Essays on Intra-household Distribution

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Abstract

In the first chapter of this thesis, I develop a model that combines intra-household bargaining with competition on the marriage market - once married, spouses bargain over the allocation of total household income. They have the option of divorce and subsequent remarriage; the value of this outside option is determined endogenously on the marriage market. I use this model to analyse the educational choice. When more women than men obtain a university degree, men without degrees benefit; university educated men, however, are not able to translate this change on the marriage market into a significantly larger share of household income. Hence, men's incentive to invest in education decreases if women's educational attainment increases. Even without assuming any heterogeneity in tastes between men and women, equilibria arise in which men and women decide to become educated at different rates.

The second chapter shows empirically, that a woman's propensity to separate from her partner depends positively on male wage inequality on her local marriage market - the more heterogeneous potential future mates are in terms of earnings power, the more likely a woman is to end her relationship. This effect is strongest for couples, where one has a college education but the other one does not. The effect is robust to the inclusion of a variety of controls on the individual level, as well as state and time fixed effects and state specific time trends.

The third chapter (co-authored with Julio Robledo) develops a two period family decision making model in which spouse bargain over the allocation of individual time and consumption. If inter-temporally binding contracts are not feasible, household time allocation might be inefficient. We compare two threat point specifications, and show that the threat point specification can influence spouses time allocation, not only the distribution of private consumption.

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Contents

Preface

This thesis consists of three separate, stand-alone articles that deal with the economics of intra-household distribution.

In the first paper, "Education in a Marriage Market without Commitment", I develop a Rubinstein type alternating offers model of intra-household bargaining, that combines elements from the family bargaining and the marriage market literature. Individuals are unable to make binding agreements on the future distribution of household resources on the marriage market, and therefore have to resort to bargaining once they are married. They do, however, have the option of divorcing their current spouse if they are not satisfied with an offer. The alternating offers structure of the model enables me to endogenise the relevant threat point in marital bargaining that is usually exogenously given in Nash-bargaining models. Furthermore, a person's expected value of divorcing and going back to the marriage market to try his or her luck again is determined completely *endogenously* within the model, through the marriage market. The marriage market situation (the quality of prospective spouses and the distribution of resources in other couples) influences the bargaining outcome in existing couples. I use this model to study the impact of changes in educational attainment of men and women on intra-household distribution. Assuming that better educated individuals contribute more to household income, I show that an increase in the number of women who obtain a university degree over and above the number of men who do so benefits men without university degrees. University educated men, however, are not able to translate this change on the marriage market into a significantly larger share of household income. Hence, men's incentive to invest in education *decreases* if more women become educated. As opposed to what a pure marriage market model (that assumes that spouses can make binding agreements on the future distribution of resources on the marriage market) would predict, the "price" (that is, the equilibrium consumption) of educated women does not decrease if their "supply" (their fraction of all women) increases - a rising fraction of university educated women therefore only adversely affects women without university education. I use this model to study the incentives of women and men to invest in education. Even without assuming any differences in tastes or capabilities between men and women, equilibria can arise in which women and men become educated at different rates. I also include two additional sections (that are not included in the paper that is in circulation) that look at two specific features of the model. One section analyses how a positive single utility might influence the model in a striped down version, and the other looks at a more general specification of marital output.

This paper provides a crucial theoretical insight that is the basis for the second, empirical paper "Marriage Markets and Divorce". Specifically, the model I develop in the first paper has the empirical prediction that couples are more likely to divorce if wage inequality between university graduates and non-graduates increases, but this is only the case for couples were both spouses do not have a university degree. As the wage inequality between the two educational groups increases, it becomes more attractive to go back to the marriage market in the hopes of finding a higher earning partner - but only, if one is not already married to a university graduate. Although I do not directly attempt to test the predictions of the first article, I do use this theoretical idea as the basis of my empirical work. Using data from the Survey of Income and Program Participation 1990-2007, I show that women's propensity to divorce is positively related to male wage inequality in their state of residence. This effect is strongest for couples, where one has a college education while the other one does not. Because of assortative matching according to education on the marriage market, college educated individuals are those most likely to marry a college graduate - if they are not currently married to one, they have the most to gain from divorcing and going back to the marriage market. This effect is robust to the inclusion of a variety of controls on the individual level, as well as state and time fixed effects and state specific time trends. It contributes to the empirical literature on divorce in economics, by suggesting a different reason for marital dissolution - changes in the marriage market climate, or changes in the spouses' *outside options* - as opposed to learning or changes in the quality of a given match.

The third paper, "Specialisation in the Bargaining Family", is joint work with Julio R. Robledo (University of Bochum). We develop a two period Nash bargaining model of family decision making, were spouses bargain over their time contributions to a family public good (say, child rearing) and the distribution of household income (private consumption). In line with empirical evidence, we assume increasing marginal benefits of labour market experience - this makes specialisation in household and market tasks within the couple efficient, even if there are no (gender) differences in tastes for, or productivities in, household and market work. Specialisation within the couple emerges endogenously from the production of the public good. If spouses are not able to enter into a binding contract governing the distribution of private consumption in the second period, the spouse specialised in market work cannot commit to compensate the other spouse for foregone investments in earnings power. As a consequence, this spouse may withdraw part of his/her contribution and the provision level of the household good is likely to be inefficiently low. We discuss the differences of the two widely discussed alternatives for the *threat point* that is crucial to the Nash bargaining solution - divorce and a non-cooperative equilibrium within marriage. We find that the choice of the threat point is important, with the non-cooperative equilibrium benefiting the spouse specialised in market work, while the divorce equilibrium benefits the spouse specialised in household tasks. Furthermore, the threat point choice can also have implications on allocative efficiency: the non-cooperative threat point that benefits the spouse with higher labour market earnings is, ceteris paribus, associated with *less* inefficiency than the threat point that benefits the spouse who specialises in household production, leading to an equity / efficiency trade-off. We also assess the effectiveness of various measures of public policy to mitigate the inefficiently low level of public good provision.

Chapter 1

Education in a Marriage Market Model without Commitment

1.1 Introduction

The closing of the gender education gap - the catching up of women with men in terms of formal training - is a widely acknowledged fact, mostly discussed in connection with the impressive rise of female labour force participation that took place throughout the second half of the last century (e.g. Lundberg and Pollak, 2007).[1] Another development receives less attention: the gender education gap actually reversed to the favour of women in the United States and is now reversing in Europe (Goldin et al., 2006). In the United States, men and women graduated from college in equal numbers in 1980, while in 2003, there were 1.35 female graduates for every graduating man. In Europe, this trend is delayed, but gender specific university enrolment and graduation rates point into the same direction in most countries.[2] This development is somewhat puzzling, given that women still earn lower wage rates than men, and spend a smaller (though rising) fraction of their lives in paid employment. The incentive to pursue higher education certainly becomes stronger for women as obstacles to female labour force participation slowly disappear and the gender wage gap declines. But these factors can only explain women's *catching up* with men in terms of education, not their *overtaking* them.

To explain this puzzle, I want to focus on an aspect of women's schooling other than its labour market reward: the marriage market return to education. By marriage market return to education I mean the effect a person's educational background has on his or her success on the marriage market, including the quality of their spouse, their risk of divorce, and their share of household consumption

If the balance of gender specific graduation rates tips into the favour of women, this will change marriage market conditions for this age cohort, and alter the marriage market returns to education for men and women. As young men and women anticipate a changed marriage market climate, their investment decisions might change, which could counterbalance or accelerate the difference in gender specific graduation rates.

To formalize this idea, I develop a non-cooperative bargaining model of marriage, that brings together elements from the intra-household bargaining and the marriage market literature. Individuals are unable to make binding agreements about the distribution within marriage on the marriage market, and therefore have to resort to intra-household bargaining; they are however free to unilaterally divorce their partner and try their luck on the marriage market again. The alternating offers structure of my model enables me

[1] Female labour force participation in the US reached a plateau at just under 60 percent in the late 1990s, and has been stable since then (Employment Projections Program, U.S. Department of Labor, U.S. Bureau of Labor Statistics, see http://www.bls.gov/emp/tables.htm).

[2] OECD Online Education Database, see www.oecd.org/education/database

to endogenise the relevant threat point in marital bargaining that is usually exogenously given in Nash-bargaining models; furthermore, the outside value of divorce is endogenously determined on the marriage market.

Because the marriage market situation (quality of alternative partners and distribution in other couples) influences the distribution within existing couples, the *total* return to education depends on the educational attainment of the cohort. If the marriage market returns to education are higher for women than for men, this leads to higher human capital investment levels for women.

The paper closest related to my work is Chiappori et al. (2009) in that they look at the marriage market to explain the reversal of the gender education gap. Their model however is very different from mine: they assume that individuals can make binding agreements on the future allocation of resources before getting married, and that the marriage market is frictionless. If additionally women have an extra incentive to invest in education to "escape discrimination" (i.e. if the labour market return to education is higher for women than for men), more women than men invest in education. This reduces the share of household resources educated women receive in equilibrium (as they are in excess supply) and adversely affects uneducated women, while benefiting men.

In contrast I find that individuals who have completed higher education are never affected by a change in the university graduation rate of their own gender. They do benefit from an increased number of university graduates of the opposite sex, but their incentive to invest in education does not decrease if their type is in greater supply. This has to do with the fact that binding agreements on the marriage market are not feasible in my model: anyone who is married to an educated individual is already in the best possible match, regardless of how many other university graduates are out there. So any individual who is matched to a university educated spouse knows that he or she has nothing to gain from going back to the marriage market regardless of their own education. They cannot credibly "threaten" with divorce, which is why the marriage market situation from the point of view of a person married to someone of higher degree level does never influence intra-household bargaining. That my model does not rely on the assumption that individuals can make binding agreements on their future consumption without incurring any cost does therefore lead to different results.

Individuals *without* a university degree, however, do suffer from an increase in university graduation rates of their own gender cohort. When women's graduation rates rise, men married to women without higher education are aware that, if they divorced, they could possibly marry a woman with a higher earnings power, and enjoy a higher standard of living. So my model predicts that if women do take over men in terms of schooling, the workings of the marriage market will accelerate this trend. Female university graduates are not adversely affected from an increase in the college graduation rate of women, while women without a university degree are; therefore, women's incentive to obtain tertiary education increases. On the other hand, the prospects of uneducated men on the marriage market brighten, because of the increased supply of university educated women. Consequently, men's incentives to invest in higher education diminish.

In the next section, I place my model within the existing literature on intra-household bargaining and the marriage market. Then, I provide some background information on the gender education gap, and argue why I think it is important to look at marriage market returns to schooling, although they are traditionally disregarded in the literature on human capital. In section 1.3 I present the bargaining model with outside options, briefly discuss how it is solved and present the outcome of the model depending on its basic parameters. I also discuss the role of wage inequality and empirical implications, and look at the influence of a rise in the college graduation rate of men on women's share of household resources. Section 1.5 adds an initial stage to the model in which individuals make their investment decisions. In this section, I discuss the efficiency of the education decision if individuals anticipate to live in households with others. Section 1.6 concludes. All detailed derivations of the results and proofs are banished to the appendix.

1.2 Related Literature

Intra-household Bargaining

How do households distribute resources among their members? In the economic literature, this question has so far been analysed from two different angles. The first proposes that the marriage market assigns a price to each individual looking to get married. This price corresponds to their later individual consumption in marriage. The second maintains that couples constantly bargain over the distribution of household resources, and aims to determine the sources of "bargaining power" in this domestic setting. The literature strands on marriage markets and intra-household bargaining are relatively unconnected. The main difference between them is that the marriage market approach generally assumes that individuals can commit to transfers within marriage on the marriage market (Chiappori et al., 2009). If binding agreements prior to marriage are feasible and the marriage market is frictionless (in particular there is perfect information and no search costs) the marriage market can pin down the exact distribution within each couple (Browning et al., 2011; Chiappori et al., 2009). The bargaining approach on the other hand argues that while binding agreements *following divorce* may be feasible, and individuals may draw up marriage contracts before marrying, agreements fixing distribution *within marriage* are not common in the western world, and it is not clear how they should be enforced (see, e.g. Lundberg and Pollak, 1996). Most family bargaining models start with a couple that is already married and neglect the marriage market, although it at very least determines who marries whom (even if one is reluctant to accept its role in intra-household resource allocation).

I want to extend this existing literature in two ways: My model incorporates a marriage market where couples form before they start bargaining about family resources, which is absent from most models in the family bargaining literature. Also, Nash Bargaining models of the family have to pick a "threat" or "disagreement" point that is crucial to intra-household distribution - normally divorce or non-cooperation within marriage - quite arbitrarily. I avoid this problem by developing an alternating offers model of marital bargaining that has an inside and an outside option. In my setting, as long as there is no agreement, an individual is free to either continue bargaining or to get divorced and to re-enter the marriage market. The marriage market prospects of an individual depend both on who is available on the marriage market (the quality of prospective spouses), and the distribution of marital resources in other couples, and is determined endogenously. As De Meza and Lockwood (1998) point out, a "disagreement point" in a Nash Bargaining game is the equivalent of an inside option in a Rubinstein type alternating offers game. Since divorce can be expected to bring intra-household bargaining to an end, it seems more natural to take it as an outside option.

Recently, Lundberg and Pollak (2008) argued that if binding agreements on the marriage market are not feasible, rational individuals should anticipate the bargaining outcome in each possible marriage on the marriage market, although they would be powerless to alter it ex ante. This is equivalent to a non-transferable utility setting, in which the payoffs to husband and wife that are associated with each match are fixed, and therefore, assignments should be made according to the Gale-Shapley algorithm.[1] Criticizing this approach, Browning et al. (2011) point out that even if binding agreements on the marriage market are completely ruled out, the situation is still not best described by the Gale-Shapley model if divorce and remarriage are possible. If marriages can be dissolved at no cost and the marriage market is plentiful in that each spouse has many close substitutes, the marriage market would still fully determine intra-household distribution. My

[1]For non-transferable utilities, Gale and Shapley (1962) show that a stable matching equilibrium exists given arbitrary preferences of women over men and vice versa, although they are not in general unique. Eeckhout (2000) shows that for for some commonly used types of preference orderings, including a common rank order over all potential mates, the stable matching equilibrium is unique.

model reconciles these two approaches by both acknowledging that, in agreeing to marry, the couple has, at least temporarily, locked themselves in, and that they are generally unable to make enforceable agreements about intra-household distribution before marrying. But, in the medium term, the option of separating and trying one's luck elsewhere always exists. Since the values of both the internal threat point and the outside option are determined endogenously, the transition between the two is determined within the model.

Family decision making has been studied extensively by economists since the seminal work of Becker (see, e.g., Becker, 1981). Since the publication of the work of Manser and Brown (1980) and Mc Elroy and Horney (1981), a lot of work has been done that emphasizes the conflict of interest between the spouses when it comes to the distribution of family resources. Most of the models in this strand of literature use the Nash Bargaining Solution to determine the allocation of family resources (see Pollak, 2011, for a short survey). Since in this solution concept, the "disagreement" or "threat point" utility (that is realized if the spouses are unable to reach an agreement) is of crucial importance, one has to decide on how to define this point in a family context. Two different specifications of this threat point have been proposed in the literature: divorce, as in Manser and Brown (1980) and Mc Elroy and Horney (1981) or non-cooperative behaviour within marriage as in Lundberg and Pollak (1993). It is not straightforward which of these two possibilities is more appropriate (Bergstrom, 1997). While the divorce threat may not always be credible, at least in the short term, it seems unrealistic to rule out divorce as an option altogether.

To address this problem, Bergstrom (1993, 1996) proposes to model the family bargaining problem non-cooperatively, as an alternating offers game allowing for inside and outside options, as in Binmore et al. (1989). He argues that neither divorce nor a non-cooperative equilibrium within marriage (a "harsh words and burnt toast equilibrium" in his diction) is likely to be the sole relevant threat point in marital bargaining. While the threat of divorce may not be credible in everyday negotiations, living in a non cooperative union may as well be worse than separation in the long term. He therefore proposes an alternating offers model of marital bargaining as follows: if one spouse rejects an offer, they have the possibility to either file for a divorce, or to make a counteroffer in the next period, in which case they receive a "conflict utility" that represents their utility during non-cooperative marriage (harsh words and burnt toast). The outcome of this model is that the outside option (divorce) utilities only influence the outcome when a divorce threat is *credible*. That is, if the bargaining outcome under disregard of the divorce option exceeds the outside option utilities of both spouses, the divorce option becomes irrelevant.

My model extends this basic setting in two respects:

- I introduce heterogeneity of individuals with respect to education - spouses can be educated or uneducated.

- I endogenise spouses' outside options. Spouses utilities if divorced are determined within the model, via the marriage market. The intra-household bargaining literature has so far been quite detached from the research on marriage markets, with Lundberg and Pollak (1993) and Bergstrom (1993) being exceptions. But both propose rather sketchy models (in particular, both assume that marital surplus is the same for all possible couples), and while Lundberg and Pollak (1993) rule out divorce, Bergstrom (1993) allows for divorce but rules out remarriage. In my setting, an individual goes back to the marriage market after a divorce and is rematched in the next period. Their payoff in this next marriage depends both on the type of their next spouse (the fraction of educated individuals of the opposite sex in the population) and the distribution of resources in other couples. Hence, it is determined endogenously within the model. Whenever a divorce threat is not credible, spouses resort to the inside option, which is making a counteroffer in their present marriage. Hence, both the choice of the threat point and its size are endogenously determined within the model and depend on the marriage market situation (the quality of prospective spouses as well as the distribution of resources in other couples). Through this channel, the marriage market situation (the prospects of divorced individuals) influences the distribution of resources in existing couples. The negotiations of all couples are interlinked through their outside options at any point in time.

