function (2) yields the following optimization problem ($t = 1, 2$, $j = c, s$, and $i = m, f$)

$$\begin{aligned}\max_{s, c_i^{tj}, \ell_i^{tj}} \quad \mathcal{W} = {} & u\left(w_m \ell_m^{1c} + w_f \ell_f^{1c} - s - c_f^{1c} - v\left(\ell_m^{1c}\right)\right) + u\left(c_f^{1c} - v\left(\ell_f^{1c}\right)\right) \\ & + \pi\left[u\left(w_m \ell_m^{2s} + \frac{s}{2} - v\left(\ell_m^{2s}\right)\right) + u\left(w_f \ell_f^{2s} + \frac{s}{2} - v\left(\ell_f^{2s}\right)\right)\right] \\ & + (1-\pi)\left[u\left(w_m \ell_m^{2c} + w_f \ell_f^{2c} + s - c_f^{2c} - v\left(\ell_m^{2c}\right)\right) + u\left(c_f^{2c} - v\left(\ell_f^{2c}\right)\right)\right]. \end{aligned} \quad (7)$$

Differentiating, rearranging, and defining consumption net of labor disutility $x_i^{tj} \equiv c_i^{tj} - v(\ell_i^{tj})$ yields the following first-order conditions

$$u'\left(x_m^{tc}\right) = u'\left(x_f^{tc}\right) \quad , \qquad \forall\, t, \quad (8)$$

$$v'\left(\ell_i^{tj}\right) = w_i \qquad \forall\, t, j, i, \quad (9)$$

$$u'\left(x_i^{1c}\right) = \frac{\pi}{2}\left[u'\left(x_m^{2s}\right) + u'\left(x_f^{2s}\right)\right] + (1-\pi)u'\left(x_i^{2c}\right) \qquad \forall\, i. \quad (10)$$

Consumption levels of married spouses are set so as to equalize their marginal utilities. Labor supply is independent of time, marital status, and gender, and is an increasing function of wage. It is chosen in order to equalize marginal labor disutility with wages.[12] The optimal level of savings equalizes an individual's marginal utility in the first period and expected marginal utility in the second period. Note that savings only act as an insurance device in the case of divorce. They provide some measure of protection for an individual who ends up single and has low productivity, and thus low labor income. Except for the risk of divorce, the two periods are perfectly symmetrical and there is otherwise no need to accumulate wealth in this

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[11] Except for the assumption that human capital investments are made (once and for all) at the beginning of married life and thus before it is known if the couple will effectively divorce or not. Formally, this implies that the levels of w_m and w_f are unique (i.e., there is no period/state of nature superscript).

[12] The simplification arises because preferences are quasi-linear. They make our argument clearer but are *not* essential for our results. In particular, our results do *not* depend on the property that labor supply increases with wage; see Appendix.

setting. Specifically, when there is no risk of divorce ($\pi = 0$), consumption possibilities are the same in both periods, and no wealth is (dis)accumulated as the interest rate and time preferences are zero.[13]

We now consider the first stage, the educational decision. More precisely, we study whether one of the extreme solutions (equalization or maximum differentiation of wages) emerges. With our quasi-linear specification, we can reduce this problem to a single dimension, namely the choice of one of the spouse's productivity level. To do so, we substitute the optimal consumption, labor supply, and savings decisions as defined by Eqs. (8) to (10) back into the welfare function (2). Additionally, we take the educational technology $w_i = 2 - w_{-i}$ as defined by Eq. (1) into account, and generate the optimal value function $\Omega(w_i) = \mathcal{W}(\mathbf{c}^*, \ell^*, s^*, w_i)$. This relates individual i's wage rate w_i with maximum welfare given optimally chosen consumption, $\mathbf{c}^*$, labor supply, ℓ^*, and savings, s^*.[14] Optimal wages w_i solve

$$w_i^* \in \arg\max_{w_i} \quad \Omega(w_i), \tag{11}$$

where $\Omega(w_i)$ is given as follows:

$$\begin{aligned}\Omega(w_i) = {} & 2u\left(\frac{(2-w_i)\ell_{-i}^* + w_i\ell_i^* - v(\ell_{-i}^*) - v(\ell_i^*) - s^*}{2}\right)\\ & +\pi\left\{u\left((2-w_i)\ell_{-i}^* - v(\ell_{-i}^*) + \frac{s^*}{2}\right) + u\left(w_i\ell_i^* - v(\ell_i^*) + \frac{s^*}{2}\right)\right\}\\ & +(1-\pi)2u\left(\frac{(2-w_i)\ell_{-i}^* + w_i\ell_i^* - v(\ell_{-i}^*) - v(\ell_i^*) + s^*}{2}\right).\end{aligned} \tag{12}$$

In the remainder of this section, we study the properties of Ω in order to determine the optimal human capital investment decision and to study the impact of parameters such as the divorce probability and risk aversion. Despite having reduced the problem to a single dimension, this is in fact a non-trivial exercise since the global behavior of Ω is more complex than one could have anticipated. We derive first- and second-order conditions and then prove additional properties (while discussing the underlying intuition). We will also make use of numerical examples in order to show that various configurations can arise. A proposition summarizing the findings will be presented at the end of the section.

Using the envelope theorem, the first-order condition (FOC) with respect to w_i is given as follows:

$$\begin{aligned}\frac{\partial\Omega(w_i)}{\partial w_i} = {} & 2u'(x^{1c})\left(\frac{-\ell_{-i}^* + \ell_i^*}{2}\right) + \pi\left(u'(x_i^{2s})\ell_i^* - u'(x_{-i}^{2s})\ell_{-i}^*\right)\\ & +(1-\pi)2u'(x^{2c})\left(\frac{-\ell_{-i}^* + \ell_i^*}{2}\right).\end{aligned} \tag{13}$$

[13] In reality, couples may save for various nondivorce-related reasons, including retirement preparation. To account for this, we could introduce a third period during which people retire. This would complicate the analysis without affecting the results.

[14] $\mathbf{c}^*$ and ℓ^* are vectors and are short for optimal consumption/labor supply of male and female in both periods and states.