The Gender Education Gap

The fact that women had a lower formal education level than men used to be one of the reasons most frequently put forward to explain both their lower wage rates and the traditional specialization patters observed in western families (e.g. Becker, 1981). Since women work more at home and less on the market than men, their lower investment in human capital was in line with standard human capital theory. Indeed, for the cohorts born a century ago, education patterns for US-American men and women differed substantially. Although, as Goldin et al. (2006) point out, college enrolment rates of men and women were about equal from 1900 to 1930, women and men pursued different careers in college: while most men enrolled in four year programs, about a third of all college women only attended two-year teacher training schools that did not award bachelor degrees. Many academically trained women chose work over marriage, since married women rarely worked outside the home. Those who did marry tended to marry college educated men. The gender imbalance in college graduation rates in favour of men did not start before the great depression in the 1930s, when unemployment motivated American men to attend college. Marriage bars (that prohibited the employment of wives) devalued teaching degrees for women and discouraged them from going to college. Male enrolments rose even further after World War II and the Korean war, when the government offered financial assistance to veterans who wanted to pursue higher education. The ratio of male to female college attendance peaked in 1947, when there were 2.3 males for every female college student.

In the US, women's college graduation rates began to rise in the 1950s and continued to rise steeply throughout the 1960s, while male graduation rates even fell slightly in the late 1960s and early 1970s. By 1980, the gender education gap had diminished, and began to reverse. Starting for cohorts born in the early 1960s (starting their college education in the early 1980s), more women than men earned college degrees. Although male graduation rates picked up a bit to reach the level of the 1960s in the 1990s, they seem to stagnate since, while female graduation rates still appear to be rising. In 2003, female undergraduates in four year programs outnumbered men by a factor of 1.3, while there were even 1.35 females for every male college graduate (Goldin et al., 2006).

The same - although delayed - trend can be observed in other OECD countries. Only five out of the 26 OECD countries that provide data on college enrolment by sex for the year 2005 - Germany, Japan, Korea, Switzerland and Turkey - report higher numbers of male than of female students. Even in those countries, the male/female student ratio follows a downward path. Germany for example is now close to parity with a male to female ratio of 1.02, while in 1995 there were 1.3 male students for every woman. The main difference between the evolution in Europe and the US seems to be that the trend is younger in Europe - out of the 15 European countries that provided data in 1985, only three - France, Portugal and Sweden - reported lower figures of male than of female enrolment, while in the US, parity was already reached in 1980. Quite a few countries who now have more female than male students reached parity only around the turn of the millennium (e.g. Austria, the Czech Republic, the Netherlands, the Slovak Republic or Spain). This could suggest that Europe might experience a gender education gap similar to the US in the future. When it comes to graduation rates, the picture looks quite similar (OECD Online Education Database, see www.oecd.org/education/database).

This lagging behind of Europe as compared to the US could be driven by the different evolution of female labour force participation in the two regions: while female labour force participation in the US rose quite quickly in the decade between 1985 and 1995, it is since stable at around 0.72, while female labour force participation in Europe rose by a further five percentage points between 1995 and 2005, and is still rising (0.61 for 2009, OECD StatExtracts, http://stats.oecd.org/index.aspx).

Given that the labour market return to education rose throughout the second half of the past century, it is not surprising that women's educational attainment has risen over that period. What is puzzling however is that women now outperform men when it comes to higher education, although women continue to have lower employment rates and are still paid at lower wage rates than men.

Goldin (2006) explains the evolution of the female educational expansion with a "time lag" in young women's expectations of the role of work in their own future lives. Female labour market participation began to rise in the 1930s when "nice and clean" jobs like clerical and office work became more readily available, and working married women were more and more accepted. The real hike in female labour force participation however did not happen until the 1960s, when high labour demand, the increasing spread of part time work and advances in household technology made market work more attractive to married women. Goldin (2006) argues that the generation of women who contributed to this hike did not anticipate that they would spend so much time in paid work. They expected to follow the paths of their mothers and be homemakers most of their adult life. Only the generation of their daughters, who had witnessed the importance of paid work in women's lives, actually trained to build careers, which explains why college graduation rates soared during the 1980s, when these women entered college. Goldin et al. (2006) also present survey evidence that shows that women's attitude towards work changed over the past four decades. For example, the fraction of young women who thought that a married woman should not work outside the family fell very quickly, especially during the 1970s. But, while this may explain why women's college enrolment rates rose - working wives became more accepted, and therefore investing in a college degree seemed more worthwhile - it does not explain why women's college enrolment rate actually surpassed men's. Other developments that are likely to have contributed to women's rising demand for college degrees - the ascent of age at first marriage and first birth following the improvements in family planning technology that shortened the fraction of a woman's life spent married, or the increasing incidence of divorce - can only be regarded as a reason for women catching up with men, not *surpassing* them.

One argument that Goldin et al. (2006) do put forward for the reversal of the college gender gap is that women's return from schooling is actually higher than men's. As soon as the societal developments cited above made women strive for proper careers, as opposed to transitional jobs, their surpassing men in terms of academic achievement was a rational response to their higher returns from schooling. Dougherty (2005) surveys a number of empirical studies that look at the influence of women's and men's education on their wage rates. Although he acknowledges that not all studies point into the same direction, he concludes that for the US the schooling coefficients for women seem to be higher than those for men. The data used in the studies he surveys reach into the late 1980s. Most, but not all look at the effect of tertiary education, and the gap between male and female coefficients is of the magnitude of two percentage points. However, not all studies reach this conclusion. Boeheim et al. (2007) for example find for Austria that women's education coefficients are below those of men, in other words, they receive a lower wage premium for every year of education than men do, although the education gap also reversed in Austria. Chiappori et al. (2009) produce data from the Current Population Survey on the impact of higher degrees on men's and women's log wages. While these data are only adjusted for potential work experience, they have the advantage that they reach into 2004 (as opposed to the studies cited by Dougherty (2005)). Interestingly, although women's supposedly higher returns to schooling are a part of their argument, these data indeed show that this gap is declining. At the end of the 1960s, women with advanced degrees earned just above two percentage points more premium than men, while women with college degrees or those with some college only earned very little more than their male counterparts (about half of a percentage point). The difference between female and male MA and PhD premiums seems to have reached its climax in the early 1980s, when women's premium was roughly 2.5 percentage points above men's. But this difference shrank rather quickly during the early 1990s, and was barely noticeable in 2004 (with women's PhD premium under 0.5 percentage points above men's). Indeed, if the sample is restricted to full time, full year workers (excluding the selection into work effect), the difference in the returns to schooling is only significant for advanced degrees from the late 1960s to the late 1990s. Given that the college gender gap continued to widen during the 1990s, it seems inconsistent that this should have occurred as a response to a higher rate of return. Furthermore, even if the empirical evidence pointed more clearly into the direction of a higher education coefficient for women, this cannot be the whole story since women still spend a smaller part of their adult life in (full time-) employment than men do. If women weight the total cost of a college degree against the benefits, they should not only look at the wage increase per hour, but over the life cycle. Therefore it does not seem very convincing that women should outnumber men by 30 percent on US-American colleges because they their wage increase might be two percentage points higher than their male counterparts'.

Education and the Marriage Market

Do people consider the marriage market implications of their educational attainment? Put differently, are educational decisions influenced by their likely effect on the probability to find a mate, and on the quality of the match? This issue has so far received little attention in the extensive literature on human capital, especially with regard to men (Gould, 2008). There are however some recent papers that explore the effect of marriage market returns on educational choices; in this section I want to quickly review this new literature. It shows that, by limiting our attention to the labour market return to education - a higher wage rate - we underestimate the full private return to education, that encompasses a higher chance of getting married, a better match quality and lower divorce rates among the well educated. These marriage market returns do influence educational choices.

Angrist (2002) analyses marriage and labour market outcomes for ethnic subgroups of immigrants into the US from 1910-1940 that are characterized by high rates of endogamy. He examines the effect of marriage market competition for women exploiting variations in the men per woman ratio of these ethnic groups. More competition for women leads to higher rates of marriage (which he interprets as a higher level of economic commitment to women) and higher household income levels (at a time where labour market participation of married women was very rare, this implies that men accumulate more human capital and / or increase their working hours). He concludes that more competition on the marriage market induces men to become more attractive to prospective mates by increasing their earnings power.

Gould (2008) develops a dynamic programming model of educational, career and marriage decisions for young men and estimates it using the National Longitudinal Survey of Youth (NLSY). He finds that higher levels of education increase young men's chances of getting married, obtaining a better match, and staying married longer. If these marriage market returns to education were absent, his model suggests that men would study and work less, and would choose the blue collar sector over the white collar sector more often. This finding is different from the "marriage premium" in the wage function, in that it shows how marriage market considerations shape young men's educational and career choices *before* and during marriage. The return to education on the marriage market furthermore increases with women's labour market participation and women's college education. Having a college degree both increases the probability of having a wife who works full time and having a college educated wife, which improves the stability of marriages. If (married) women would not work full time, or if there were no female college graduates, fewer men would obtain college degrees and work in the white-collar sector.

Ge (2010) develops a similar model for women, also using the NLSY data set. In her model, young female high school graduates take sequential decisions on whether to enrol or to remain in college, start or remain in work and get or stay married to maximise their lifetime expected utility; the model incorporates children and allows for stochastic fertility. In her model, college educated women enjoy three types of gains in the marriage market: they increase their chance of getting a marriage offer, they have a preference for husbands with a similar education (so being a college graduate benefits them if the graduation rate of their prospective husbands increases), and they have a higher chance of being married to a highly educated man, which allows them to benefit from his earnings. She estimates her model using data of young women graduating from high school in the early 1980's. This empirical implementation allows her to simulate counter-factual experiments.[1] Her simulations show that, if college enrolment did not influence the probability of receiving a marriage offer, women's college enrolment rate would drop from 58 percent to 50 percent, while their graduation rate would increase slightly by 3 percentage points. This is due to the fewer marriage offers received by women in college, and the fact that getting married reduces the chance of completing a college degree. She also looks at how women's education decisions would be affected if they would not consider transfers received from their husbands within marriage or after divorce. As women with some college education or college graduates are more likely to marry high-wage, college educated men, this could be an incentive for college enrolment. If women were to disregard this incentive when deciding to go to college, college enrolment rates would decrease by four percentage points, while college graduation rates would slightly increase. This is due to the decreased value of marriage (since there are no transfers) that leads to fewer women getting married while in college.

These studies suggest that traditional estimates of the returns to education that disregard marriage market returns underestimate the true private returns to education.

[1] She also uses her model to predict college enrolment and graduation rates for a younger cohort graduating high school in the late 1990's. The good fit of the model indicates that the parameters of her model are very stable over time.

1.3 The Model

Population and Agents

At this stage, I assume that human capital is exogenously given (I extend the model to include the educational choice of men and women in section 1.5). Women and men are of two types: either they are educated e or uneducated u. Denote an educated woman by w^e and an uneducated woman by w^u. Likewise, denote educated and uneducated men by m^e and m^u respectively.

The marriage market consists of two equally sized populations, one of men, one of women, with measures $\lambda^m = \lambda^f$. A measure of λ_e^i, $i \in \{m, f\}$ is educated, while a measure of $\lambda_u^i, i \in \{m, f\}$ is uneducated, where $\lambda_e^i + \lambda_u^i = \lambda^i$, $i \in \{m, f\}$. For simplicity I assume that individuals on the marriage market are randomly matched into couples. Nature assigns a partner of the opposite sex to each unmarried individual at the beginning of each period. The interpretation of this assumption is that "love is blind" in that matches are random, but after the honeymoon is over, day to day negotiation about household spending becomes an issue.[1]

If a couple agrees on the division of the marital surplus, they leave the market. In order to guarantee that the marriage market is in a steady state at each point in time I make the "clones" assumption as discussed in Burdett and Coles (1997) and used in Bloch and Ryder (2000): whenever a couple leaves the market, they are replaced by a man and a woman of the same education.[2] The probability a man faces to be matched to an educated woman is therefore $p = \frac{\lambda_e^f}{\lambda^f}$, while the probability to be matched to an uneducated woman is $(1-p) = \frac{\lambda_u^f}{\lambda^f}$. Correspondingly, any woman is matched to an educated man with probability $q = \frac{\lambda_e^m}{\lambda^m}$, while she is matched to an uneducated man with probability $(1-q) = \frac{\lambda_u^m}{\lambda^m}$.

Individuals cannot decide to remain single, every unmarried person is matched at the beginning of each period. However, given that the marital output of every couple is positive, while the utility of being single is zero,[3] no one would prefer to remain single.

[1] Although the assumption of a stochastic marriage market clearly is very crude, some degree of uncertainty about who one is going to end up with is likely to remain also if individuals were allowed to propose to their preferred partners. This is because without binding agreements, there is no reason to believe that there will not be a subgroup on the marriage market that is in short supply (Bergstrom, 1993). These individuals would then randomize among their proposers, which would also result in uncertainty on the marriage market.

[2] As Bloch and Ryder (2000) point out, it would be preferable to allow the educational distribution of the influx into the marriage market to be exogenous. The steady state education rates of single men and women would then depend endogenously on marriage strategies. Given the complexity of the model, this is beyond the scope of this paper.

[3] Allowing for a positive single utility does not add much in the way of interesting results and is

Since there is an equal number of males and females in the population, there is always an equal number of males and females on the marriage market.

Payoffs

Marital Outputs

Denote the marital product of the marriage between some woman i with $i \in \{e, u\}$ and some man j with $j \in \{e, u\}$ by ζ_{ij}. Since I assumed that women and men differ only with respect to their education, we can write their marital output as depending only on their educational class. I denote the wage rate of an educated worker by W and the wage of an uneducated worker by w, with $W > w$. We can normalize the wage rate of an uneducated worker to 1 by dividing both wage rates by w. An educated person then earns $r = \frac{W}{w}$, where $r > 1$ is a measure of wage inequality between educated and uneducated individuals. There are four different kinds of couples:

- couples consisting of an educated woman and an educated man generate the output $\zeta_e = 2r$,
- couples consisting of two uneducated individuals, produce the output $\zeta_u = 2$,
- couples consisting of an educated woman and an uneducated man, the associated output being $\zeta_m = r + 1$,
- couples consisting of an uneducated woman and an educated man also produce the output $\zeta_m = r + 1$.

A union of two educated individuals generates more marital output than a "mixed" couple, who in turn generate more output than a couple consisting of two uneducated individuals.[1]

Preferences

There are no "emotional gains", no altruism nor any other, non-economic consequence to marriage. Individuals are only interested in their own consumption, which is their share of marital output.[2]

therefore omitted for simplicity. See section 1.7 for an analysis of the model that allows for a positive single utility.

[1] For a more general specification of marital output, see section 1.7.

[2] This is a simplifying assumption, that helps keep the model tractable and focused on intra-household distribution. In particular, I assume that individuals value the education of their partner only because

In each period t individuals receive an instantaneous utility π_t depending on their marital status:

- When single, individuals receive a utility of 0. Since all other marital outputs are positive, this assumption implies that individuals always prefer getting married, even if it is to the less preferred type of spouse, over remaining single.

- When a couple has agreed on a division of marital output, their utility is linear in the share of output they receive (transferable utility). The utility of a woman of type i, who is married to a man of the educational class j in any given period t is therefore given by
$$\pi_t^i = \mu_j^i \cdot \zeta_{i,j} \tag{1.1}$$
where μ_j^i is the fraction of marital output a woman of type i receives in a marriage to a man of type j in equilibrium. The *equilibrium partition* of output in all marriages of a woman w_i to a man of educational level j is $\left(\mu_j^i \cdot \zeta_k, \left(1 - \mu_j^i\right) \zeta_i, j\right)$. Thus, if at time t an educated woman is married to an uneducated man, her utility flow is $\pi_t^{w_e} = \mu_u^e \cdot (r+1)$. Her husband's utility flow is $\pi_t^{m_u} = (1 - \mu_u^e) \cdot (r+1)$.

- Finally, if a couple fails to agree in period t, and the responder opted to make a counteroffer in the next period, both spouses receive a conflict utility which I normalize to 0.

Each woman i has an inter-temporal utility function of the form

$$U^i = \sum_{t=0}^{\infty} \delta^t \cdot \pi_t^i, \tag{1.2}$$

where π_t^i corresponds to one of the three possible utility levels described above, and $\delta \in (0,1)$ is a discount factor. Interchanging superscripts gives the analogous inter-temporal utility functions for males.

Extensive Form

Bargaining takes the form of a simple alternating offers model, similar to that discussed by Bergstrom (1996, 1993).

of the associated earnings potential, while empirically, assortative mating according to education is a very important feature of marriage markets (see, e.g. Bruze et al., 2012). In particular, individuals are indifferent between two mates of different educational attainment as long as they enjoy the same level of private consumption in both marriages.

Individuals have an infinite time horizon. At the beginning of each period, all single l individuals are matched into couples and start bargaining. In each new match, the first proposer is randomly selected, so each individual makes the first offer with a probability of $\frac{1}{2}$. The offer is always in the form of the woman's share of resources, μ_j^i if the first proposer is the woman and $\widetilde{\mu_j^i}$ if it is the man. The responder has three options:

1. Accepting the offer would lead to immediate payoffs $\mu_j^i \cdot \zeta_{i,j}$ ($\widetilde{\mu_j^i} \cdot \zeta_{i,j}$) for the wife if she (he) is the first proposer and $(1 - \mu_j^i) \cdot \zeta_{i,j}$ (respectively $(1 - \widetilde{\mu_j^i}) \cdot \zeta_{i,j}$) for the husband. Once an offer is accepted, the couple leave the marriage market and enjoy these payoffs forever after.

2. His or her second option is to reject the offer and wait another period to make a counter offer. In this case, man and woman receive a "conflict" utility, that can be interpreted as non-cooperative marriage in the sense of Lundberg and Pollak (1993), in the first period. I normalize this conflict utility to 0. In the next period, the bargaining game is the same with the roles of proposer and responder reversed.

3. The third option is to dissolve the match (the responder can do this unilaterally). Both partners then receive the single utility of 0 in the first period,[1] and go back to the marriage market in the next period.

One can imagine that matching takes place at the beginning of each period, and bargaining and maybe divorce happens at the end of each period. The timeline for this game is depicted in table 1.1, while figure 1.1 shows the extensive form. Section A.1 in the Appendix provides a detailed analytical description of the game.

[1]Allowing for a positive single utility does not enrich the model in very interesting ways. If all individuals have the same single utility, this amounts to a simple rescaling of the model. If we assume that educated individuals have a higher single utility (due to their higher income), but that the single utility of two educated individuals is still smaller than ζ_e, e.g. because of returns to scale in consumption and the joint consumption of public goods, we can normalize so that the single utility of uneducated individuals is zero, while the single utility of educated individuals is some $\zeta_s < r$. This has two effects. First, educated individuals are more likely to dissolve a match rather than make a counteroffer in the next period, because they still enjoy ζ_s if they are single, while their utility in non-cooperative marriage is zero. Second, because educated individuals can always guarantee themselves the single utility, the cake over which spouses bargain in each period simply shrinks by this amount. This makes educated individuals somewhat less attractive for uneducated individuals. A detailed derivation of these results can be found in section 1.7.

Table 1.1: Timeline

t	**Events**
0	Everyone is on the marriage market - matching
	Nature determines the identity of the first proposer
	The first offer is made
	Responders either accept, reject and wait to make a counteroffer or dissolve the match. Couples who have agreed on a distribution leave the market.
1	New (young) entries and divorced match on marriage market.
	Nature determines the identity of the first proposer in new matches
	First offers are made in newly matched couples
	Those who rejected offers in period 0 make counteroffers
	Their partners either accept, reject and wait to make a counteroffer, or dissolve the match. Couples who have agreed on a distribution leave the market.
⋮	⋮

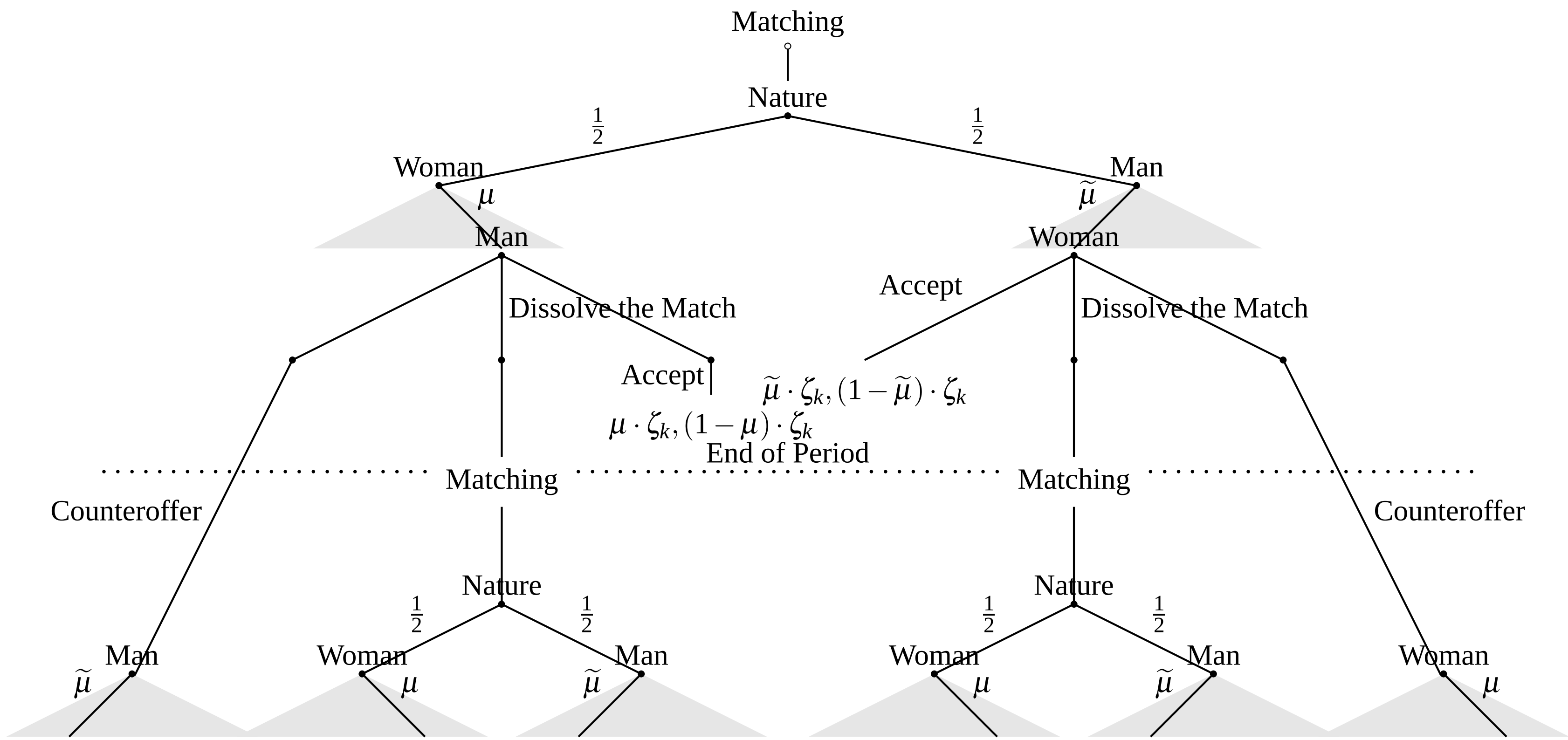

Figure 1.1: Extensive Form

1.4 Analysis

Solving the Game

I only consider symmetric subgame perfect equilibria in stationary strategies. A stationary strategy is independent of the history of the game (all individuals take the same action every time they reach the same node),[1] while in a symmetric equilibrium all individuals of the same type have the same strategy. As a consequence, the bargaining outcome is the same in all couples of the same type. In such an equilibrium, all couples either settle on a distribution of resources in the first period, or divorce without delay (there are no delayed agreements). The subgame perfect equilibrium of the intra-household bargaining game with outside options will pin down the distribution of resources in all couples (it will render μ_j^i and $\widetilde{\mu_j^i}$ $\forall\ i \in \{w_e, w_u\}$ and $j \in \{e, u\}$).

Here, I only present a basic outline on how the game is solved, please see section A.2 for a more technical description.

Suppose, an educated woman finds herself divorced at the end of the current period. Then, her payoff for this period is the single payoff 0. She knows that she will be rematched in the next period, and that her probability of marrying an educated man is the frequency of educated men in the population, q. Also, she will be the first proposer in such a match with probability $\frac{1}{2}$. Hence, her *continuation value* (her present expected lifetime value) of being divorced in any period is

$$\begin{aligned} D^{f_e} \quad = \quad & \frac{\delta}{2} \cdot \Bigg(q \cdot \Bigg(\max \left\{ \frac{1}{(1-\delta)} \cdot \mu_e^e \cdot 2r, D^{f_e} \right\} + \max \left\{ \frac{1}{(1-\delta)} \cdot \widetilde{\mu_e^e} \cdot 2r, D^{f_e} \right\} \Bigg) \\ & + (1-q) \cdot \Bigg(\max \left\{ \frac{1}{(1-\delta)} \cdot \mu_u^e \cdot (r+1) \, , D^{f_e} \right\} \\ & + \max \left\{ \frac{1}{(1-\delta)} \cdot \widetilde{\mu_u^e} \cdot (r+1) \, , D^{f_e} \right\} \Bigg) \Bigg) \end{aligned} \tag{1.3}$$

I refer to these continuation values of divorce in the next period both as *outside option* and *divorce* utilities. The *inside option* for the responder in any given period is the continuation value of staying married and making a counteroffer in the next period. If the inside option utility of an individual in a period in which he or she is the responder

[1] More formally, for any history after which it is an individual's turn to propose a partition of intra-household resources to a partner of type i, $i \in \{e, u\}$, and for each history after which it is her turn to respond to an offer by a partner of type i, she uses the same criterion to choose her action. See, e.g. Osborne and Rubinstein (1994).

exceeds his or her divorce utility, I say that a divorce threat is not credible. That is, the outside option influences the bargaining outcome for any couple only if at least one spouse has a credible divorce threat.

If both have a credible divorce threat, there are no gains from cooperation in this marriage, as both partners could obtain a higher utility with different partners. This can happen only because the matching process is entirely stochastic (choosing a partner to propose to is not permitted). In couples were the joint surplus of accepting the match falls short of the sum of outside option utilities, the proposer may make any offer that will be rejected by the responder. E.g. he or she could propose a share equal to his or her outside option utility. This offer will be rejected by the responder (because the residual of the marital output is smaller than his or her outside option utility). Because the partner knows that he or she will not get her outside option utility by making a counteroffer in the next period (because joint outside option utilities exceed the marital output of this union) the partner will divorce right away. Therefore, the proposer's action to offer a partition of resources that is sure to be rejected by his or her partner is tantamount to rejecting the match.

If neither the husband nor the wife have a credible divorce threat, the bargaining outcome is the standard Rubinstein solution. If only one of the spouses has a credible divorce threat, this spouse gets his or her outside option utility, while the other spouse gets the residual (Binmore et al., 1989). Via this channel, the distribution of resources within different couples are interconnected. The outside option and therefore the equilibrium payoff of every individual depends on the equilibrium resource distribution in all other couples.

The following proposition characterizes the outcome of the intra-household bargaining game with endogenous outside options.

Proposition 1. *For each set of parameter values δ, p, q and r, there exists a unique symmetric subgame perfect equilibrium in stationary strategies. There are nine different equilibria that are associated with nine different, non-overlapping ranges of parameter configurations.*

Proof. See appendix, section A.3.

SSP Equilibria in Stationary Strategies

The nine symmetric subgame perfect (SSP) equilibria in stationary strategies differ in which type of individual has a credible divorce threat in what type of couple - table 1.2 summarizes this. If both individuals have a credible divorce threat, the couple divorces right away, as both of them could do better in a different match, given present marriage market conditions. If only one spouse has a credible divorce threat, this means that he or she can extract a premium over and above their Rubinstein share from their partner.

In none of the equilibria, either spouse has a credible divorce threat in the "best" couple, the couple made up of two educated individuals. Also, the uneducated spouse never has a credible divorce threat in mixed marriages. That means that the dynamics of the marriage market do not allow for anyone to prefer to be married to a person of lesser earnings power, although this would mean more control over household income.

Table 1.2: For Whom is Divorce Attractive?

	$w^e\ m^e$	$w^u\ m^u$	$w^e\ m^u$	$w^u\ m^e$
forever after	N N	N N	N N	N N
holding out for someone better	N N	Y Y	N N	N N
out of your league	N N	Y Y	Y N	N Y
uneducated women get a premium	N N	Y N	N N	N N
uneducated men get a premium	N N	N Y	N N	N N
uneducated women suffer	N N	N Y	N N	N Y
uneducated men suffer	N N	Y N	Y N	N N
men can expect more	N N	Y Y	N N	N Y
women can expect more	N N	Y Y	Y N	N N
market equilibrium	NN	NN	Y N	N Y

The first three equilibria listed in table 1.2 are symmetric in that men and women of the same educational class have the same expected payoff from entering the marriage market. In the *Forever after* equilibrium, marriage market conditions do not matter for intra-household distribution. All couples immediately settle on a distribution of resources according to the standard Rubinstein solution, and there are no divorces.

In the equilibrium I name *holding out for someone better*, both partners in matches of two uneducated individuals have a binding outside option, so these matches immediately dissolve. Uneducated individuals are willing to wait for their chance to be matched to an educated partner, and they can expect to get a Rubinstein share of household resources in such a marriage.

The *out of your league* equilibrium is characterized by all individuals wanting to be married to an educated person: educated individuals in mixed marriages have a binding outside option, so their partners have to pay them a premium to stay married. But mixed marriages are still attractive enough for uneducated individuals to give them a divorce threat in homogeneous marriages, so these matches immediately dissolve.

For the last six equilibria, the marriage market situation is tilted to the favour of either men or women of a certain educational class. In equilibrium *uneducated women get a premium*, uneducated women married to uneducated men have a credible divorce threat, and are able to extract a premium from their husbands; all other couples distribute their household income according to the Rubinstein solution. The equilibrium *uneducated men get a premium* is the equivalent for uneducated men.

In the *uneducated women suffer* equilibrium, uneducated women have to pay a premium to their husbands regardless of their educational class. Uneducated men married to educated women, on the other hand, do not have to pay such a premium. The same is true for uneducated men in the *uneducated men suffer* equilibrium.

Finally, the *men can expect more* equilibrium is characterized by both types of men having a credible divorce threat whenever they are matched to an uneducated woman. In contrast to the *uneducated women suffer* equilibrium, though, this premium is either too high, or there are sufficient educated men on the market, so that uneducated women married to uneducated men also have a credible divorce threat. Hence, these couples divorce in equilibrium. The same is true for women in the *women can expect more* equilibrium.

Only couples where both spouses are uneducated divorce in equilibrium. This is due to the random matching; if these individuals could choose ex-ante that they want to stay single instead of being matched to an uneducated individual, they would receive the same payoff as they do by divorcing.

The next proposition characterizes the outcome of the bargaining game with outside options if individuals are infinitely patient.

Proposition 2 (Behaviour in the Limit)**.** *For $\delta \to 1$, there is a unique symmetric subgame perfect equilibrium in stationary strategies that stretches over the entire parameter space. In this equilibrium, only educated individuals in mixed marriages have a credible divorce threat.*

Proof. See appendix, section A.3.

In this equilibrium (which I call *market equilibrium*, see table 1.2), each individual's share of joint household income corresponds to his or her contribution to it, that is, educated individuals receive a share of r, irrespective of their partner's education. It is not surprising that, for infinitely patient individuals, the unique SSPE is the Walrasian outcome, since there is a large marriage market individuals can fall back on, and matching is random. This equilibrium only exists if $\delta = 1$.

This also highlights the lack of assortative mating in my model: even with infinitely patient individuals, there are still mixed marriages in equilibrium - this is because educated individuals get exactly their contribution to the marriage, r, regardless of the education of their partner. In section 1.7, I allow for more generic marital outputs in a simplified version of the model - I only require that $\zeta_u < \zeta_m < \zeta_e$. In this case, if marital outputs are such that aggregate marital output over the entire economy is maximised if there are as many homogenous couples as possible (given p and q), that is, if $\zeta_e + \zeta_u > 2 \cdot \zeta_m$, there will be assortative mating on the marriage market (that is, if $p = q$, there will only be homogenous couples).

Off-equilibrium Path Payoffs and Delayed Agreements

I only consider subgame perfect equilibria in stationary strategies. In section A.3 in the appendix, I prove subgame perfection for one equilibrium, *forever after* (the Rubinstein-type equilibrium). In this section, I want to show one example of how one-shot deviations from the equilibrium strategy profile are not optimal (as implied by subgame perfection). Then I want to briefly discuss the literature on multiple equilibria and delay in sequential non-cooperative bargaining games in the context of my model.

First, consider one-shot deviations from the equilibrium strategy profile in the *holding out for someone better* equilibrium. In this equilibrium, a couple of two uneducated individuals divorce right away, while there are immediate agreements in all other types of couples. The marriage market influences the bargaining outcome in this equilibrium, because uneducated individuals have a credible divorce threat in homogenous marriages. For the exact parameter configurations for which this equilibrium exists and the equilibrium shares, please see section A.3 in the appendix. The strategy profile that implements this equilibrium is the following:

- Educated women: Regardless of the type of the husband, always offer $\mu_j^e = \frac{1}{1+\delta}$, $j \in \{e, u\}$, accept any offer $\widetilde{\mu_j^{e}}' \geq \frac{\delta}{1+\delta}$, reject any other offer. Always make a counteroffer after rejecting an offer.
- Educated men: Regardless of the type of the wife, always offer $\widetilde{\mu_e^j} = \frac{\delta}{1+\delta}$, accept any offer $\mu_e^{j\prime} \leq \frac{1}{1+\delta}$, $j \in \{e, u\}$, reject any other offer. Always make a counteroffer after rejecting an offer.
- Uneducated women: When matched to an educated man, always offer $\mu_e^u = \frac{1}{1+\delta}$,

accept any offer $\widetilde{\mu_e^u}' \geq \frac{\delta}{1+\delta}$, reject any other offer. Always choose to make a counteroffer after rejecting an offer. When matched to an uneducated man: Always offer any

$$\mu_u^{u\prime} > \frac{(\delta-2)(4\delta-3p\delta-4)+q\delta(-3\delta+2p\delta+4)-r\delta(2p-p\delta-q\delta+2pq\delta)}{4(-2\delta+p\delta+q\delta+2)} \tag{1.4}$$

(any strategy profile with a $\mu_u^{u\prime}$ satisfying condition (1.4) implements *holding out for someone better* as an equilibrium).

Accept any

$$\widetilde{\mu_u^u}' \quad \geq \quad -\frac{\delta(2q+4\delta-3p\delta-3q\delta-2qr+2pq\delta+pr\delta+qr\delta-2pqr\delta-4)}{4(-2\delta+p\delta+q\delta+2)}, \tag{1.5}$$

reject any other offer. Always divorce after rejecting an offer.

- Uneducated men: When matched to an educated woman, always offer $\widetilde{\mu_u^e} = \frac{\delta}{1+\delta}$, accept any offer $\mu_u^{e\prime} \leq \frac{1}{1+\delta}$, reject any other offer. Always make a counteroffer after rejecting an offer.

  When matched to an uneducated woman, always offer any

  $$\widetilde{\mu_u^u}' \quad < \quad -\frac{\delta(2q+4\delta-3p\delta-3q\delta-2qr+2pq\delta+pr\delta+qr\delta-2pqr\delta-4)}{4(-2\delta+p\delta+q\delta+2)},$$

  (again, there is a continuum of strategy profiles implementing this equilibrium) accept any

  $$\mu_u^{u\prime} \leq \frac{(\delta-2)(4\delta-3p\delta-4)+q\delta(-3\delta+2p\delta+4)-r\delta(2p-p\delta-q\delta+2pq\delta)}{4(-2\delta+p\delta+q\delta+2)}, \tag{1.6}$$

  reject any other offer. Always divorce after rejecting an offer.