Evaluating Eq. (13) at equal wages $w_i = w_{-i} = 1$ yields

$$\frac{\partial \Omega(1)}{\partial w_i} = 0 \tag{14}$$

as $\ell_m^*|_{w_m=1} = \ell_f^*|_{w_f=1} = \ell^*$ and $s^*|_{w_m=w_f=1} = 0$ implying $x_i^{tj} = x^* \ \forall\ t, i, j$. In other words, the FOC is always satisfied for equal wages, which might be taken to suggest that it is always optimal for the couple to equalize wage rates. However, we already know from Cremer et al. (2011) that when $\pi = 0$, wage equalization is *never* optimal. Consequently, we certainly cannot restrict our attention to the FOC at equal wages. We must also examine the second-order condition (SOC) and the global behavior of the objective function. A first interesting fact is revealed by evaluating the FOC (13) at unequal wages $w_i = 2$ and $w_{-i} = 0$ which yields

$$\frac{\partial \Omega(2)}{\partial w_i} = 2u'(x^{1c})\frac{\ell_i^*}{2} + \pi u'\left(x_i^{2s}\right)\ell_i^* + (1-\pi)2u'(x^{2c})\frac{\ell_i^*}{2} > 0. \tag{15}$$

Alternatively, considering the symmetric solution $w_i = 0$ and $w_{-i} = 2$ yields[15]

$$\frac{\partial \Omega(0)}{\partial w_i} = -2u'(x^{1c})\frac{\ell_{-i}^*}{2} - \pi u'\left(x_{-i}^{2s}\right)\ell_{-i}^* - (1-\pi)2u'(x^{2c})\frac{\ell_{-i}^*}{2} < 0. \tag{16}$$

In other words, moving slightly away from the extreme solution with maximum wage differentiation always reduces welfare. In order to get further insights, we now turn to the second-order condition (SOC).

3.2 Second-order condition

The SOC is given as follows:

$$\begin{aligned}\frac{\partial^2 \Omega(w_i)}{\partial w_i^2} &= 2\left(u''(x^{1c}) + (1-\pi)u''(x^{2c})\right)\left(\frac{-\ell_{-i}^* + \ell_i^*}{2}\right)^2 \\ &\quad + \pi\left[u'\left(x_i^{2s}\right)\frac{\partial \ell_i^*}{\partial w_i} - u'\left(x_{-i}^{2s}\right)\frac{\partial \ell_{-i}^*}{\partial w_i}\right] + \pi\left[u''\left(x_i^{2s}\right)\left(\ell_i^*\right)^2 + u''\left(x_{-i}^{2s}\right)\left(\ell_{-i}^*\right)^2\right] \\ &\quad + \left(u'(x^{1c}) + (1-\pi)u'(x^{2c})\right)\left(\frac{\partial \ell_i^*}{\partial w_i} - \frac{\partial \ell_{-i}^*}{\partial w_i}\right).\end{aligned} \tag{17}$$

Evaluating this expression at equal wage rates yields

$$\frac{\partial^2 \Omega(1)}{\partial w_i^2} = 2\pi u''(x^*)(\ell^*)^2 + 4u''(x^*)\frac{\partial \ell^*}{\partial w_i} = 2u'(x^*)\ell^*\left(2\varepsilon_{\ell,w} - \sigma\pi\ell^*\right) \gtrless 0,$$

where $\sigma = -u''/u'$ denotes absolute risk aversion and $\varepsilon_{\ell,w} = (\partial \ell^*/\partial w)(w/\ell^*)$ the labor supply elasticity. The couple's welfare is thus a convex function of w_i at equal wages whenever

$$\varepsilon_{\ell,w} > \frac{\sigma\pi\ell^*}{2}. \tag{18}$$

[15] Where ℓ_i^* for $w_i = 2$ and $w_{-i} = 0$ is equal to ℓ_{-i}^* for $w_i = 0$ and $w_{-i} = 2$.

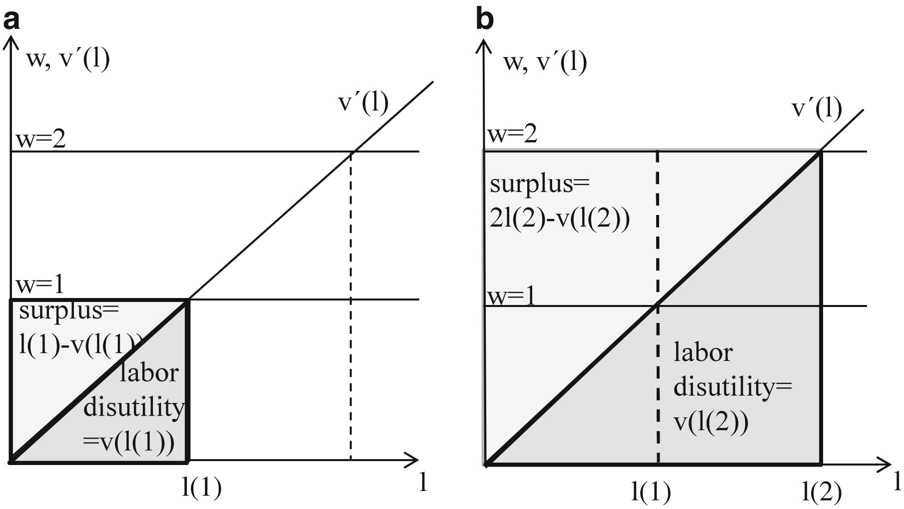

Fig. 1 Optimal labor supply and surplus for **a** equal and **b** unequal wages. The *dotted line* in *panel* **b** represents the effect of a switch from equal wages to maximal wage differentiation when labor supply of the educated spouse is held constant. We achieve the same income but labor disutility is smaller

When this condition holds, we can rule out wage equalization, as it is then a local minimum. This is the case when the divorce probability or the degree of risk aversion are sufficiently small (i.e., particularly when the couple is risk neutral), or when labor supply elasticity is sufficiently large.When the possibility of divorce is absent ($\pi = 0$), we return to the setting of Cremer et al. (2011), who show that welfare (which reduces to surplus with our quasi-linear specification) is highest under maximum wage differentiation. Under risk neutrality, it is clear that this result remains valid when divorce is introduced ($\pi > 0$). While divorce affects individual utility of the (ex)spouses, it has no impact on total surplus which is the main consideration in this case.

3.3 The no divorce case: intuition

Before proceeding further, it is interesting to note the intuition for the wage differentiation result when there is no divorce. When the couple remains married in period 2, the two period setting is of no relevance, and the couple's objective is equivalent to the maximization of total surplus. When the couple equally shares the education budget, both spouses work, incurring labor disutility $v(\ell(1))$, and their labor income amounts to $1\ell(1) + 1\ell(1) = 2\ell(1)$; see Fig. 1a. Total surplus (or net income) is equal to twice the area of the upper triangle. On the other hand, when the entire education budget is invested in a single spouse, total labor income (earned solely by the spouse with a wage of 2) amounts to $2\ell(2)$. In the process, one spouse incurs no labor disutility while the other's disutility is determined by a labor of $\ell(2)$; see Fig. 1b. Total surplus is now equal to the area of the upper triangle which exceeds the level achieved in (a). It is tempting to consider that this result is based on the property that labor supply increases with wage so that $\ell(2) > \ell(1)$; however, this is *not* necessary. In fact, labor supply need not be adjusted in an optimal way. For example, when we switch from equal wages to maximal wage differentiation, we could achieve a welfare improvement simply by maintaining labor supply of the productive spouse at $\ell(1)$ who would then earn $2\ell(1)$. In other words, total income is unchanged, but labor disutility is cut in half; see the dotted line in Fig. 1b. This argument is presented more formally in Appendix, where we show that the result continues to hold for general utility function (irrespective of the properties of labor supply).

This argument does not change when $\pi > 0$ but individuals are risk-neutral with $u'' = 0$ and thus $\sigma = 0$. However, when individuals are risk averse, the possibility of divorce may affect the couple's human capital investment decisions. In particular, the equal wage solution now becomes more attractive. In order to demonstrate this, we study how $\Delta \equiv \Omega(2) - \Omega(1)$ changes as π increases. We have

$$\Omega(1) = 4u[\ell(1) - v(\ell(1))], \tag{19}$$

$$\Omega(2) = 2u\left(\frac{2\ell(2) - v(\ell(2)) - s^*}{2}\right) + \pi\left\{u\left(\frac{s^*}{2}\right) + u\left(2\ell(2) - v(\ell(2)) + \frac{s^*}{2}\right)\right\} + (1-\pi)2u\left(\frac{2\ell(2) - v(\ell(2)) + s^*}{2}\right). \tag{20}$$

Differentiating with respect to π and making use of Jensen's inequality yields

$$\frac{\partial \Delta}{\partial \pi} = u\left(\frac{s^*}{2}\right) + u\left(2\ell(2) - v(\ell(2)) + \frac{s^*}{2}\right) - 2u\left(\frac{2\ell(2) - v(\ell(2)) + s^*}{2}\right) \leq 0, \tag{21}$$

where the inequality is strict when $u'' < 0$.

While the couple's utility under wage equalization does not depend on π, welfare under maximum wage differentiation decreases as the probability of divorce increases. Intuitively, when divorce is possible, under wage differentiation, the spouses' second period consumption levels are random which is not desirable when individuals are risk averse. More specifically, the total surplus of the couple in the second period is the same in both states of nature, but is split unequally in the case of divorce. This decreases expected utility. Observe that this welfare loss will be greater the higher the degree of concavity of u (as measured for instance by the degree of risk aversion σ). Once again, this result appears to rely on our specification of preferences because we use the property that the couple's total surplus is the same in both states of nature. However, this is not effectively necessary for our result to obtain. A simple inspection of Eq. (20) suggests that Δ will be decreasing in w as long as the couple's utility in case of divorce is smaller than that when the couple persists. But this is necessarily true because the married couple can always choose the same consumption and labor profile that it would under divorce; see Appendix for a formal proof.

To summarize, we have shown that wage equalization becomes more attractive as the divorce probability increases (provided that $\sigma > 0$). In addition, the second-order condition (18) shows that as π increases (and provided that σ is sufficiently large), wage equalization will eventually become a local maximum. Putting these two properties together, it may be possible to conjecture that when π and σ are sufficiently large, wage equalization would necessarily become the optimal policy. However, this conjecture is misleading as the following example with a quadratic disutility of labor shows.

3.4 Example: quadratic labor disutility

Assume for now that labor disutility is given by $v(\ell) = \ell^2/2$. Then, by Eq. (9) optimal labor supply is $\ell_i^{tj} = w_i \; \forall\, t, j, i$. From Eq. (8), we know that consumption levels while married are chosen so as to equalize marginal utilities of the male and female, i.e., $x_m^{1c} = x_f^{1c}$. Substituting the education technology $w_{-i} = 2 - w_i$ into the objective function yields

$$\begin{aligned}\mathcal{W}(w_i, s) &= 2u\left(\frac{\left(w_i^2 + (2 - w_i)^2\right)/2 - s}{2}\right) + \pi\left[u\left(\frac{w_i^2 + s}{2}\right) + u\left(\frac{(2 - w_i)^2 + s}{2}\right)\right]\\ &\quad + (1 - \pi)2u\left(\frac{\left(w_i^2 + (2 - w_i)^2\right)/2 + s}{2}\right).\end{aligned}$$

Welfare with equal wages, $\mathcal{W}(w_i = w_{-i} = 1)$, and unequal wages, $\mathcal{W}(w_i = 2, w_{-i} = 0)$, is given by the following two expressions

$$\begin{aligned}\mathcal{W}(w_i = 1, s) &= 2u\left(\frac{1 - s}{2}\right) + \pi\left[u\left(\frac{1 + s}{2}\right) + u\left(\frac{1 + s}{2}\right)\right] + (1 - \pi)2u\left(\frac{1 + s}{2}\right),\\ \mathcal{W}(w_i = 2, s) &= 2u\left(\frac{2 - s}{2}\right) + \pi\left[u\left(\frac{4 + s}{2}\right) + u\left(\frac{0 + s}{2}\right)\right] + (1 - \pi)2u\left(\frac{2 + s}{2}\right).\end{aligned}$$

The optimal savings decision for equal wages is given by $s = 0$ implying $x_i^{tj} = 1/2 \; \forall\, t, i, j$. Consequently, each spouse has a utility level of $u(1/2)$ in both periods and states of nature. Now consider unequal wages and set savings equal to one, i.e., $s = 1$; while this is not, in general, the optimal savings decision, it represents a feasible level. Then, utility for each spouse in the first period and for the single household with low productivity remains at $u(1/2)$. However, utility when married in the second period and utility for the high-productivity single household increases (exceeds $u(1/2)$). Consequently, extreme wage differentiation *always* dominates wage equalization, even when π is equal or close to 1 and when the degree of risk aversion tends to infinity. In other words, it is never optimal for the couple to equalize wages with quadratic labor disutility. Intuitively, this result arises because with quadratic labor disutility the gain in surplus achieved by wage differentiation (as compared to equalization) is so large that the couple can generate a sufficient amount of saving in order to ensure that each spouse is better off in any contingency.