Consider an educated woman confronted with an uneducated man's equilibrium offer of $\widetilde{\mu_u^e} = \frac{\delta}{\delta+1}$. If she follows her equilibrium strategy of accepting, the present value of her utility flow is $\frac{1}{1-\delta}\frac{\delta}{\delta+1}\cdot(r+1)$. A one shot deviation from her equilibrium strategy, say, rejecting her partner's equilibrium offer and divorcing instead, implies a utility of 0 in the present period. Reverting back to her equilibrium strategy in the next period is associated with a continuation value of $\frac{\delta}{2}\left(q\cdot\left(\frac{1}{\delta+1}+\frac{\delta}{\delta+1}\right)\cdot 2r+(1-q)\left(\frac{1}{\delta+1}+\frac{\delta}{\delta+1}\right)\cdot(1+r)\right)$ given the equilibrium strategy profile. This is higher than the continuation value associated with her equilibrium strategy only if $2r \leq (1-\delta^2)(r\cdot(1+q)+1-q)$, which cannot be the case given that $r > 1$, $\delta < 1$ and $q \leq 1$.

Can there be multiple equilibria, or delayed agreements, in this model setup? In games of complete information, equilibria with delayed agreements typically only occur if there are multiple equilibria in stationary strategies that can function as threats; since threats can only be credible if actions can be conditioned on history of the game, these equilibria are generally not stationary (Merlo and Wilson, 1995). Merlo and Wilson (1995) show that if all players have a linear von Neuman-Morgenstern utility defined over their physical consumption of the cake (as it is the case in my model), the stationary subgame perfect payoff is unique.[1] Moreover, if it is impossible to achieve a Pareto improvement of the equilibrium payoffs by delaying agreement, as it is the case with a deterministic cake, this SSP is Pareto efficient (there are no delayed agreements). For two player games, they show furthermore that the subgame perfect equilibrium payoff is unique if and only if the stationary subgame perfect payoff is unique (so, if there exists a unique subgame perfect equilibrium in stationary strategies, it is the unique subgame perfect equilibrium).

Avery and Zemsky (1994) show that there can be multiple equilibria in alternating offers bargaining games with complete information when one player can credibly threaten to "burn money" (destroy surplus) when her offer is rejected. They point out that whenever a player can only take up her outside option after *rejecting* an offer, her threat can be diffused by her opponent by offering whatever is greater, the outside option or the continuation payoff of making a counteroffer. Multiple equilibria can only be sustained if a player can take up an outside option after her offer is refused. This is the case for "intermediate" outside option payoffs, where the player's threat to leave relies on the fact that not leaving will only give her the residual of her partner's outside option payoff, discounted by two periods (because it will only be her turn to propose again in two period's time). Osborne and Rubinstein (1990, section 13.2.1) show that if a player can opt out only after rejecting an offer, there is a unique subgame perfect equilibrium, where the outside option is either small and does not influence bargaining at all, or big enough to completely determine the bargaining outcome. Ponsati and Sakovics (1998) point out that when only the responder can decide to terminate the bargaining and take up an outside option, there is a unique subgame perfect equilibrium, whereas two-sided outside options can lead to multiple equilibria.

[1] They proof this for a quite generic framework that incorporates a wide range of non-cooperative sequential bargaining games with complete information. My model fits into this framework as a sequential bargaining model with only one offer per period, but the continuation game in the event of the rejection of an offer (counteroffer or divorce) does depend on the actions of the players in my model, in contrast to Merlo and Wilson (1995).

In summary, I concentrate my analysis on symmetric subgame perfect equilibria in stationary strategies. In my model, a player can only take up her outside option after rejecting an offer. This is associated with a unique equilibrium: either, the outside option is so small that it is irrelevant (and the players agree on the Rubinstein partition), or it is so big that it completely determines the outcome (the responding player gets her outside option, and the other player the residual). As Merlo and Wilson (1995) point out, in games with complete information and a deterministic "cake", delayed equilibria typically rely on multiple equilbria in stationary strategies, where an equilibrium can be used as a threat of punishment. Non-stationary strategies are needed to support these kinds of equilibria, so punishments can be conditioned on the opponents' past behaviour. Since, if a match is dissolved, agreement between these two players ceases, it is not possible to exercise any punishments after the divorce outside option is taken up. Therefore, because the equilibrium in stationary strategies is unique, equilibria with delay cannot be constructed in my model even with non-stationary strategies.

Discussion

In this section, I look at which equilibrium characterizes intra-household distribution depending on the economically interesting parameters of the model (r and p and q). I state the (analytical) conditions for the existence of each of these equilibria in the appendix (A.3).

Figure 1.2 depicts the range of parameters in which the nine equilibria exist if the tertiary education rate of women is relatively low - at thirty percent - for varying values of men's educational attainment q and the measure of wage inequality r.

For a low level of wage inequality r, divorce is very unattractive, no matter how many men become educated. If the wage for an educated person is less than 50 percent more than the wage of an uneducated person, women do not want to get divorced from uneducated men, even if everyone else in the marriage market is educated (this area is shrinking for an increasing δ). This is the standard Rubinstein equilibrium, in which the outside options are irrelevant, and every matched couple stays together.

As wage inequality increases, uneducated men married to women of the same educational level get a binding divorce threat and are able to extract a premium in these marriages - this is equilibrium *uneducated men get a premium.* As wage inequality further increases, while the fraction of educated men decreases (in the bottom right corner of figure 1.2), uneducated women have to pay a premium regardless of the educational level of their partner - that is, uneducated men can extract a premium in homogeneous, and

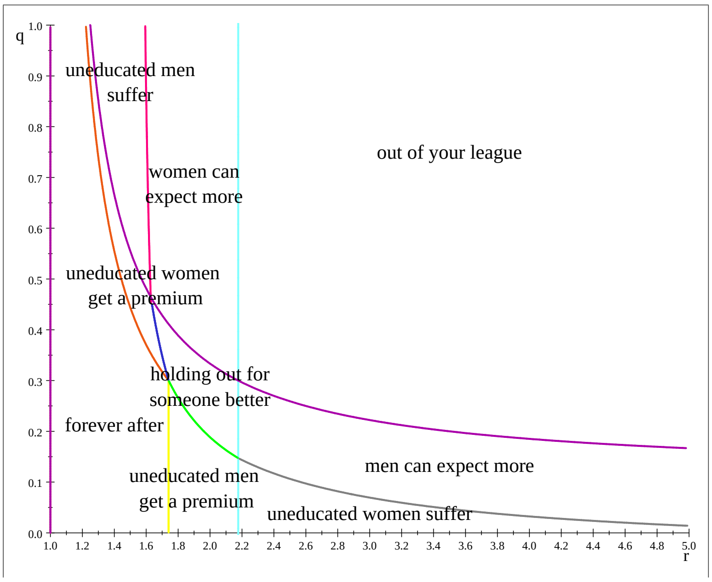

Figure 1.2: $\delta = 0.8, p = 0.3$

educated men in mixed marriages. This is the equilibrium I named *uneducated women suffer*.

The reverse happens for higher values of q: in equilibrium *uneducated women get a premium*, uneducated women have a binding divorce threat when married to uneducated men, while, for even higher values of q, women can extract a premium whenever they are matched to an uneducated man.

For intermediate levels of q and r, uneducated men and women have a binding divorce threat when they are matched with each other, that is, matches of two uneducated individuals immediately dissolve. This is because, given the immediate level of r, educated partners in mixed marriages cannot extract a premium, so they are very attractive for uneducated individuals (this is the *holding out for someone better equilibrium*).

As r further increases to the right of this area, matches of uneducated individuals still dissolve immediately, but now educated men in mixed marriages can ask for a premium - this is the *Men can expect more* equilibrium. Conversely, as q increases to the north of the *holding out for someone better* area, educated women can ask for a premium in mixed marriages (and matches of uneducated individuals dissolve). In this area, the equilibrium then is *women can expect more*.

Finally, in the top left corner of figure 1.2, r and q are big enough so that educated individuals in mixed marriages have a credible divorce threat. Uneducated couples still dissolve, so everyone who is married to an uneducated individual has a credible divorce threat - everyone wants to be matched to an educated person.

Due to the complete symmetry of the model, the same analysis applies if we keep q fixed and let p vary, with all equilibria mirrored on the main axis. I produce this graphic in the appendix (section A.4).

The role of wage inequality

As is apparent from the above discussion, the level of wage inequality, or the return to education, increases inequality within couples - as we move from the left to the right of the graph, the number of individuals who have a credible divorce threat within marriage increases. But a higher wage inequality also destabilizes marriages for most values of p and q. To see this, consider figures 1.3 and 1.4. They depict the partition of the parameter map into the nine equilibria for $r = 1.5$ and $r = 2$ respectively for all possible combinations of women's and men's educational attainment. If wage inequality is moderate - educated workers earn 50 percent more than uneducated workers - there is no divorce in equilibrium unless more than half of all men or women obtain a university degree; and even then at least 40 percent of the other gender group would also have to get educated to produce divorce in equilibrium (these are the *uneducated men/ women suffer* equilibria). If educational attainment for both men and women is under 44 percent, intra-household distribution is egalitarian, and uneducated individuals benefit from marrying "up". For a higher level of wage inequality, as depicted in 1.4, this *forever after* equilibrium is a SSPE only if education is very exclusive, only up to 22 percent of men and women can become educated for it to exist. On the other hand, we will see divorce in equilibrium, if at least one third of men or women obtain a degree, while at the same time around 20 percent of the other gender group also get educated. If we increase the level of wage inequality further to $r = 2.4$, the college attainment rates required to produce divorce in equilibrium further decrease, see figure A.2 in the appendix (section A.5).

The above discussion does not rely on the alternating offers structure of my model. Wage inequality would increase inequality within couples in many marriage market models with binding agreements on the marriage market stage, while models with random matching could generate divorce rates that rise with wage inequality. Where the bargaining setup does cause a difference between the empirical implications of my model and other marriage market models is the role of gender specific education rates, see section "payoffs" below.

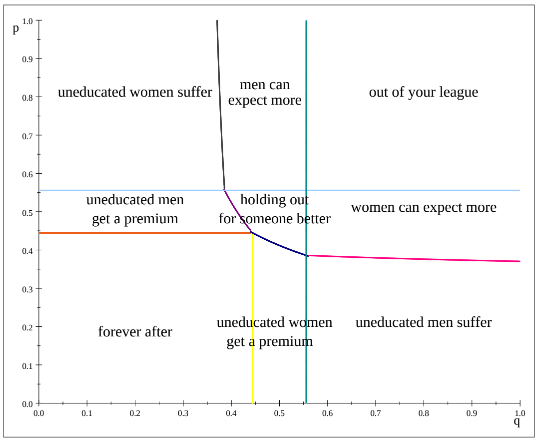

Figure 1.3: $\delta = 0.8, r = 1.5$

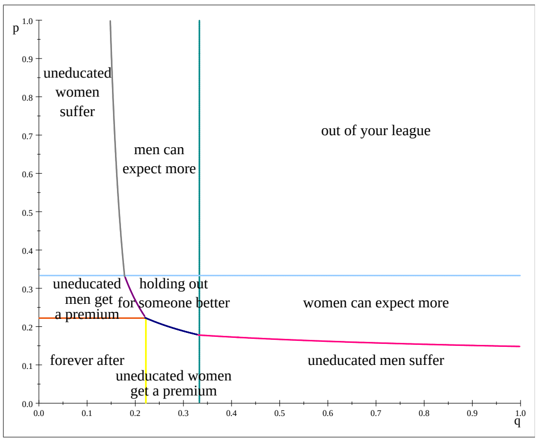

Figure 1.4: $\delta = 0.8, r = 2$

Empirical Implications

One result of my model is that that increasing wage inequality destabilizes marriages. This is in line with empirical evidence. Gould and Paserman (2003) examine the influence of male wage inequality on marriage rates. They show that women search longer for a husband in cities with higher wage inequality, and attribute about 25 percent of the decrease in the marriage rate in the US over the last decades to increased income inequality. A higher range in the quality of potential husbands makes it worthwhile for women to stay on the marriage market for a longer time. This is equivalent to the increased occurrence of divorce for higher levels of wage inequality in my model, if we interpret the bargaining as pre-marital.

My model also predicts that the less educated are more likely to get divorced, a fact that is well established in the empirical literature. Stevenson and Wolfers (2007) use data from the 1950-1955 US birth cohort to show that by age 45, 34.8 percent of all college graduates who ever married saw their first marriages end in divorce, while among those without a college degree, 44.3 went through a divorce. Using Data for the cohort of the US high school class of 1972, Weiss and Willis (1997) show that, compared to the baseline case were both spouses' highest education is high school, two college graduates have a 50 percent lower chance of getting divorced; while a couple were she is a college graduate and he is not still have a 13 percent lower change of getting divorced. A husband's university degree, if the wife is a high school graduate, decreases the divorce hazard by 25 percent.

Payoffs

How do marriage market conditions influence individual consumption within marriage quantitatively? If an individual has a credible divorce threat within a marriage, they will ceteris paribus be able to control a share of household income that exceeds their Rubinstein share.

To see how a change in the educational attainment of men influences women's share of household income, assume that thirty percent of all women become educated. Then, for a society where educated individuals earn fifty percent more than uneducated individuals, figure 1.5 depicts how intra-household distribution evolves as the proportion of men who obtain an educational degree, q, changes. The wife's share of household resources if she makes the first offer is plotted on the y axis, while the share of educated men is plotted on the x axis. Marriage market conditions do not influence intra-household distribution

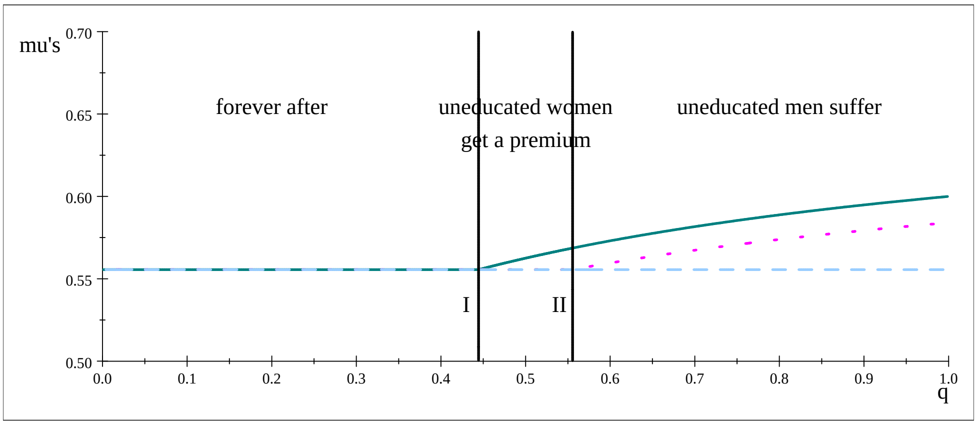

Figure 1.5: Payoffs for $\delta = 0.8, p = 0.3, r = 1.5$. μ_u^u=blue green solid, μ_u^e=pink dotted, μ_e^u= light blue dashed

if less than 44 percent of all men become educated; the wife's share in the subgame in which she makes the first offer is in line with her first mover advantage in all couples. As we transit the line I, uneducated women obtain a credible divorce threat when they are married to uneducated men, because their chance of meeting an educated man if they divorce increases. Their share of household resources rises in these matches, and increases steadily with q. As we transit line II, also educated women in mixed marriages can credibly threaten with divorce, so all women who are married to uneducated men can extract a premium - the increase in men's educational level hurts uneducated men.

For a higher level of wage inequality, $r = 2$, the wife's share of household resources if she is the first proposer is plotted against q in figure 1.6. If educated men are scarce on the

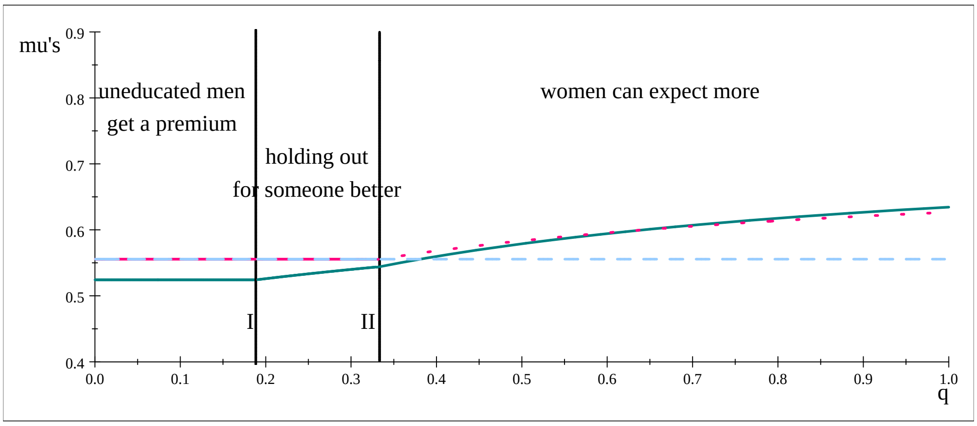

Figure 1.6: Payoffs for $\delta = 0.8, p = 0.3, r = 2$. μ_u^u=blue green solid, μ_u^e=pink dotted, μ_e^u= light blue dashed

marriage market, uneducated men have a credible divorce threat in homogeneous couples (remember that thirty percent of all women are educated), so the woman's first mover advantage is compromised - this is equilibrium *uneducated men get a premium*. As the share of educated men increases, uneducated women in those matches also get a binding divorce threat, so their partners would have to offer them a premium to persuade them to remain in the match. But these matches are dissolved in equilibrium in the *holding out for someone better* equilibrium, because both partners hope to be matched to an educated individual the next time around. As we move past line II, also educated women in mixed marriages have a credible divorce threat, so both educated and uneducated women can increase their shares when married to an uneducated man. As before, all matches of two uneducated individuals immediately dissolve, while uneducated men are willing to pay a premium in mixed marriages.