In short, we have established that maximum wage differentiation is optimal when the probability of divorce is zero, and that it *may* remain optimal even when divorce probability and risk aversion are high. On the other hand, we have shown that wage

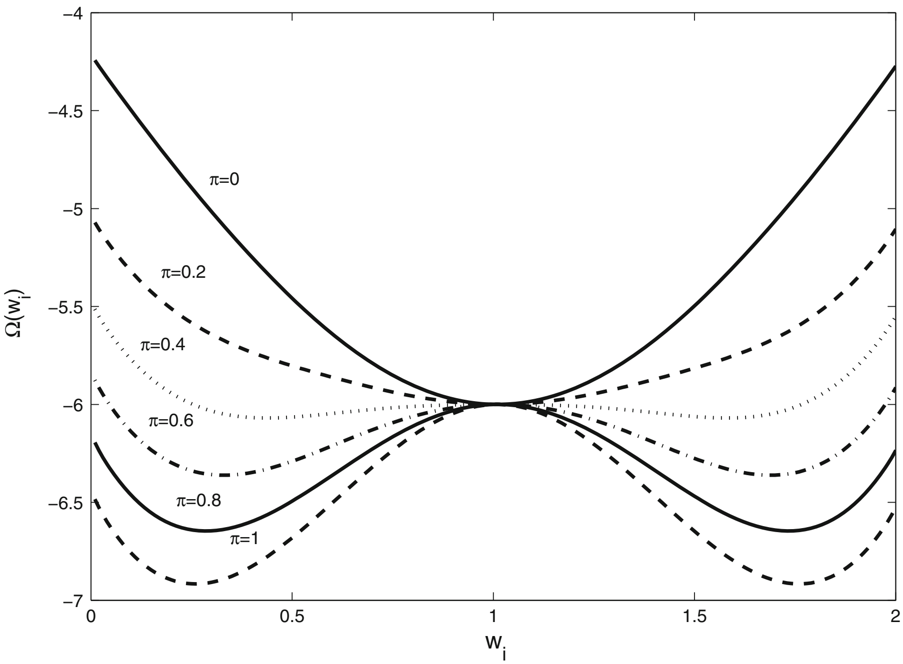

Fig. 2 $\Omega(w_i)$ for $\sigma = 2$ and $\varepsilon = 0.5$ and for various levels of the divorce probability. Wage differentiation always dominates when $\pi = 0$, but it becomes less attractive as π increases

equalization becomes more attractive as π increases. This naturally leads to the following two questions. First, are there cases in which wage equalization effectively becomes the optimal policy? Second, can we ever have an "interior solution," that is, a situation where neither of the extreme policies is optimal?

Since the answer to both of these questions is affirmative, it is easiest to show this by a series of numerical illustrations.

3.5 Numerical illustration

Our simulations are based on the following functional form for individual utility

$$u(c,\ell) = \begin{cases} \frac{\left(c - \frac{\ell^{1+1/\varepsilon}}{1+1/\varepsilon}\right)^{1-\sigma}}{1-\sigma} & \text{for } \sigma \neq 1, \\ \ln\left(c - \frac{\ell^{1+1/\varepsilon}}{1+1/\varepsilon}\right) & \text{for } \sigma = 1. \end{cases} \tag{22}$$

Notations are chosen so that σ and ε effectively represent relative risk aversion and labor supply elasticity with this specific functional form.

Figure 2 depicts $\Omega(w)$ for $\sigma = 2$ and $\varepsilon = 0.5$ and for various levels of the divorce probability, ranging from 0 to 1. Not surprisingly, all the curves are symmetric around $w = 1$ and welfare always decreases in the neighborhood of $w = 0$ or $w = 2$. When the divorce probability is zero, Ω is a "nice" u-shaped function; maximum wage differentiation is optimal and equal wages yield a local (and global) minimum.

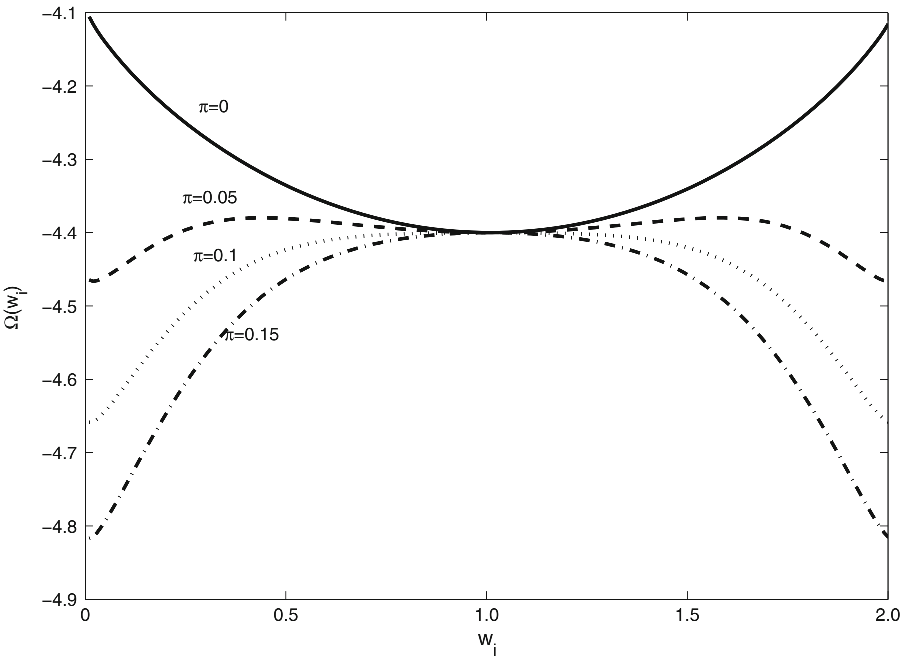

Fig. 3 $\Omega(w_i)$ for $\sigma = 2$ and $\varepsilon = 0.1$ and for various levels of the divorce probability. This combination of parameter values illustrates the possibility of an interior solution

As π increases, (extreme) wage differentiation becomes less attractive. First, wage equalization becomes a local (but not global) optimum (see $\pi = 0.4$) and eventually the global optimum ($\pi = 0.60$). For the parameter values considered in this example, there is never an intermediate solution with partial wage differentiation.

Figure 3 shows that such an intermediate wage differentiation is possible for $\sigma = 2$, $\varepsilon = 0.1$, and $\pi = 0.05$. However, the range of parameter values for which such a solution occurs is small. The bang-bang type of solution described in the previous figure is a more typical outcome. However, since our examples have no pretense to be empirically realistic, the meaning of the word “typical” has to be qualified accordingly.

Figures 4 and 5 illustrate our results concerning the impact of labor supply elasticity and (relative) risk aversion, which are established in Section 3.3 and summarized in Proposition 1, (iv). Both figures assume a positive probability of divorce (namely $\pi = 0.4$).[16] The figures show that for larger elasticities, or for a lower degree of risk aversion, the unequal wage solution is welfare maximizing while for smaller values of labor supply elasticities ($\varepsilon = 0.2$ and $\varepsilon = 0.4$), and higher values of (relative) risk

[16]Recall that when $\pi = 0$, unequal wages are *always* optimal (irrespective of labor supply elasticity and risk-aversion).

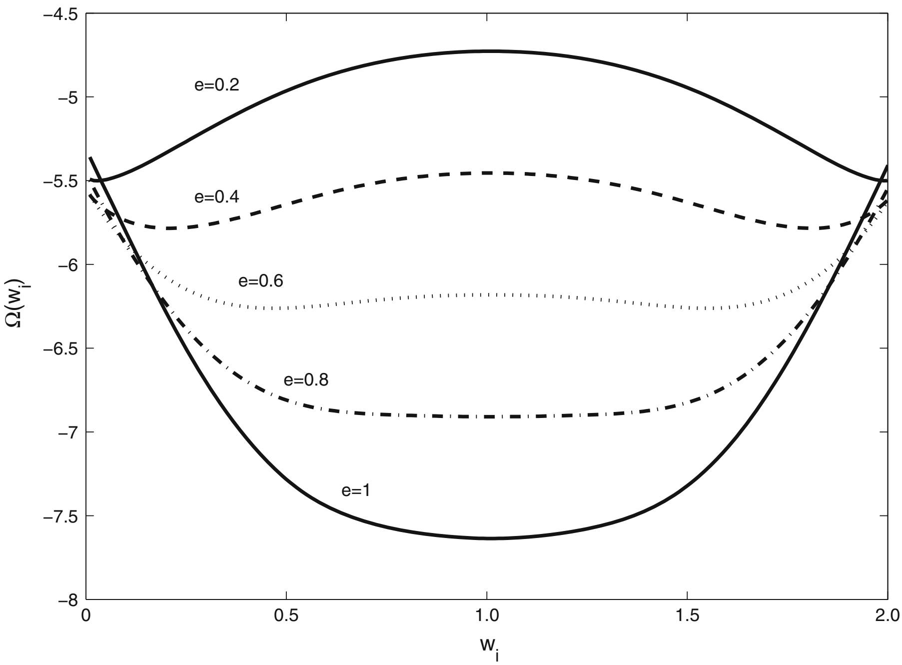

Fig. 4 $\Omega(w_i)$ for $\sigma = 2$ and $\pi = 0.4$ and for various levels of labor elasticity. A larger labor supply elasticity makes unequal wages more attractive

aversion, equal wages are optimal. The impact of risk aversion is easily understood, but the impact of labor elasticity is more subtle. When labor supply elasticity is large, the (more) educated spouse (in the unequal wage case) earns an income that is so large that the couple can generate a sufficient amount of savings to ensure that each spouse is better off in any contingency; see Section 3.4 which considers a quadratic disutility of labor supply and corresponds to the case where $\varepsilon = 1$.

3.6 Section summary

The main results obtained in this section are summarized in the following proposition.

Proposition 1 *Consider a couple which determines its human capital investment according to the education technology* (1) *and whose welfare function is given by* Eq. (2). *We have the following:*

(i) *When there is no divorce* ($\pi = 0$) *and/or spouses are risk neutral* ($\sigma = 0$), *maximum wage differentiation* ($w_i = 2$ *and* $w_{-i} = 0$) *is always optimal. This solution continues to be a local maximum for all* $0 < \pi \leq 1$ *and* $\sigma > 0$*;*

(ii) *Welfare under maximum wage differentiation decreases with* π *(provided that* $\sigma > 0$*), while welfare with equal wages does not depend on* π*;*

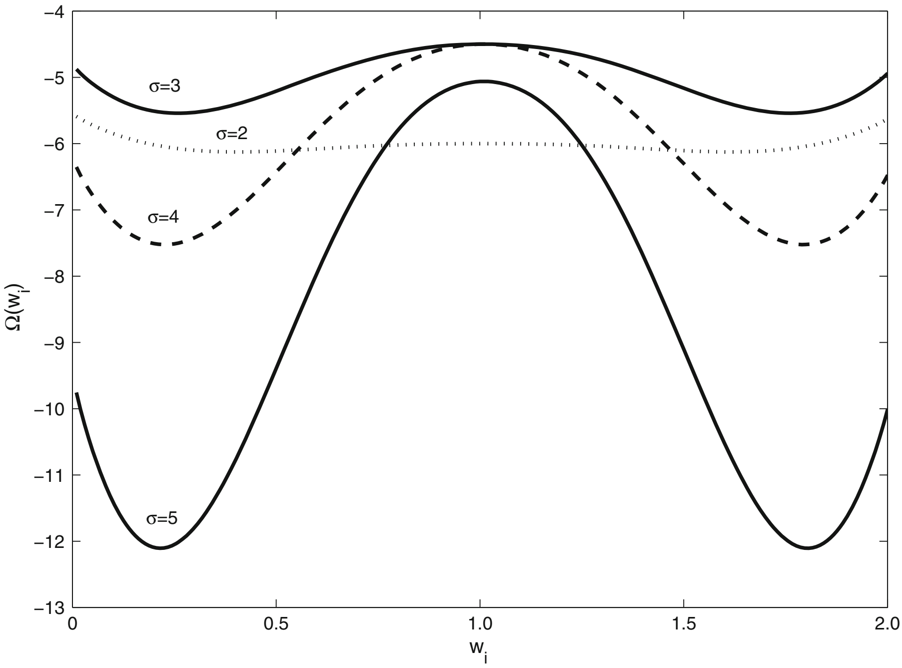

Fig. 5 $\Omega(w_i)$ for $\varepsilon = 0.5$ and $\pi = 0.4$ and for various levels of (relative) risk aversion. A large degree of risk aversion makes wage equalization more attractive