If we set r even higher, to 2.4, payoffs are depicted in 1.7. For low levels of q, men have a credible divorce threat whenever married to an uneducated woman, regardless of their own educational attainment - this is the *uneducated women suffer* equilibrium. However, as can be seen in figure 1.7, this hits women married to uneducated men much harder than women in mixed marriages, who only loose very little of their first mover advantage (about one percentage point).

As the frequency of educated men in the marriage market increases beyond the line I, uneducated women married to uneducated men also obtain a credible divorce threat. Their likelihood of being matched to an educated man is higher in this region, while their share in a mixed marriage would still be very close to the Rubinstein solution. This

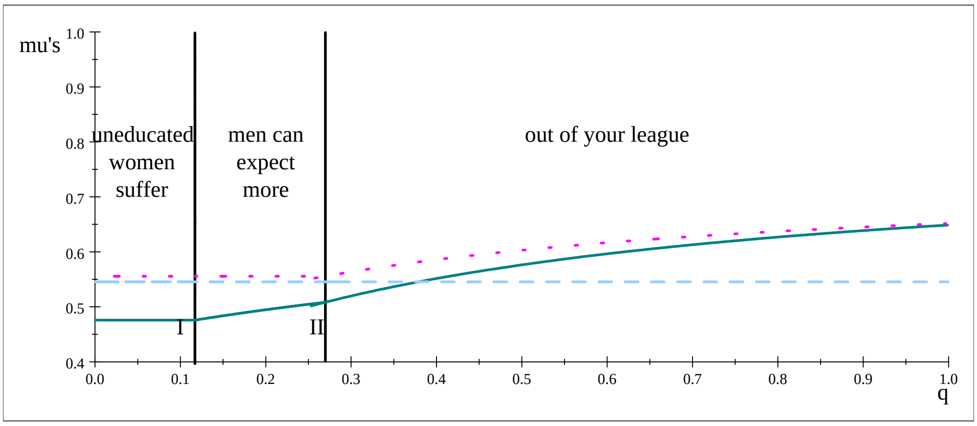

Figure 1.7: Payoffs for $\delta = 0.8, p = 0.3, r = 2.4$. μ_u^u=blue green solid, μ_u^e=pink dotted, μ_e^u= light blue dashed

however is off the equilibrium path, as both partners have a credible divorce threat in this situation, and these matches dissolve. As q increases further to the right of II, also educated women in mixed marriages have a credible divorce threat, which causes their share to rise. The share of educated men in mixed marriages is stable, because it only depends on men's marriage market prospects, as indicated by p, which we hold constant. Since their wives do not have a binding outside option (wage inequality r is so big, that marrying an uneducated man would mean sacrificing a lot of income), their marriage market prospects do not influence the distribution of resources.

Note that an increase in men's educational attainment while holding women's fixed does not "drive down the price" of educated men. They always control their Rubinstein share of joint resources. It does, however, reduce the payoff of uneducated men. Therefore, the higher men's educational attainment, the higher is ceteris paribus their incentive to invest in education. Uneducated women on the other hand see their share of resources increase with a rise in men's educational attainment, notwithstanding the schooling of their own husbands. Hence, their investment incentive ceteris paribus becomes weaker with a rise of male education.

Also, quantitatively, *within* household inequality increases with wage inequality: the area in which household income is distributed evenly (according to the Rubinstein shares) shrinks as r rises, and the premium for those with credible divorce threats increases quantitatively.

1.5 Education Decision

The decision whether to obtain a college degree or not is driven by many factors, only some of which are economic in the narrow sense of the word. The socio-economic background, especially parental education, and the attitude to education prevalent in a student's social environment are crucial for explaining a young person's decision whether to go to college or not (see, e.g. Akerlof and Kranton, 2010). Therefore, marriage market responses to changes in the relative educational attainment of men and women and their influence on intra-household distribution as discussed above are of interest in their own right.

Although the marriage market has been shown to influence educational choices (see section 1.2), young men and women may be unable to accurately predict the marriage market situation they are going to face in the future at the time they decide whether to go for a college degree or not, or they may take this decision on the basis of other, non-economic considerations. Knowing how a new generation's education choices influence the marriage market gives us valuable information on intra-household distribution and therefore well-being at the individual level, even if the influence on their personal relationships is only one in many factors students consider when thinking about aiming for a university degree.

Nevertheless, in this section I want to look at how education rates would evolve in the baseline case were individuals take their education decision considering the overall return to education - that is the labour market return (the wage advantage college graduates have over non graduates), and the marriage market return (total household income and its distribution between spouses).

I assume that individuals decide whether or not to obtain a university degree before entering the marriage market, and that the degree comes at the lump sum cost of k, which represents a direct cost of education that is incurred at the time an educational course is started - either fees or the present value of a student loan. This is the simplest possible way to introduce the educational choice into the model; I do not assume any intrinsic differences between men and women, or any heterogeneity within the population. The results are exclusively driven by the dynamics of the marriage market and household bargaining.

In the absence of a marriage market (if everyone remained single forever) individuals would become educated as long as the present value of their lifetime wage increase due to their education outweighs its cost:

$$k \leq \frac{\delta}{(1-\delta)} \cdot (r-1)\,. \tag{1.7}$$

There would be both educated and uneducated individuals only if condition (1.7) were to hold with strict equality. I will use this condition as a benchmark for efficiency in my discussion of the educational choice because, in my model, the surplus from education comes from the labour market, but is distributed on the marriage market. To maximise the total payoff in the economy, this is the only relevant statistic. The individual return to education of course does depend on the marriage market return and therefore on the marriage market equilibrium. For a given equilibrium on the marriage market, and parameter values k and r, there will be both educated and uneducated men and women only if the utility of being educated is the same as the utility of remaining uneducated. Otherwise, either everyone or no-one decides to invest in education (there are corner solutions for either or both p and q, see section A.6 in the appendix for details).

Not all equilibria identified in the analysis without education decision continue to be subgame perfect with the addition of this first stage. I discuss them here in turn. Please see appendix section A.6 for a detailed discussion of how I arrive at these results.

Proposition 3 (Forever after)**.** *If individuals expect to obtain a Rubinstein share of household income on the marriage market, nobody decides to obtain a university degree if*

$$k > \frac{1}{2} \cdot \frac{\delta}{(1-\delta)} \cdot (r-1)\,. \tag{1.8}$$

If condition (1.8) holds with equality, men and women are indifferent between obtaining an education and refraining from doing so, regardless of the values of p and q. Therefore, any combination of p and q that is a SSPE in the marriage market game is a SSPE in the augmented game. If k is small and condition (1.8) does not hold, forever after *is not a SSPE of the augmented game.*

It is not surprising that the the graduation rates do not influence the education decision in the *forever after* equilibrium, since there is no credible divorce threat in any type of couple, so individuals completely disregard the marriage market while bargaining.

If condition (1.8) holds, then the *forever after* equilibrium is subgame perfect, everyone remains uneducated and obtains the Rubinstein share of the household income. If it holds with equality, any combination of p and q can be sustained as an SSPE, as long as p and q do not become high enough to cause the *forever-after* equilibrium to break down at the marriage market stage.

Proposition 4 (Holding out for someone better)**.** *Men and women becoming educated at equal rates $p = q$ is a SSPE equilibrium of the game with education decision for the range of p and q which support* holding out for someone better *at the marriage market stage.*

In this equilibrium, uneducated couples get divorced at the marriage market stage, while the distribution is according to the Rubinstein shares in all other couples. Anticipating this equilibrium on the marriage market, women find it optimal to become educated if

$$k < \frac{\delta\left(r - 2q - \delta + 2q\delta - r\delta - q^2\delta + q^2 r\delta + 1\right)}{2\left(q\delta - \delta + 1\right)\left(1 - \delta\right)}. \tag{1.9}$$

Interchanging p and q gives the same condition for men, this equilibrium is fully symmetric. Everyone invests in education at very low levels of k (e.g., for $r = 1.5$ and $\delta = 0.8$ everyone invests if $k < 1$). This however is not subgame perfect, as *holding out for someone better* is not an SSPE on the marriage market stage for high levels of p and q. The willingness to pay for education for both sexes decreases with the educational attainment of the opposite sex, which we would expect, since for an uneducated individual being matched to someone of the same type is tantamount to getting divorced.

Proposition 5 (Out of your league)**.** *All values of p and q along the 45 degree line were $p = q$ that support* out of your league *as a SSPE on the marriage market stage are also SSPE's of the augmented game with education decision.*

In this equilibrium, both uneducated partners in a marriage have a credible divorce threat, and break up right away, while educated partners in mixed marriages also credibly threaten with a divorce, and are able to extract a premium. If individuals expect their personal income to be determined by this equilibrium, their education decisions follow the following pattern: For a given k, women are more likely to invest in education for low levels of q - this is because their probability of being matched into an uneducated couple and subsequently getting divorced decreases with q. Their propensity to invest in education increases with p, because the premium uneducated women have to pay educated men in mixed marriages increases with the fraction of educated women. Men's educational choices are driven by the same forces.

Proposition 6 (Uneducated men get a premium)**.** *If k is such that*

$$k = \frac{\delta}{2\left(1 - \delta\right)} \cdot \left(r - 1\right), \tag{1.10}$$

uneducated men get a premium *is a SSPE of the augmented game with education decision. The associated equilibrium values of p and q satisfy*

$$p = \frac{2(1-\delta)}{(r-1)(\delta+1)} \quad \textit{and} \quad q < p. \tag{1.11}$$

For example, if the measure of wage inequality $r = 1.5$ and the discount factor is $\delta = 0.8$, $p = 0.44$ is a SSPE equilibrium of the extended game with education decision if the fraction of men who become educated is lower than 44 percent. In figure 1.3, the entire lower boundary of equilibrium *uneducated men get a premium*, depicted in orange, is supported as an equilibrium were women's educational attainment is higher than men's.

If condition 1.10 is not satisfied, equilibrium *uneducated men get a premium* cannot be sustained as a SSPE in the augmented game. Depending on k, either all men or women or nobody becomes educated; these values of p and q however do not support *uneducated men get a premium* as a SSPE on the marriage market stage.

Women's willingness to pay for education is lowest for both p and q close to 0 (then, the premium men receive in uneducated couples is actually negative, but this is off the equilibrium path). They are willing to become educated at the highest values of k if there are hardly any educated men on the marriage market, and all other women become educated as well - they want to escape the maximum punishment of being matched to an uneducated man (very likely for a low value of q) when the premium women have to pay in these marriages is high (since educated women are abundant in the marriage market). While the education decision of a man is independent of the rate of men's educational attainment q, men have the highest willingness to pay for education if educated women are very scarce on the marriage market (so the premium they would get if matched to an uneducated woman would be quite low). Their willingness to pay for education falls in p and reaches a minimum at $p = 0.7$, increasing marginally for higher values of p. Since the share of uneducated males in homogeneous marriages increases with p, it is not surprising that their propensity to invest in education falls as p increases. That it reaches a minimum and goes up again reflects the increased likelihood of men to be matched with an educated woman, and enjoy a part of her income, too - this only kicks in at quite high values of p.

Proposition 7 (Uneducated women suffer)**.** *There are values of k and r for which* uneducated women suffer *is a SSPE of the extended game with education decision, and some men and women decide to become educated while others do not. The fraction of* *educated men and women in this equilibrium is:*

$$p = \frac{(1-\delta)\left(k\left(\delta+\delta^2-2\right)+\delta\,(r-1)\right)}{\delta\,(k\,(1-\delta^2)-\delta\,(r-1))}, \tag{1.12}$$

$$q = \frac{\left(\delta\left(r^2-1\right)-k\,(1-\delta)\,(3r+\delta+r\delta-1)\right)}{(r-1)\,(k\,(1-\delta^2)-\delta\,(r-1))}. \tag{1.13}$$

In this equilibrium, uneducated women have to pay a premium in marriage, notwithstanding their husband's educational attainment. Anticipating this equilibrium, women want to become educated if

$$k < \frac{\delta\left(r\delta\,(q+\delta-q\delta+1)+\delta\,(-q-3\delta+q\delta+1)-2\left(p\delta+p\delta^2+1\right)(r-1)\right)}{2\,(\delta-1)\,(p\delta-\delta-\delta^2+p\delta^2+2)} \tag{1.14}$$

They are more inclined to become educated the higher p (that is, the higher the premium they have to pay if they are uneducated, regardless of the type of their partner) and the lower q (if matched to an uneducated man, they receive a small share of a smaller cake). Men are willing to invest in education as long as

$$k < \frac{\delta\,(r-1)\,(-\delta+p\delta+1)}{(1-\delta)\,(-\delta+p\delta-\delta^2+p\delta^2+2)} \tag{1.15}$$

holds. Their willingness to pay for education increases with their probability to be matched to an educated woman, however their general willingness to pay for education is lower than that of women.

The interior solution presented in the proposition implies a stark asymmetry between male and female graduation rates and is only an equilibrium for a slim interval of values for r and k (see appendix A.6). As an example, consider $r = 1.2$, $k = 0.45$ and $\delta = 0.8$. Then, roughly ninety-eight percent of all women, and nine percent of all men would obtain a university degree.

If k becomes big enough so (1.15) does not hold, men are at a corner solution and no man becomes educated. Some women decide to become educated and some do not until k becomes prohibitively large. For example, for $r = 1.5$ and $\delta = 0.8$ there are values of k that support every level of women's educational attainment between 55 and 100 percent, as long as men do not become educated. These values are SSPE on the marriage market stage, see figure 1.8. In this figure, it can clearly be seen how women's willingness to pay for education increases, if more women become educated.

Proposition 8 (Men can expect more)**.** *There are no interior solutions for p and q that*

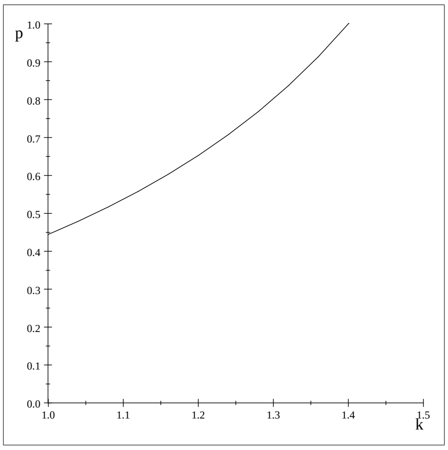

Figure 1.8: Women's educational attainment in *Uneducated women suffer* for $\delta = 0.8, r = 1.5$ and $k > 1$.

are supported as SSPE equilibria on the marriage market stage. If, however,

$$k = \frac{\delta}{2(1-\delta)} \cdot (r+1), \tag{1.16}$$

k is high enough to deter all men from becoming educated. Then, every level of p that is supported as a SSPE in the marriage market game is a SSPE in the augmented game.

In this equilibrium, matches of two uneducated individuals break up right away, and educated men can extract a premium in mixed marriages. Women's willingness to pay for education is the highest for low levels of q, notwithstanding how many other women become educated. At low levels of q, women are poised to pay for education to escape the risk of divorce if matched to an uneducated man. Only for higher levels of q, women's willingness to pay for education increases with the number of other women who decide to become educated. This is because educated men can demand a premium in mixed marriages, and it increases in p. Hence, if the probability to be matched into this type of couple is high, and such matches are increasingly unattractive, women have a higher incentive to become educated.

Men's education decision is independent of the decision of other men. They are more likely to invest for lower values of p (also to escape the divorce risk) and lower values of k.

If the cost of education becomes high enough to deter all men from becoming educated, there are equilibria were some women become educated and others do not, as stated in the proposition. However, that wage inequality r has to be quite high to implement *men can expect more* as a SSPE in the marriage market game, if no man decides to become educated.

The equilibria *uneducated women get a premium*, *uneducated men suffer* and *uneducated women suffer* are akin to equilibria *uneducated men get a premium*, *uneducated women suffer* and *men can expect more* with the roles of women and men reversed.

Efficiency of Premarital Investments

Much has been made in the literature of how the prospect of a future marriage might influence the efficiency of investments in human capital that are made at a relatively young age. There are two opposing stories about how the anticipation of the marriage market could distort the incentives for investments in education: first, the hold-up problem could lead to inefficiently low investments in human capital. Because income is a public good within the household, individuals cannot reap the entire benefit of their costly investment in human capital, and since education is normally completed before marriage, spouses cannot coordinate their investment choices. As a consequence, individuals fail to take into account the welfare that will accrue to their future partner from their higher income, which results in inefficiently low education levels.

Secondly, competition on the marriage market could lead to investment in education over and above the level indicated by the expected labour market return, because individuals want to keep up with the rest of their cohort in order to stay in the race for the most attractive partners in marriage (Peters, 2007). A prisoner's dilemma type of situation arises, in which everyone obtains more than the efficient amount of education.

Peters and Siow (2002) and Iyigun and Walsh (2007) on the other hand show that in a large and frictionless marriage market that is characterised by assortative matching, all externalities of the premarital education decision are internalised, and in equilibrium, investment decisions are efficient. In a recent paper, Bhaskar and Hopkins (2011) challenge the strong efficiency result of Peters and Siow (2002), and show that in the frictionless marriage market environment with non-transferable utility they propose, there is typically a multiplicity of equilibria, some of which are characterised by inefficient levels of education. They introduce a stochastic component to the returns to education to obtain a unique equilibrium. Investment in education is only efficient if women and men are completely symmetric - gender differences or an unbalanced sex ratio on the marriage market lead to inefficient investment levels (mostly over-investment).