(iii) *Couples who choose maximum differentiation under a positive divorce probability use savings to self-insure against the divorce risk. This is costly because saving per se is inefficient in our model;*

(iv) *A sufficiently large divorce probability may or may not make wage equalization optimal. Wage equalization is less likely to be optimal when the degree of risk aversion is sufficiently small (particularly when the couple is risk neutral), or when labor supply elasticity is sufficiently large. Specifically, with a quadratic disutility of labor maximum differentiation remains optimal, irrespective of the degree of risk aversion* $\sigma > 0$ *and the divorce probability.*

4 The marriage contract

Our model shows that for a positive divorce probability, the optimal education decision faces a tradeoff between maximization of net income and hedging against the risk of divorce and relying on one own's income. While the former calls for maximum wage differentiation, the latter calls for equal wages. This result is contingent on the underlying institutional and legal framework which assumes that savings are equally divided in case of divorce. Wealth accumulation while being married implies a hedge (although imperfect) against ending up with low human capital and, hence, low income in case of divorce. Now, assume the institutional framework also includes the possibility to write a marriage contract which can be enforced by law at no cost. That is, in the first period, the couple has the option to commit to a transfer scheme for the case of divorce in the second period. The optimal transfer scheme, or alimony, $\{T_m; T_f\}$ the couple agrees upon in the first period is determined by solving

$$\max_{s,c_i^{tj},\ell_i^{tj},T_i} \quad \mathcal{W} = u\left(c_m^{1c} - v\left(\ell_m^{1c}\right)\right) + u\left(c_f^{1c} - v\left(\ell_f^{1c}\right)\right) + \pi\left[u\left(c_m^{2s} - v\left(\ell_m^{2s}\right)\right) + u\left(c_f^{2s} - v\left(\ell_f^{2s}\right)\right)\right]$$

$$+ \ (1-\pi)\left[u\left(c_m^{2c} - v\left(\ell_m^{2c}\right)\right) + u\left(c_f^{2c} - v\left(\ell_f^{2c}\right)\right)\right]$$

$$\text{s.t.} \qquad \text{Eq. (3)}, \quad \text{Eq. (4)}, \quad T_m + T_f = 0,$$

$$c_m^{2s} = w_m \ell_m^{2s} + 0.5s + T_m, \quad \text{and} \quad c_f^{2s} = w_f \ell_f^{2s} + 0.5s + T_f.$$

Again, labor supply and consumption are chosen according to Eqs. (8) and (9). The optimal transfer in case of divorce equalizes marginal utilities of the male and female when single

$$T_f^* = -T_m^* = \frac{w_m \ell_m^* - v(\ell_m^*) - (2 - w_m)\ell_f^* + v(\ell_f^*)}{2}.$$

With the above marriage contract, savings are no longer needed in order to ensure a minimum consumption of the low-wage single household in case of divorce, so we now have $s^* = 0$. Thus, the optimization problem reduces to

$$\max_{w_i} \quad \mathcal{W}(w_i) = 4u\left(\frac{(2 - w_i)\ell_{-i}^* + w_i \ell_i^* - v(\ell_{-i}^*) - v(\ell_i^*)}{2}\right).$$

In other words, we return to the case where the couple maximizes total surplus, as in the previous section when $\pi = 0$ and/or $\sigma = 0$. Consequently, if the couple agrees on a marriage contract in the first period, the solution *always* implies maximum wage differentiation. Divorce, which was problematic for the low productivity ex-spouse in the absence of marriage contracts, is now no longer a problem. The human capital decision can be based on efficiency only, even if that results in concentrating all investments on a single individual. Due to the optimally designed marriage contract, the less productive spouse is fully protected against the risk of divorce. This result relies on the assumption that there is no uncertainty as to the enforcement of the marriage contract.[17]

Comparing this solution with that obtained in the previous section shows that the availability of (perfect) marriage contracts corrects two potential types of inefficiency brought about by divorce. First, it ensures that the surplus maximizing human capital allocation is implemented. Second, there is no longer any need for the couple to have positive saving in order to self-insure.

[17] Since the amount the better educated spouse has to pay in case of divorce is fixed from the second period's perspective, there is no moral hazard in the paying spouse's labor force participation.

Proposition 2 *If the couple can commit to a marriage contract while married in the first period, the entire educational budget is invested in one spouse, yielding maximum wage differentiation ($w_i^* = 0$ and $w_{-i}^* = 2$) irrespective of the probability of divorce or the degree of risk aversion. Savings are equal to zero and the higher educated spouse transfers a lump-sum amount to the other spouse in case of divorce. This transfer corresponds to half of his/her net income (consumption minus the monetary loss due to labor supply) evaluated at the efficient solution.*

5 The (economic) use of marriage

Our earlier analysis shows that the more unequal the educational budget is divided between the spouses, the higher the surplus the couple generates. We can now discuss the economic "use" (or benefit) of the marriage. Specifically, from an economic point of view, is it worthwhile for both the male and the female to marry in the first place? In Becker's (1973, 1974) seminal theory of marriage, two individuals marry when the surplus from doing so is positive relative to the two individuals remaining single.[18] Assume each of the two individuals has half of the education budget without getting married, then wages are given by $w_f = w_m = 1$ and utility when staying single amounts to

$$U_i^{single} = 2u(1\ell_i - v(\ell_i)) \quad \text{for} \quad i = m, f.$$

On the other hand, when getting married, utility of each individual is given as follows,

$$U_i^{married} = u(c_i^{1c} - v(\ell_i^{1c})) + \pi u(c_i^{2s} - v(\ell_i^{2s})) + (1-\pi)u(c_i^{2c} - v(\ell_i^{2c}))$$

where consumption, labor supply, savings, and wages are determined by Eqs. (8) to (10) and (13). Obviously, if an equal wage distribution is optimal from the couple's point of view, then both partners are equally well off when marrying and when remaining single. However, whenever an unequal wage distribution is optimal, utility while married differs between the male and female unless $\pi = 0$. While the spouse who receives the higher share of the education budget is never worse off compared to his/her single status, the one who gets the smaller share of the budget may well be better off in staying single. From Section 3.4, we know that for quadratic labor disutility, an unequal wage distribution Pareto-dominates equal wages. In other words, the economic use of a marriage is always positive for the female and the male if the labor supply elasticity is $\varepsilon = 1$. If the probability of divorce is zero, or the two can commit to a marriage contract, then even the lower educated individual profits from the surplus generated by investing the whole education budget in one spouse, as this

[18]Cigno (2012) shows that the decision to marry also depends on the choice of game after marriage. He finds that a couple will marry only if marriage serves as a commitment device for cooperation.

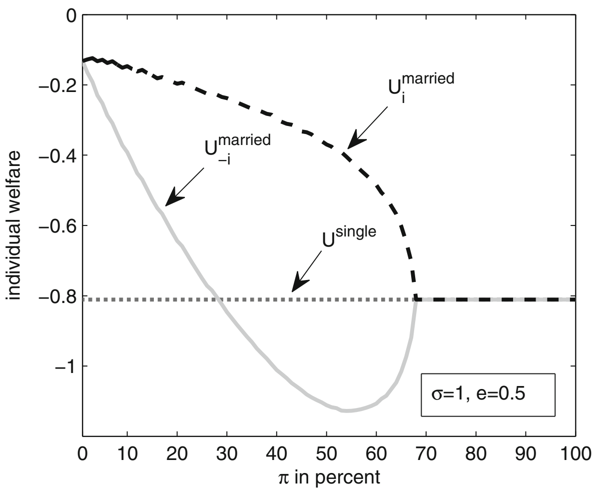

Fig. 6 Utility of single individuals U_i^{single}, and of married individuals $U_i^{married}$ and $U_{-i}^{married}$ for $\sigma = 1$, $\varepsilon = 0.5$, and for various levels of π

surplus is equally divided between the two of them. We summarize our findings in the following proposition:

Proposition 3 *Both spouses necessarily profit from a marriage if (i) the divorce probability is zero, (ii) labor disutility is quadratic, or (iii) they can commit to a marriage contract.*

While this proposition provides a number of cases where marriage is beneficial for both spouses, there is no guarantee that this is always the case in our setting. In fact, it is easy to provide counterexamples. In order to see this, we return to the numerical specification used in Section 3.5 which assumes that utility is defined by Eq. (22). Figure 6 illustrates the economic use for each individual for $\sigma = 1$ and $\varepsilon = 0.5$. For small divorce probabilities, the expected utility of a marriage is higher for both individuals than when staying single. Even though in this case an unequal wage distribution is optimal, the additional surplus generated through specialization in the marriage exceeds the possible loss in case of divorce. For larger divorce probabilities, the partner with the lower productivity is worse off within a marriage. The surplus created through specialization is too low to offset the possible utility losses in case of divorce. Finally, for even higher divorce rates (i.e., above 60 % in the considered example) equal wages are optimal, so that utility when getting married and when staying single coincide.

In summary, for low divorce probabilities, marriage is beneficial for both partners, while for intermediate levels, the low productivity spouse is worse off. Additionally, when the divorce probability is sufficiently large (and parameters are so that equal wages become optimal), marriage leaves utilities (and human capital investment decisions) unaffected.

6 Conclusion

This paper examines how a couple's (tertiary) education choices are affected by the possibility of divorce, which is seen as a random exogenous event. We have considered a simple setting where, absent the possibility of divorce, it is optimal for the couple to specialize and invest the whole educational budget in one spouse. This maximum wage differentiation maximizes the couple's overall surplus and hence welfare. If the probability of divorce becomes positive, optimal human capital investments depend on risk aversion and the labor supply elasticity. A higher risk aversion thereby makes the symmetric solution (i.e., equal wage distribution) more likely, whereas a higher labor supply elasticity provokes more specialization (i.e., a more unequal wage distribution) between the husband and wife. This result presumes that accumulated wealth is divided equally between the two individuals. If, additionally, the couple can commit to a marriage contract at the beginning of their marriage, specialization is always optimal granted that the contract fully compensates the loser for his/her losses. While the marriage decision is always positive with a marriage contract, it may turn negative for one of the spouses in the case of medium divorce probabilities and no marriage contract.

To obtain a clear benchmark, we have assumed constant returns to education. Decreasing returns in the couple's education technology could affect the no divorce benchmark. However, the degree of decreasing returns must be sufficiently strong to do away with the specialization result (see also Cremer et al. 2011). When this occurs, there is no longer any need to provide insurance against (the financial implications) of divorce. Additionally, we have assumed a uniform learning ability. If we were to assume different learning abilities, then our results are only strengthened. The main difference would be that the spouse with the higher wage level would be the more able.

We assume throughout the paper that no discounting is applied to second period utility; neither do we have an interest rate, so we effectively assume that the discount and interest rate are equal. To keep the model consistent, the introduction of a discount rate has to go hand-in-hand with the introduction of a positive interest rate.[19] Positive discount and interest rates would not change our results. A positive discount rate increases the welfare-weight of the couple *relative* to that of divorced singles. This is because in the case of divorce, the utility is discounted. The second period utility of the united couple is also discounted, but the first period utility is not. Consequently, the relative weight of the couple in the welfare function increases and this only increases the attractiveness of the unequal wage solution. Additionally, with a higher (or positive) interest rate, the "costs" of self-insurance via savings are reduced, which also promotes the unequal wage solution.