Cole et al. (2001) develop a model were agents make complementary investments before meeting on the market, were they bargain over the surplus generated from their investments. Investment choices are made non-cooperatively before matching, while bargaining on the market is cooperative. They show that assuming a *continuum* of agents on both sides of the market complicates the definition of a feasible and stable match.[1] Defining feasibility such that each agent knows his or her return as a function of the return of the other agents (which is necessary so the agent can choose his or her investment) is non-trivial in this case.[2]

In the framework of Felli and Roberts (2011), a finite number of buyers and sellers choose a match specific investment before entering the market. The surplus of a match between a buyer and a seller depends on both their innate characteristics and their match specific investments. After having made their investment choices, the buyers compete on the market for sellers according to a Bertrand competition game. Because of Bertrand competition, the sellers' payoff is completely determined by their outside option (the second best offer they get in the Bertrand game), and, as a consequence, they always underinvest in equilibrium. Although the (efficient) equilibrium in which buyers and sellers match assortatively according to their innate abilities always exists, equilibria in which buyers' qualities (innate abilities combined with investment choices) do not have the same rank as their innate abilities, can be constructed, which leads to inefficient matches.[3] The efficiency of the ex-ante investments therefore depends on the efficiency of the match in equilibirum.

In my model, both over and underinvestment in education are possible, depending on the equilibrium (although the source of over-investment is different from the one discussed by Peters (2007)).

As stated at the beginning of section 1.5, efficiency demands that all individuals invest in education as long as

$$k \leq \frac{\delta}{(1-\delta)} \cdot (r-1)\,. \tag{1.17}$$

[1]Specifically, assume that the investment (or attribute choice) is a strictly increasing function of agent characteristics. Then, if the surplus function displays strict complementarity in investments (attributes) of both partners, a stable assignment on the market must be positively assortative in investments. With a finite population of agents, this is equivalent to agents matching according to their rank in the investment distribution, and therefore according to their rank in the characteristics-distribution. The same is true in the case of a continuum of agents if the investment choices are a continuous function of agent characteristics, but this does not need to be the case. Since one would want that, with a continuum of agents, no agent can adversely affect the payoffs of all other agents, a feasible and stable bargaining outcome should have the feature that if one agent chooses an attribute at a point in the investment function were it is not continuous, the payoffs of the other agents are not affected. This is not the case for a usual pairwise feasibility definition.

[2]This is not a problem in my model, because agents are not heterogeneous ex-ante, and the attribute choice is discrete.

[3]Since in my model, individuals do not differ according to their abilities, this is not an issue.

How many individuals invest in education crucially depends on the cost of education k which is a parameter in my model. When I say that investment in education can be inefficiently low I mean that there are levels of k that satisfy (1.17), but still deter some or all individuals from investing in education.[1] Conversely, I say that over-investment can occur if at least some individuals would invest in education at a cost k that violates (1.17).

Clearly, in the *forever-after* equilibrium, underinvestment occurs because individuals correctly anticipate that they will only enjoy half of the returns to education - this is the classic hold-up problem. Because divorce threats are not credible here, the marriage market cannot mitigate the inefficiency arising from the fact that income is a household public good. The same is true for the *uneducated men/women get a premium* type equilibria, and underinvestment is stronger for the gender group that can demand a premium above the Rubinstein share in equilibrium (since this premium is an extra incentive to remain uneducated).

Also in the *uneducated men/women suffer* equilibria, investment in education is inefficiently low. As expected, the inefficiency is more pronounced for the gender group that has a credible divorce threat in equilibrium, but also the other group's education falls short of the efficient level. Although women want to escape having to pay a premium to their partner if they remain uneducated, the fraction of educated men in the *uneducated women suffer* equilibrium is low enough that the hold-up problem prevents them from investing in education at levels of k for which the labour market return would still warrant an investment.

But the dynamics of the model also allow the competition effect to outweigh the hold-up effect and cause inefficiently high levels of education. Condition (1.16) implies that in the *men can expect more* equilibrium, women invest in education at values of k that exceed their expected lifetime labour market return from education (at least if $r < 3$). Because there are no educated men on the marriage market, the threat of divorce induces them to still opt for education despite it's high cost (the same is true for *women can expect more*).

In the *holding out for someone better* equilibrium, both over- and underinvestment could occur. As can be seen from condition (1.9), the equilibrium values of p and q could

[1]This does not necessarily mean that the equilibrium values of p and q will be inefficiently low, since k can be set arbitrarily small, even negative, by policy makers. It means that at least some individuals would decide to refrain from obtaining a university degree at a cost that would make it worthwhile from a pure labour market perspective.

be either inefficiently high or low, depending on whether

$$\frac{\left(2q + 3\delta - 4q\delta + q^2\delta - 3\right)}{\left(\delta - 1 + q^2\delta - 2q\delta\right)} \gtrless r. \tag{1.18}$$

For most equilibrium values of p and q the threshold for k at which individuals stop to invest in education is inefficiently high, i.e. overall investment in education could be inefficiently low. If, however, individuals are very patient (δ is close to 1), very small values of p and q can be sustained as equilibria on the marriage market stage. This leads to a high risk of divorce for individuals who decide to remain uneducated, which in turn can lead to inefficiently high investment in education as an insurance policy against divorce.

It is easy to show that in the *out of your league* equilibrium, individuals investment levels are always over and above the efficient value, although the propensity to over-invest decreases quickly in the fraction of educated individuals. By becoming educated, individuals do not only escape the risk of divorce, but they also gain a premium if they are matched to an uneducated individual, this pushes their expected gain from obtaining a degree above the labour market return. If they are matched to an individual of the same educational class, however, they will only receive a Rubinstein share of household income, the expected value of which is their own contribution to it. Hence, if they expect with relative certainty to be matched to an educated individual on the marriage market, their reservation price for education approaches the expected labour market return.

Finally, if individuals are infinitely patient ($\delta \to 1$), all frictions in the model vanish, and all individuals receive exactly their labour market income as private consumption on the marriage market. Therefore, they invest in education only if the efficiency condition (1.7) holds. This is not surprising: if individuals are infinitely patient, the model becomes equivalent to a standard marriage market model that allows for binding agreements before marriage - each individual has many close substitutes he or she can be exchanged for, so there is no room for bargaining about rents. This result mirrors the result of Iyigun and Walsh (2007), that the marriage market "internalizes" the externality of the education choice on the partner's consumption.

Note that underinvestment occurs in all equilibria in which no couple ever divorces in equilibrium - these are the equilibria in which intra-household distribution is relatively egalitarian, and therefore not all proceeds of the private investment can be reaped by the individual. On the other side, all equilibria that do exhibit divorce can lead to individuals getting educated to a level that is not justified by the labour market returns, both as an insurance against divorce and as a way to gain more bargaining power within marriage.

1.6 Conclusion

This paper presents a model of intra-household distribution that combines elements of the family bargaining and the marriage market literature. Because unilateral divorce is possible at every stage of the bargaining process, the prevailing conditions on the marriage market - both the availability of potential spouses and the income distribution within other marriages - influence negotiations about the distribution of household income within existing couples.

I use this model to analyse individual incentives to pursue higher education. The return to education is not limited to the labour market return - a higher wage rate - but there is a marriage market return: the extent to which education influences a person's prospect on the marriage market, the stability of his or her marital life and and his or her bargaining power within marriage. The set-up of my model enables me to look at the overall return to education.

I find that wage inequality within the economy, as indicated by a high education premium on the labour market, is associated with relatively more distributional inequality *within* families, and more marital instability. The prospect of divorcing and hoping for a better catch the next time around seems more appealing the more prospective partners on the marriage market differ with respect to their earnings power. Also, educated individuals are never affected by the quality of their competitors (other singles on their own side of the market). Because they are the most desirable matches, no spouse can ever credibly threaten to leave them to try their luck again.

A particularly interesting recent phenomenon in the western world is the widening gender education gap to the favour of women. Over the past decade, more young women than men obtained university degrees in most western countries, despite the fact that women are still less likely to be in full time employment, and that their wage rates continue to be below those of men. My results show that, if one gender group overtakes the other in terms of higher education, the marriage market tends to reinforce this trend. An increase in the number of educated women over and above the number of educated men increases the bargaining power of men without university degrees, who are married to women of the same educational attainment, while the bargaining power of university graduates married to non graduates does not increase to the same extent. Therefore, as women's educational attainment increases, men in fact face less incentive to invest in university education. Educated women do not suffer from this trend - their "prize" on the marriage market is not influenced. Uneducated women on the other hand, suffer from diminished bargaining power. This further fuels the educational gender imbalance on the marriage market.

When I internalize the educational investment decision, I find that there are subgame perfect equilibria in which different fractions of men and women decide to obtain a university degree. The level of investment in education can either be inefficiently low or inefficiently high: underinvestment is more likely if intra-household distribution is very equitable and divorce unlikely, while more inequality - both within and between households - and the incidence of divorce in equilibrium leads to inefficiently high levels of educational attainment.

1.7 Supplementary Material

Allowing for a Positive Single Utility

In this section, I relax the assumption that the single utility is 0 for all individuals, but assume, that it is 0 only for uneducated, but positive for educated individuals.[1] This difference could for example come from the satisfaction educated individuals derive from their career or other intellectual interests they also enjoy when single, and that uneducated individuals lack.

I do this in a simplified version of the model described in chapter 1. The simplifications are: First, I assume that $q = 0$, that is that all men in the population are uneducated. With this assumption there are only two different kinds of couples: couples were both spouses are uneducated, and mixed couples consisting of an educated female and an uneducated male. This radically reduces the number of cases I have to consider - from 256 to 16. Second, I assume that women always make the first offer in marital bargaining. This further reduces the number of relevant cases (see below). Because there are only two types of couples, there are only two levels of output: output of a union of two uneducated individuals ζ_u and the output of a mixed couple, ζ_m, with $\zeta_u < \zeta_m$. These are obviously important simplifications, but I do think that the main intuition carries over to the richer model.

To guarantee that educated individuals still want to get married, I assume that $2 \cdot \zeta_s^e < \zeta_m$. Because $\zeta_s^u = 0$, I write ζ_s for ζ_s^m .

In this modified version, an educated woman's continuation value of being divorced in the current period is

$$D^{f_e} = \zeta_s + \delta \cdot \max \left\{ \frac{1}{(1-\delta)} \cdot \mu^e \cdot \zeta_m, D^{f_e} \right\}, \tag{1.19}$$

were the subscripts are omitted because there are only uneducated men. For an uneducated woman, the continuation value of divorce is

$$D^{f_u} = \delta \cdot \max \left\{ \frac{1}{(1-\delta)} \cdot \mu^u \cdot \zeta_u, D^{f_u} \right\}, \tag{1.20}$$

[1] This is equivalent to assuming that the single utility is smaller for uneducated than for educated individuals, and then subtracting the single utility for uneducated individuals from all single utilities and marital pay-offs.

while an (uneducated) man's value of divorce is

$$D^{m_u} = \delta\Bigg(p \cdot \max\left\{\frac{1}{(1-\delta)} \cdot (1-\mu^e) \cdot \zeta_m, D^{m_u}\right\} + (1-p)\max\left\{\frac{1}{(1-\delta)} \cdot (1-\mu^u) \cdot \zeta_u, D^{m_u}\right\}\Bigg). \tag{1.21}$$

The rest of the model, especially the preference structure and the structure of intra-household bargaining as described in sections 1.3 and 1.3 remain unaltered. The game is solved in the same fashion. As above, see section A.7 in the appendix for a more detailed description of this modified version of the game, and how it is solved.

Proposition 9. *For each set of parameter values δ, p, ζ_m and ζ_u, there exists a unique symmetric subgame perfect equilibrium in stationary strategies. There are three different equilibria that are associated with three different, non-overlapping ranges of parameter configurations.*

Proof. See appendix.

Assuming that $\zeta_s > 0$ for educated women, and 0 for everybody else, means that educated women will never wait to make a counteroffer after rejecting an offer - it is always optimal for them to divorce because then they enjoy a positive single utility in this same period. The introduction of a positive single utility for educated women therefore amounts to a rescaling of the bargaining game: since they can guarantee themselves ζ_s each period without their husband's consent, they claim at least that amount of the cake, so the couple bargains only over the distribution of the residual, $\zeta_m - \zeta_s$. Uneducated women on the other hand always wait to make a counteroffer (this is because there are no educated men on the marriage market, and I made the tie-breaking assumption that individuals stay put if they are indifferent between making a counteroffer and divorcing). The cases only differ with respect to the action men take if they are unsatisfied with an offer. I discuss the three equilibria briefly here, the exact shares, and proofs that these are indeed SSPEs can be found in the appendix (section A.7).

Figure 1.9 depicts the range of parameters in which these three equilibria exist, for a fixed δ. As mentioned above, the relevant parameter here is the relationship between the marital output that can actually be distributed in a marriage involving an educated woman (because she always claims the value of the single utility for herself) and the marital output of two uneducated individuals, $\frac{\zeta_m - \zeta_s}{\zeta_u}$.

High single utility In this equilibrium, men in mixed marriages have a credible divorce threat, while intra-household distribution in homogeneous marriages is according to the

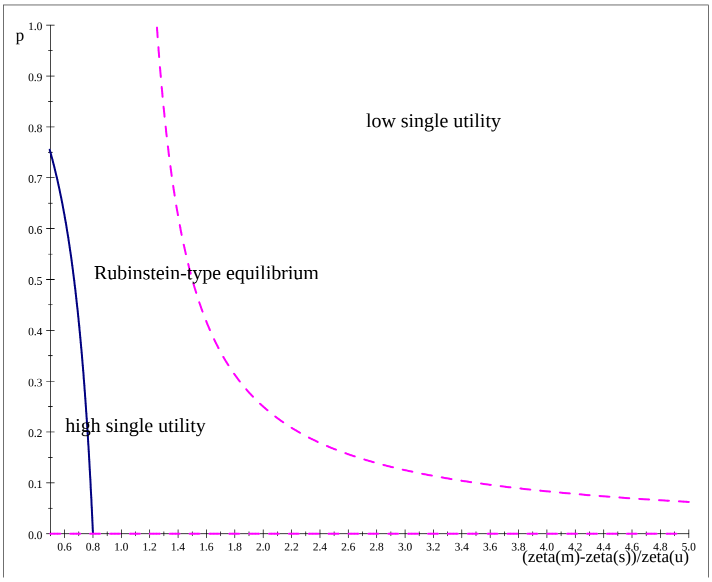

Figure 1.9: $\delta = 0.8$

Rubinstein shares. As can be seen in figure 1.9, this equilibrium only exists if either the extra contribution of educated women to marital output is relatively low, if the single utility is relatively high, or both. This is the main difference between the model with and without a single utility: in the absence of a single utility, uneducated individuals can never have a credible divorce threat when married to educated individuals, because they contribute the most to the union. Since with a single utility, the pie that can be divided shrinks, uneducated men can have a binding divorce threat, and, depending on p, the equilibrium payoff of uneducated women might be little higher than their single utility.

Rubinstein-type equilibrium. In this equilibrium men do not have a credible divorce threat in either type of couple.

Low single utility In this equilibrium, uneducated women have to pay a premium to persuade men to stay with them. This is akin to the *uneducated women suffer* equilibrium.

From this brief discussion, it is obvious that the main effect of allowing for a single utility that varies with education is to make educated individuals relatively less attractive on the marriage market. Because they are more self sufficient, they can not be coerced into unfavorable household allocations by marriage market conditions.

A more General Specification of Marital Output

In this section, I want to relax an assumption I made in section 1.3, namely that the contribution of an individual to the output of a union is always constant, and does not depend on the educational class of his or her partner. It could be the case, for example, that an educated woman contributes more to a marriage with an educated man because of consumption complementarities. Conversely, the essential determinant for marital satisfaction might be that at least one individual is solidly educated, while the education of the second spouse does make a huge difference (an example of this is a society were intergenerational transmission of human capital is important, see, e.g., Gould et al. (2008)). I therefore abstract from educated / uneducated individuals earning wage rates W and w respectively, and assume that the total marital output of a union of two educated individuals is higher than the output of a mixed couple, which is in turn higher than the product of the union of two uneducated individuals:

$$\zeta_e > \zeta_m > \zeta_u. \tag{1.22}$$

Again, I am looking at this in a stripped down version of the model I present in section 1: I consider a marriage market in which individuals are genderless "hybrids" who could marry any individual on the marriage market. This greatly simplifies the analysis, because with hybrid individuals, there are only three different kinds of couples - two types of homogeneous couples formed of two educated and two uneducated individuals, respectively, and one "mixed" couple formed of an educated and an uneducated individual - and not four like in the original model. Everything else (the structure of the game and the marriage market) remains unchanged. A brief discussion of this simplified model and how it is solved can be found in the appendix (A.8).

We have the following proposition:

Proposition 10. *For each set of parameter values δ, p, ζ_e, ζ_m and ζ_u, there exists a unique symmetric subgame perfect equilibrium in stationary strategies. There are five different equilibria that are associated with three different, non-overlapping ranges of parameter configurations.*

Proof. Analogous to the proofs to propositions 1 and 9 and therefore omitted.

Four of these equilibria are analogous to equilibria *forever after*, *holding out for someone better*, *out of your league* and *market equilibrium*, which is why I do not discuss them in here. The existence conditions and equilibrium shares of marital output can be found in section A.8. There is only one equilibrium that does not exist in the model with the constant contributions to marital output. In this equilibrium, both educated *and* uneducated individuals have a credible divorce threat in mixed marriages. The premium educated individuals claim in mixed marriages is high enough to induce uneducated individuals to prefer being matched to someone of their own educational class - everyone wants to be matched to someone with the same level of education. I dub this equilibrium *birds of a feather*. The comparative static results for this reduced version of the model are very similar to full version. Here, I therefore only discuss the solution of the game for indefinitely patient individuals ($\delta \to 1$), were allowing for more general marital output adds new insight.

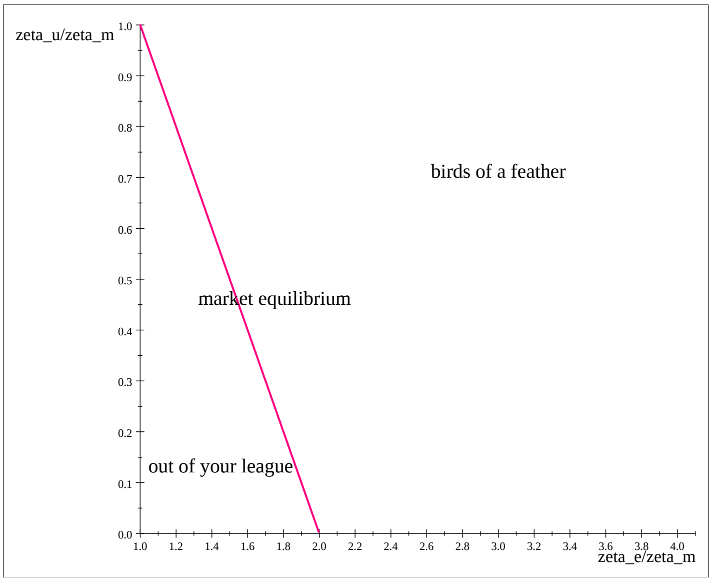

Figure 1.10: $\delta \to 1$

Figure 1.10 depicts the parameter map if individuals are infinitely patient. As can be readily verified by taking limits in the existence conditions in section A.8, the equilibria *forever after* and *holding out for someone better* disappear as $\delta \to 1$, like in the original version of the model. The original version of the model, were uneducated individuals contributed 1 to each union, while educated individuals contributed $r > 1$ regardless of their parter's education, is a special case here, where

$$\zeta_e + \zeta_u = 2 \cdot \zeta_m. \tag{1.23}$$

In this case, *aggregate* output over the entire economy is unaffected by matching patterns on the marriage market. As in the original model, the *market equilibrium* is the unique SSPE in this area. Because individuals are patient, educated individuals have a credible divorce threat (they do not loose much by being single for a period), even if ζ_e and ζ_m are quite close together. Uneducated individuals are happy in both mixed and homogenous marriages: either ζ_e, ζ_u, and ζ_m are very close together, so that partner choice does not really matter, or ζ_e and ζ_u are far apart, with ζ_m in the middle, so uneducated individuals in mixed marriages have to pay a high premium.

If aggregate marital output over the entire economy is maximised if there are only homogenous couples - that is, if assortative marting is efficient,

$$\zeta_e + \zeta_u > 2 \cdot \zeta_m, \tag{1.24}$$

the *birds of a feather* equilibrium is the unique SSPE. For parameter values satisfying 1.24, the marginal contribution educated individuals bring to homogeneous marriages is very high; this enables them to extract a premium in mixed marriages that is big enough to deter uneducated individuals from mixed marriages.

Conversely, if the highest aggregate output on the market is generated if all couples are mixed,

$$\zeta_e + \zeta_u < 2 \cdot \zeta_m, \tag{1.25}$$

out of your league is the unique SSPE. Although the outside option is binding for educated individuals in mixed marriages, uneducated individuals are willing to pay this premium, because the contribution educated individuals make to mixed marriages is substantial.

Chapter 2

Marriage Markets and Divorce

2.1 Introduction

Motivation

Most of the economics literature on divorce concentrates on match quality - couples divorce because they either, with time, learn that the quality of their match is lower than they anticipated (e.g. Weiss and Willis, 1997), or because the match quality changes with time (e.g. Marinescu, 2011). But are couples at all influenced by their prospects for remarriage? That is, can it be shown empirically that women are more likely to divorce their husbands if their marriage market prospects change for the better? If we assume that women prefer men with a high earnings capacity (as shown by Hitsch et al. (2010) using a revealed preference framework) would they be more inclined to leave their husbands if more high wage men became available on the (re-)marriage market?

It has been shown before that male wage inequality influences the time young women spend "searching" for a husband (see Gould and Paserman, 2003; Loughran, 2002; Coughlin and Drewianka, 2011). This literature applies an idea coming from search theory to the marriage market: a woman's value of continuing her search for a husband increases as the heterogeneity of potential mates (as indicated by the larger dispersion in male wage rates) increases. These papers show that an increase in wage inequality in a locally defined marriage market is associated with a higher age at first marriage for women who live in this area. I apply this idea to divorce, emphasising the outside option, as captured by a an individual's remarriage prospect as a deciding factor in the decision to divorce (as opposed to the inherent quality of the the persons' current match).

Assume that individuals meet randomly on the marriage market, or are, at least at the time of the wedding, sufficiently influenced by factors other than their partners' education or earnings power - e.g. Chiappori et al. (2010) show that matching on the marriage market is influenced by physical attractiveness (as indicated by a low Body Mass Index), while Hitsch et al. (2010) show that looks matter to both genders when choosing a mate (these results pertain to dating however, and not marriage). Once the honeymoon period is over, an individual might assess the quality of the match, and his or her outside opportunities, more soberly. If the wage difference between men who are college graduates and men who are not is relatively small, a woman currently married to a man whose highest qualification is a high school degree is likely to find the prospect of divorcing her husband and spending some time searching for another partner not very attractive. But, if the wage premium associated with a college degree is sizeable, a woman who finds herself married to a man without a college degree might find it worthwhile to divorce and try her luck again.

I make this point more formally in Hyee (2011). In this paper, I develop a model of the marriage market, were couples randomly meet and bargain over their individual consumption level once married. A person with a better education contributes more income to the union than a person who is not well educated.[1] Bargaining takes the form of a Rubinstein - type alternating offers game with outside options - individuals can divorce and go back to the marriage market if they are unsatisfied with the offer their current partner makes. The value of this outside option - the expected utility of divorce and remarriage - is determined completely endogenously within the model, and depends on the quality of prospective spouses on the marriage market and the distribution of resources within other couples. If the education premium - the wage premium college graduates enjoy over non-graduates - is small, prospective spouses on the marriage market are relatively homogeneous. Even if one finds him- or herself attached to a spouse with little formal education, it is not worthwhile to divorce and search for another mate. If there is considerable wage inequality between college graduates and non-graduates, however, divorcing a less educated mate in the hopes of making a better match on the marriage market becomes a more interesting option. Although I do not directly test the model I propose in Hyee (2011), it provides crucial theoretical insight into the relationship between (income-) heterogeneity on the marriage market and the divorce hazard that is the basis of this empirical work: it has the empirical implication, that, other things equal, the overall divorce rate could increase with the education premium (especially if the education premium is already relatively high).[2] This effect should, however, not be present for couples were both spouses have a college degree. The reason is that these couples, neither spouse can improve their situation by going back to the marriage market; they are already married to a person with the highest qualification, and therefore, nothing better awaits them on the marriage market. Individuals who are married to partners who do not have a college degree, however, have a higher incentive to dissolve their marriage and try to marry someone with more education, when the education premium increases.[3]

Since most of this theoretical argument is just about *earnings* inequality, one could argue that I should in fact look at the effect of overall wage inequality, rather than

[1] In this model world, there are only two types of individuals - "educated" - which I understand to mean that they have a college degree - and "uneducated".

[2] In Hyee (2011), the divorce rate depends not only on wage inequality but also on the proportion of men and women with a college degree, as well as on their discount rates. I do not directly estimate this model; I only use its implication that an increase in wage inequality may increase the divorce rate, or it may leave it unaffected - but it can never decrease it.

[3] In fact, in the model I develop in Hyee (2011), only couples formed of two uneducated partners divorce in equilibrium. "Mixed" couples, were one partner has a college degree while the other does not, never divorce, but the educated partner can increase their share of household resources when the education premium rises.

the return to education. Although I do repeat the analysis with a measure for overall wage inequality as a robustness check, I concentrate on the return to education for two reasons. First, it connects better to the model I develop in Hyee (2011). Secondly, I want to investigate the differential effect of wage inequality on couples of different earnings power; when looking at couples of different educational attainment, using a between-group measure of inequality is more consistent. Of course I could define cut-off points for low and medium incomes etc., but I think that education has a special appeal in the marriage market context: it is strongly correlated with income, easily observable, and most people marry when they have completed most of their formal education, while the full extent of a person's earnings power is typically only revealed later in life.

Although the same model could be clearly estimated for men reacting to female wage inequality, I follow the literature in only considering male wage inequality (Loughran, 2002; Gould and Paserman, 2003; Coughlin and Drewianka, 2011). Gould and Paserman (2003) argue that, given the traditional division of labour between men and women, a man's earnings capacity should be more important for his attractiveness on the marriage market than a woman's. Hitsch et al. (2010) show that the preference for a higher earning mate is much more pronounced for women than it is for men. This argument also implies that men would be less inclined to get divorced than women if potential mates with higher earnings capacity become available on the marriage market. Another issue with female wage inequality has to do with female labour supply: a measure of wage inequality between full time working women who are college graduates and full time working women who are not is prone to measurement error, as there is a selection into work effect. What should matter for marriage market attractiveness is *earnings potential*, which is stronger correlated with actual earnings for men than for women.

Aggregate Trends in Divorce and Wage inequality

It is a seldom noticed fact that divorce rates in the United States have been falling in recent decades. While marital dissolution was on the rise for much of the twentieth century, reaching a plateau in the late 1970s, the divorce rate in 2005 was at the level of the mid-1960s (Stevenson and Wolfers, 2007).[1] The time period covered by my dataset (1990-2007) is therefore a period of overall declining divorce rates.[2] This might be attributable to the decline in marriage rates that took place in the second half of the twentieth century

[1]The shift from a consent to a unilateral divorce law regime in many states, that has been associated with a rise in divorce rates (see, e.g. Wolfers, 2006, for a recent discussion) had already been completed at the beginning of my panel (1990).

[2]I do not produce a graph on divorce-rates because the SIPP is not nationally representative for individuals who divorce or separate (U.S. Census Bureau, 2001).

- entry into marriage in the US is now at an all time low (Stevenson and Wolfers, 2007) - that increased the average match quality in marriages that did form.

During the same time period overall wage inequality has only risen moderately (Coughlin and Drewianka, 2011). My main indicator of wage inequality is the ratio of mean log weakly wages of full time working men with and without a college degree. Nationally, this education premium only rose from roughly 1.16 to 1.22 in the period 1990-2007 (although the development of the education premium differed significantly across states, even falling in some like New Mexico). That is, on average, a college educated man earned about 16% more than a man without a college degree in 1990; in 2007 the average difference was 22%, see figure 2.1.

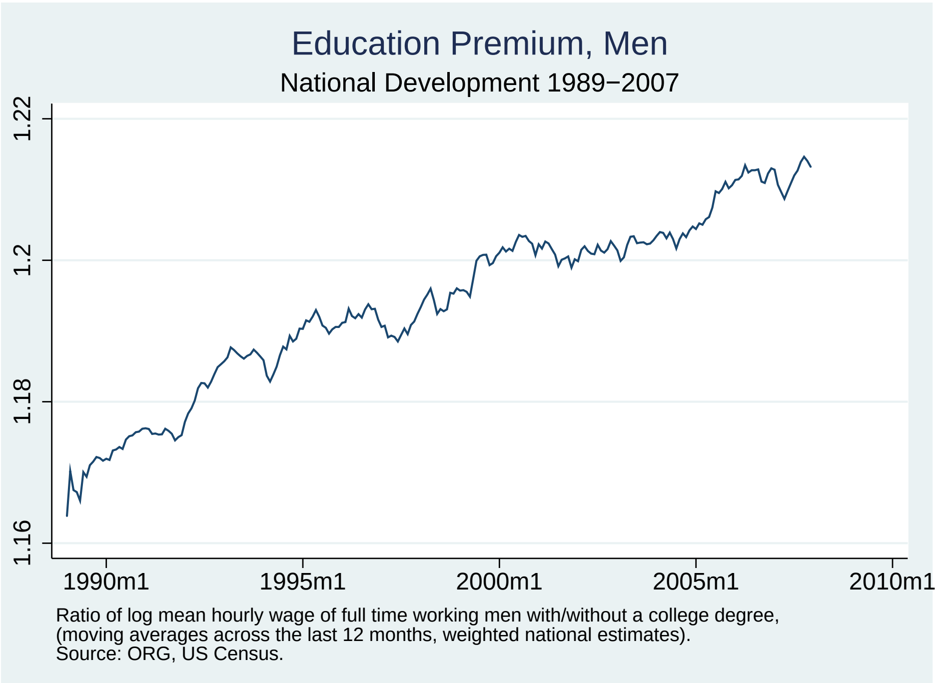

Figure 2.1: Male education premium

My theoretical argument therefore postulates a positive relationship between two variables that, on the national aggregate, changed only mildly, and in opposite directions, during the period covered by my study - should we expect to see the same, negative relationship between the education premium and the divorce risk in the micro data? That is, should we expect women who are faced with a higher male education premium in their local marriage market to have a lower divorce risk, as is indicated by the macro trend?

I investigate this question using a dataset of married women and women with live-in partners from the Survey of Income and Program Participation (SIPP), 1990-2007.[1] Exploiting disparities in the returns to education across US states and across time, I show that increases in the returns to college education for men are indeed associated with an increased divorce hazard for young women. The effect is robust to the inclusion of state and year fixed effects, and even to the inclusion of state specific linear time trends, while controlling for a number of socio-economic characteristics that have been shown to influence match quality. Moreover, they are statistically more significant for couples in which at least one partner has no college education than for couples in which both partners are college graduates. In fact, the effect is most significant for couples in which one partner has at least some college education while the other one does not. Because of assortative mating on the marriage market, individuals with some college education or a college degree are more likely to marry a college graduate than those with less education. Therefore, women with some college education or a college degree who are married to a man whose highest educational attainment is a high school degree have the highest expected gain from going back to the marriage market in response to an increase in the male education premium.

The paper is structured as follows: in the next section, I briefly review the relevant literature on divorce, and the small literature on wage inequality and marriage rates. Section 2.3 describes the data sources I use, while section 2.4 discusses my estimation strategy. Section 2.5 presents descriptive statistics on the socio-economic characteristics of young married and cohabiting women in the United States from 1990-2007, as well as patterns of assortative mating according to education. I present the main results of my paper in section 2.6, while section 2.7 concludes. Section B provides the reader with additional detailed information on the complex SIPP survey design and how I construct many of the variables I use.

2.2 Related Literature

The seminal work on divorce is Becker et al. (1977), who also discuss the role of the remarriage market in the decision to divorce. Not surprisingly, they predict that the possibility to remarry after a divorce tends to increase marital instability. Unexpected developments in the traits and qualities of either spouse in the course of a marriage - "surprises", that were not anticipated at the beginning of the marriage - can have a stabilizing or damaging effect on a relationship. The direction of the effect depends on

[1] I partly use the excellent clean CEPR extracts, (Center for Economic and Policy Research, 2011a).

whether they increase or decrease the the gains from the relationship, and whether and to which extent couples are able to reallocate these gains freely between them.[1]

Becker's theory of marriage emphasises the role of the division of labour in marriage (e.g. Becker, 1981). Consequently he argues that the effect of education on the probability of the dissolution of a marriage is ambiguous: on the one hand, a couple's joint education should increase the gains from marriage, because income tends to increase with education, on the other hand, gains from specialization between spouses decrease because highly educated women are more attached to the labour market.[2] In the modern literature on the topic, the general finding is that education is a very important factor contributing to the stability of marriages (Weiss and Willis, 1997). This could be due to the changing nature of the gains from marriage over the past decades, away from household production to joint consumption.[3] Using a novel approach, Lundberg (2010) provides evidence that the personality traits that are predictive of individuals sorting into marriage changed from cohorts born in post war years in Germany to younger cohorts born in the 1960s and 1970s: while for older birth cohorts, men and women were selected into marriage by differential traits indicating a division of labour within the couple, there is no gender difference in the traits that influence a person's likelihood to be married for the later cohorts, indicating that specialization within married couples lost significance.

As mentioned above, most of the empirical literature on divorce concentrates on learning about, or shocks to, match quality. Weiss and Willis (1997) use data from the high school class of 1972 (that is, the birth cohort of 1954) to show that "earnings-surprises" (revealed earnings that differ from what was a reasonable expectation at the time of marriage) influence the divorce hazard. If the husband's earnings exceed the expected value at the time of marriage, it stabilizes the union; while higher than expected earnings of the wife tend to increase the divorce hazard. This corroborates the theory

[1] Say, a husband's earnings capacity is revealed to be higher than expected at the beginning of a marriage. In the absence of a remarriage market, this should strengthen the relationship, because it increases the gains to marriage (especially if the spouses are specialized in household and market tasks, it increases the gains to specialization). If however there is a remarriage market, such a development might raise the probability of marital dissolution - the husband might find that he could attract a more attractive spouse, and might find it worthwhile to try if his current wife can not shift more of the increased surplus to him.

[2] Becker et al. (1977) corroborate this conjecture in their empirical analysis.

[3] Isen and Stevenson (2010) argue that improvements in household production technology, that made time dedicated to household tasks less important in a couple's overall time budget, decreased the importance of specialization in household and market tasks. Families enjoy more leisure time and higher levels of consumption than in the 1950s and 1960s, which makes consumption complementaries between spouses and the joint consumption of public goods more valuable. They cite the increasing fraction of college educated women who marry, and increasing levels of assortative mating according to education in the marriage market, as indications of this shift in the source of the gains to marriage.

that specialization within marriage played a role in divorce for this generation. Also, Charles and Stephens (2004) test the "surprises" theory of divorce by examining the effect of negative earnings shocks on a couple's likelihood to separate. They look at negative earnings shocks following three types of job losses: lay-offs, redundancies and negative health shocks (disabilities). They show that lay-offs are the only type of earnings shocks that increase the divorce hazard - lay-offs seem to convey more information about the future earnings capacity to a spouse.[1]

Using the same dataset as I do in this paper, the 1990-2004 panels of the SIPP, Marinescu (2011) investigates the relative importance of learning about match quality versus real changes in match quality on the probability of divorce. She finds that learning seems to be relatively unimportant as a determinant for the divorce hazard.[2] She does however find support for a model of changes in match quality, again using job loss as an example of a wage shock.[3]

The literature most closely related to this paper is the literature on wage inequality and age at marriage, because it is, to my knowledge, the only literature that explicitly addresses the "marriage market side" of marital behaviour. Gould and Paserman (2003) use male wage inequality to explain changes in the proportion of single females ages 21-30 over time in different metropolitan areas, using data from the 1970, 1980 and 1990 1% Public use micro data sample (PUMS) of the US census. They show that women do delay marriage in response to increasing male wage inequality - that is, increasing heterogeneity on the marriage market. They estimate that rising male wage inequality can explain between 18% and 28% of the decline of the marriage rate of young women between the ages of 21 and 30. Using the same dataset, Loughran (2002) looks at the influence of male wage inequality on female marriage rates within educationally, racially and geographically segregated marriage markets, thus taking into account assortative

[1] Also, divorcing a spouse who lost their job because their factory closed down, or because they became disabled, is likely to be met by judgement from family and friends, while leaving someone who got fired is more likely to be accepted by society.