Among possible extensions to this paper, myopia and taxation could be considered. It is often argued that "love is blind"; in other words, when newly married, the couple may ignore the possibility of getting divorced later in life. Witness the

[19] One can easily show that as long as both rates are equal, labor supply and savings (for given wages) are unaffected. In particular, savings continue to play no role other than providing self-insurance.

reluctance of young couples to sign a marriage contract that would cope with the possibility of divorce and its unpleasant outcomes. In France, 16 % of all couples draw up a contract when they get married and 3 % do so in the years that follow, making a total of 19 % of married couples (see Barthez and Laferrère 1996). Myopia has consequences for human capital investments. Assume the couple completely ignores a possible divorce in the second period, then the optimization problem reduces to maximization of the couple's common budget, and this is maximized whenever the couple puts all their eggs in one basket. In other words, myopia concerning the divorce probability leads to a more unequal wage distribution between the male and the female.

Another natural extension concerns public policy, which is assumed away in this paper, with the exception of the marriage contract that needs a public authority to be enforced. Here, we have only considered two types of contracts. A richer variety of contracts and alimony rules could also be analyzed. Furthermore, in the case where couples may decide to choose an equal investment in human capital and excessive saving, one could achieve a more efficient level of saving and educational choice through an appropriate tax/transfer policy.

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Appendix: General utility

Throughout this paper, we assume quasi-linear preference (with no income effect) and a utility function given by $u(c_i - v(\ell_i))$. This specification implies that labor supply is always increasing in wage, and one might be tempted to consider that this is crucial for our results. However, this is *not* the case. We use this specification for simplicity and to be able to reduce the problem to a single dimension. But this is simply a matter of exposition. Proposition 1 continues to be valid for general utility functions. This is obvious for items (iii) and (iv), but needs to be established for (i) and (ii).

The result that maximum wage differentiation is optimal for $\pi = 0$ with general utility functions follows directly from Cremer et al. (2011). The theoretical argument effectively formalizes the intuition explained in Section 3.3 above. To make this paper self-contained, we briefly sketch this main argument. Assume the general utility function $u(c_i, \ell_i)$, then for equal wages and $\pi = 0$ we will have $c_i = w_i \ell_i = \ell_i$ and $s = 0$ (i.e., spouses consume their own incomes, which are equal and saving is zero). Welfare is then given as follows,

$$\mathcal{W}^E = 4u\left(\ell^E, \ell^E\right), \tag{A1}$$

where

$$\ell^E = \arg\max_{\ell} \; u(\ell, \ell). \tag{A2}$$

With unequal wages, $w_i = 2$ and $w_{-i} = 0$, the spouse with $w_i = 0$ does not work and earns no income but he/she receives a compensation from the spouse with higher human capital, as optimally marginal utilities are equalized. Denoting this transfer T, the couple's welfare is given as follows,

$$\begin{aligned} \mathcal{W}^{MD} &= \max_{\ell_i, \ell_{-i}, T} 2u\left(w_i \ell_i - T, \ell_i\right) + 2u\left(w_{-i}\ell_{-i} + T, \ell_{-i}\right), \\ &= 2u(2\ell_i^{MD} - T, \ell_i^{MD}) + 2u(0 + T, 0), \end{aligned}$$

where we have $\ell_{-i} = 0$. Observe that as long as $\pi = 0$ we have $s = 0$, and the two periods are perfectly symmetrical. Now assume the individual with higher human capital simply gives half of his/her income to his/her spouse ($T = \ell_i^{MD}$) so that consumption levels are equalized (which is generally not the optimal level). Additionally, set $\ell_i^{MD} = \ell^E$, so that the individual with $w_i = 2$ works the same number of hours with equal wages (which is also generally not optimal). With these two assumptions, we have

$$\mathcal{W}^{MD} = 2u\left(\ell^E, \ell^E\right) + 2u\left(\ell^E, 0\right) > \mathcal{W}^E.$$

In other words, under wage differentiation the couple can achieve the same consumption levels as under wage equalization by having only a single individual work (the same amount as under wage equalization). Intuitively, this is simply a generalization of the argument discussed in Section 3.3 and represented in Fig. 1. This establishes that item (i) of Proposition 1 continues to be valid with more general utility function.

Introducing a positive π, a couple's welfare with general utility functions is redefined as follows:

$$\begin{aligned} \mathcal{W} = u\left(c_m^{1c}, \ell_m^{1c}\right) + u\left(c_f^{1c}, \ell_f^{1c}\right) + \pi\left[u\left(c_m^{2s}, \ell_m^{2s}\right) + u\left(c_f^{2s}, \ell_f^{2s}\right)\right] \\ +(1-\pi)\left[u\left(c_m^{2c}, \ell_m^{2c}\right) + u\left(c_f^{2c}, \ell_f^{2c}\right)\right]. \end{aligned} \tag{A3}$$

Budget constraints are unchanged and continue to be given by Eqs. (3)–(6).[20] Under equal wages, maximizing (A3) subject to Eqs. (3)–(6) yields $c_i^{tj} = \ell_i^{tj} = \ell^E$ defined by Eq. (A2) so that welfare is given by $\mathcal{W}^E = 4u\left(\ell^E, \ell^E\right)$ which does not depend on π. Under unequal wages ($w_i = 2$ and $w_{-i} = 0$), differentiating welfare with respect to π, while using the envelope theorem yields

$$\frac{\partial \mathcal{W}}{\partial \pi} = \left[u\left(c_m^{2s}, \ell_m^{2s}\right) + u\left(c_f^{2s}, \ell_f^{2s}\right)\right] - \left[u\left(c_m^{2c}, \ell_m^{2c}\right) + u\left(c_f^{2c}, \ell_f^{2c}\right)\right] \leq 0.$$

To establish the inequality, observe that the second term in brackets is the utility of the married couple, while the first term is the utility of the divorced spouses. Since savings and productivities are the same in both cases, the utility of the married couple is always at least as large as that of the divorced spouses. This is because the (c, ℓ)

[20] Differentiating the Lagrangian expression, $\mathcal{L}$, associated with this problem (after substituting w_{-i} by $1 - w_i$, one easily shows that at $w_i = 2$ and $w_{-i} = 0$ we have $\partial\mathcal{L}/\partial w_i > 0$ so that a local deviation from maximum differentiation decreases welfare irrespective of π and σ even with general utilties. However, unlike in the quasi-linear setting the problem cannot be reduced to a single dimension so that this property is no longer very meaningful.

bundles chosen by the divorced spouses are feasible for the married couple, while the opposite is not true. Consequently, item (ii) of the proposition stating that wage differentiation becomes less attractive as π increases, remains valid with general utility. To summarize, none of these results requires an increasing labor supply function.

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