[2] Specifically, she finds that the divorce hazard does not approach zero even after twenty years of marriage (at which point she argues that one should know everything that is important about the quality of a match).

[3] She finds that job loss is associated with an increase in the divorce hazard, and that this effect becomes stronger with relationship duration - the effect of a husband being laid off increases the divorce hazard more for couples who have been married for a while than for new couples. She conjectures that this is because the quality of a relationship tends to decrease over time, leading to a higher proportion of "fairly mediocre" relationships at higher marriage durations. Being at risk of dissolution anyway, these relationships are more likely to be pushed over the brink by an adverse earnings shock. She confirms this hypothesis by using marital happiness data from the National Survey of Families and Households. She finds that wives do become less likely to report the highest level of happiness with their marriage the longer they are married, which, in itself, is an argument against a learning-about-match-quality model of divorce.

matching on the marriage market. He also finds that increased male wage inequality is associated with women remaining single for longer. His results attribute between 7% and 18% of the decline of the marriage rate of young white women (ages 22-30) between 1970 and 1990 to increased male wage inequality.

In a recent paper, Coughlin and Drewianka (2011) investigate the effect of wage inequality on aggregate marriage rates. In contrast to Gould and Paserman (2003) and Loughran (2002), and relevant to my study, they also consider somewhat older women.[1] While they are able to replicate the results of Gould and Paserman (2003) for young women (younger than 30) for the time period 1970-1990, they find that the effect diminished significantly in the time period 1990-2005. They conclude that slower growing wage inequality during this time, coupled with a relatively old "single pool" (a consequence of low marriage rates in the preceding decades) led to a weakening of the link between marriage rates and male inequality.[2]

My contribution to the literature on wage inequality and marriage consists in showing that heterogeneity of potential partners on the marriage market not only influences young singles, but also married women - my results indicate that women in existing relationships do keep an eye on the marriage market. I add to the literature on divorce by emphasising effect of the *aggregate marriage market situation* a woman faces in her geographical environment at a given point in time. Although I do control for factors commonly associated with the quality of the match in the empirical literature, my focus is not on changes of, or shocks to, match quality on the couple level, but changes in the quality of potential candidates on the relevant marriage market.

[1] One of their dependent variables is the aggregate marriage rate by state, defined as the number of marriages in a given state and year, gathered from administrative sources, and divided by the single population younger than 55.

[2] They argue that, although it has been shown that (young) women delay marriage in response to a more heterogeneous supply of young men on the marriage market, most women get married eventually. Consequently, male wage inequality should diminish in significance for a woman's decision to marry as she grows older. Since wage inequality has been increasing from 1970-1990, the time period covered by Coughlin and Drewianka (2011) and Loughran (2002), women delaying marriage would lead to a fall in the aggregate marriage rate in the short run, but it would be expected to pick up again once the pool of singles becomes "old enough".

2.3 Data

Marital History and Socio-economic Background

I use data from the 1990 - 2004 Panels of the Survey of Income and Program Participation (SIPP).[1] The SIPP is a panel study that follows a nationally representative sample of the US population for three to four years. At the end of each panel the sample is dropped and a new one is drawn. The periodicity of the SIPP is monthly; interviews are conducted four times a year, covering the previous four months. The main reason why I chose this survey is its size - contrary to public perception, divorce is actually a quite rare phenomenon. Since I want to exploit variations between states and over time, I need a large sample. Furthermore, I need detailed and reliable information on the exact timing and locality of a divorce or separation. Other popular micro datasets (like the PUMS and the CPS) do not provide information on the timing of divorce, only of current marital status;[2] while other panel studies, like the National Longitudinal Study of Youth, do not provide geographical information, or are too small to analyse divorce (like the British Household Panel Survey).

The SIPP contains rich information on personal characteristics (race, marital history, fertility, family composition etc.), and, because it is a household panel survey, it contains matched data on married couples, and information on unmarried couples living together (from 1996 onwards). The SIPP also provides detailed information on labour force participation, wage rates and income, both on the person as well as on the household level.

I only keep observations of women who are married or cohabiting with a partner during the reference period. A woman who was single at the beginning of the reference period enters my sample upon her marriage or when she begins living with a partner; conversely, a woman who was married or had a live-in partner at the beginning of the reference period shows up as divorced or separated in the first month she reports her marital status as divorced, or is no longer living with her partner, and then exits the panel. If a divorced woman remarries or is reported to have a live-in partner at a later point during the panel, she re-enters my sample. Of course, a cohabiting relationship can end in marriage; these women remain in the panel.

My sample contains data on 125,074 women who were married or cohabiting during

[1] In part from Center for Economic and Policy Research (2011a).

[2] It is not a problem for Gould and Paserman (2003) that their dependent variable, the proportion of single women in a given metropolitan area, is a stock, because married women of in this age group must have taken their marriage decision quite recently, in an economic climate very similar to the one in the census year. Knowing when exactly they got married (information that is not asked in the US census) is therefore not vital.

the panel - the large majority of these women, 116,723, are married.[1] The maximum period of time I observe any woman is 47 months or a little under four years; on average, I observe a woman for 33 months. Of these women, 6.927 or 5.5% dissolve their relationship during the reference period, 4.927 divorce and 2000 terminate their cohabiting relationship.

Wage inequality

The SIPP is not designed to be representative at the state level (U.S. Census Bureau, 2001). Because I am interested in the effects of marriage market characteristics, I use monthly earnings data from the Outgoing Rotation Group (ORG) of the Current Population Survey (CPS) to calculate wage inequality indicators at the state level.[2] Because I am especially interested in the role of education, I use the ratio of the means of the log weekly wages of educated and uneducated men in each state as my basic measure of wage inequality.[3] As "educated" I count men who hold a college degree or higher qualification, as "uneducated" men who do not (this includes men who report their highest educational attainment to be "some college"). In order to limit these measures more closely to presumable "marriage material" for women ages 18-45, I only consider the mean wages of men ages 18-50 (see section B for details).

I use the weights of the CPSORG to calculate the sex-ratio of a cohort of "marriageable age" at the state level - the ratio of the number of males between the ages of 18 and 45 to the total population of that age group - as well as the ratio of that age group who hold a college degree, by sex.

There is seasonality in the wage data. I deal with this by regressing my measure of the education premium on a full set of month/ state interactions (thus allowing the seasonality to vary by state), and using the residual wage inequality that can not be accounted for by pure monthly variations; the R-squared of this regression is 0.23. Another way to deal with the seasonality would be to use the raw data, and directly control for the month of the observation in the regression - this does not allow the seasonality to vary at the state level. I ran the base regressions using the raw education premium and a full set

[1] Marinescu (2011) also uses the SIPP for all to date available panel years, and reports only having data on 93,505 marriages. This is very likely due to the fact that, using a Cox proportional hazard model, she needs data for both spouses at each point in time, and therefore cannot use the observations on women who report their spouse to be absent; she also makes more use of the SIPP's labour market data that has more missing values than the socio-economic data I use.

[2] The ORG is designed to be representative at the state level (Center for Economic and Policy Research, 2011b).

[3] Gould and Paserman (2003) use the standard deviation of the log weekly earnings of full time male employees, but their study does not focus on education like mine.

of month dummies, these results are available upon request. The coefficient estimates of the regressions to not differ from those I present here, but the standard errors become smaller - the approach I use is therefore more conservative.[1] For the sake of consistency, I also deseasonalise the other marriage market indicators in the same fashion.

Geography

Unfortunately, the smallest geographical entity the SIPP identifies is the state, so I have to consider the state as the relevant local marriage market.[2] The 2004 panel identifies fifty states and the District of Columbia, the 1996 and 2001 panel identify forty-five states and the District of Columbia, while the pre- 1996 panels only identify 41 states and the district of Columbia. The states that are not identified are small states that are combined into groups to safeguard respondents' privacy. I therefore have to exclude observations from Maine, Vermont, Iowa, North Dakota, South Dakota, Alaska, Idaho, Montana and Wyoming.[3] I do not loose too many observations this way however: in my dataset, only 2,274 married women were from these states.

2.4 Empirical Methodology

I am interested in the effect of male wage inequality - more precisely, the wage advantage college educated individuals enjoy over those without a college degree - on the probability that a woman divorces in a given month. The basic empirical specification is:

$$P(d_{ijt} = 1) = \Phi(\alpha \cdot Ineq_{jt} + \beta \cdot Ineq_{jt} \cdot Couple\_educ_{ijt} + \gamma \cdot Z_{ijt} + \delta \cdot Y_{ijt} + \eta_{jt}), \quad (2.1)$$

where $d_{ijt} = 1$ if married woman i, residing in state j got divorced in month t and 0 otherwise, Φ is the functional form that determines the relationship between the depen-

[1] An obvious alternative would be to use yearly averages, as do Gould and Paserman (2003); Coughlin and Drewianka (2011) and Loughran (2002). This poses the conceptual problem that, since my data is monthly, it would incorporate anticipated shocks by calendar year. Also it saturates the regression when I control for state specific linear time trends in addition to state and time fixed effects.

[2] Coughlin and Drewianka (2011) also use the state as the relevant local marriage market. They are able to replicate previous estimates of the link between age at marriage and male wage inequality closely, which indicates that treating the state as the local marriage market does not introduce a worrying degree of measurement error.

[3] It is tempting to treat the state groups of the SIPP as local marriage markets. The problem is that the groups are not the same across panels: only the Main/ Vermont group stays the same, and it is difficult to justify that these two states should form one marriage market when there is New Hampshire wedged between them that is treated as one marriage market. In the 1996 panel, the two Dakotas and Wyoming could pass as a marriage market, but in the pre- 1996 panels Idaho and Alaska are added to this group, so this again seems arbitrary from a marriage market perspective.

dent and independent variables (in the case of the probit model, the standard normal distribution), $Ineq_{jt}$ is a measure of wage inequality in state j at time t, $Couple\_educ_{ijt}$ is a dummy variable indicating the joint educational level of husband and wife, Z_{ijt} is a vector of controls for the local marriage market j in which woman i lives at time t (see below), X_{ijt} is a vector of a couple's individual characteristics and of characteristics that indicate the quality of the match (this includes a full set of joint education dummies that I allow into the regressions *without* interaction with the inequality measure), and η_{jt} is a state-time effect, that influences individual divorce probabilities independently of individual characteristics and wage inequality at the state level.

My main measure of wage inequality is the ratio of the mean log hourly wage rates of full time working men who are university graduates to the mean of those who are not, at each time t, and state j. This indicator measures the mean wage premium university graduates enjoy as compared to those who do not hold a university degree.[1]

In addition to including an *overall* effect of the male education premium in the model, I allow the effect of the male education premium to vary with the joint educational attainment of the couple. The first term of equation (2.1) measures the direct effect of the level of wage inequality on the divorce hazard, while the second term measures whether this effect varies across educational groups. The theoretical prediction of the model I develop in Hyee (2011) is that the effect of changes in the male wage premium on the divorce hazard should be stronger for couples in which at least one partner is not a college graduate (because women married to college graduates cannot improve on the education of their spouse on the marriage market). It would therefore support my hypothesis if there was little or no *overall* effect of the male education premium, but if the effect only worked through the interactions with the education dummies. I verify this by also running a base regression excluding the interactions of the education premium with the the education dummies. As a measure of a couple's education, I use the same three dummies Marinescu (2011) uses in her study with the same dataset: a dummy equalling one if either both spouses' highest degree is high school, or if one of the spouses is a high school graduate while the other one is not; a dummy indicating if one of the spouses' highest qualification is high-school, while the other spouse has some college education or more (a college degree or a post-graduate degree); and a dummy equal to one if both spouses have some college education or more. The base is a couple were both partners did not successfully graduate from high school. Also couples for which the educational attainment of husband and wife differ widely are not captured by either of these dummies

[1] I use hourly wages to abstract from labour supply decisions, see section 2.3 for details on the calculation of this measure.

- these are couples were one partner is a high school drop-out while the other partner has some college education or a higher qualification. Due to assortative mating on the marriage market, these couples are very rare (see table 2.1), only 3.5% of my sample belong to this category.

I proxy the local marriage market conditions by the sex ratio of the relevant age group in a given state, by the proportions of men and women of that age group who hold a college degree, and the mean hourly wage rate of full time working men.

Equation (2.1) does not include a term controlling for the latent quality of the match. Although my dataset is a panel study, I do not actually take advantage of the panel design in my analysis. Using panel data techniques (like individual fixed effects) would restrict my sample to women who separate multiple times during the panel reference period, which would be a very special sub-population of women, especially given that the maximum duration of each panel is four years.[1] Instead, I control for marriage specific match quality with control variables that are likely to influence the quality of the match, an approach also used by Weiss and Willis (1997) and Charles and Stephens (2004). I use the same controls as Marinescu (2011), with some slight modifications. I include cohabiting couples in my main sample (from 1996 onwards) and include a dummy variable for cohabiting relationships. My results are very similar if I exclude cohabiting relationships, and all of my main variables of interest retain significance without them, but they do provide me with extra variation because of their higher propensity to dissolve.

Marinescu (2011) controls for the number of a couple's own children interacted with the duration of their relationship - this specification limits cohabiting partnerships to those that started during the panel reference period, because the start date of a relationship is only asked for marriages; which excludes most cohabiting relationships from the analysis. This is sensible in the context of her modelling approach, because she uses a Cox proportional hazard model where the divorce hazard depends on the relationship duration. Because this is not true in my set-up, I just control for the number of own children in the household.[2] Furthermore, I follow her lead in including a dummy indicating if there are other children under the age of eighteen living in the household, a dummy indicating if there is an age-difference larger than five years between the spouses, a dummy indicating if the man is white, and a dummy indicating if the partners share the same racial background. I also add a dummy indicating if the couple are home-owners, and the number of times previously married for both partners. I also control for the age

[1] The panel structure of the dataset is important for me since it enables me to observe the exact time when women transition in and out of relationships.

[2] I have however estimated the same model with the interaction of relationship duration - hence with only a very small number of cohabiting couples in the sample - and arrive at very similar results.

of both partners - Marinescu (2011) does not, but she controls for relationship duration, which is strongly correlated with the partner's ages.

With regards to the exact specification of the state-time fixed effect η_{jt}, I follow Gould and Paserman (2003) in running several regressions of varying degrees of conservativeness.

I want to make a short comment on the estimation of standard errors. Since my main variables of interest, the marriage market indicators - especially the male education premium, the sex-ratio, and the proportion of university educated men and women - vary at the state- and not the individual level, current practice in the applied micro-econometric literature would indicate that I cluster the standard errors at the state level. Ignoring the group structure of the data can lead to serious underestimation of the sample variances (e.g. Angrist and Pischke, 2008). The dataset I use (the Survey of Income and Program Participation) is based on a complex survey design I describe in some detail in section B.2. In a nutshell, the SIPP is not a random sample of the US population, but has a multi-stage stratified sampling design - the US territory is divided into *strata*, and groups of counties or independent cities are sampled within those strata (these are the primary sampling units, or PSU, of the SIPP). The US Census Bureau provides recommendations for the estimation of robust standard errors under this complex survey design. It is not possible to cluster the standard errors at the state level *and* follow the Census Bureau guidelines, since those cluster the standard errors at the smaller primary sampling units, which can cross state lines (Siegel and Mack, 1998). Because clustering the standard errors at the state level disregards between-PSU-variation, the estimated standard errors are actually *smaller* when clustered at the state level, as opposed to according to U.S. Census Bureau recommendations. This only influences the standard errors, and not the point estimates of the coefficients in the probit regressions. The differences between the two specifications are small (at most one percentage point difference in the p-value of the t-statistic of the probit regression), and do not cause any of my main variables of interest to become insignificant. Also, on an individual level analysis, the effects of the survey design on the variances should not be too important. Working with the same dataset, Marinescu (2011) completely disregards the SIPP survey design and treats it as a simple random sample (since hazard models are difficult to estimate using weights). I ran all regressions I discuss here both clustering the standard errors at the state level, and following US Census Bureau guidelines. I present the regressions with the standard errors clustered according to US Census Bureau recommendations because they are more conservative (that is, the standard errors are larger).

2.5 Descriptive Statistics

Marriage and Divorce in the SIPP 1990-2004

I do not include same sex relationships in my sample because the marriage market implications of such relationships are unclear: in the case of women, it is difficult to construct a good measure of female wage inequality because of non-participation in the labour force and part time work. For men, reverse causation would be an issue, because men in same-sex relationships "fish in the same pond" for potential partners.

The SIPP has several categories of marital status: it distinguishes between individuals who are married with a present or absent spouse (absent spouses are either institutionalized, mostly in the correctional system or the armed forces, or permanently away from home for reasons *not* connected to marital problems). I subsume these categories under "married". However, absent spouses do not have any data on personal characteristics. Whenever I observe them living at home at some point in the panel, I extend their relatively permanent characteristics (education, race etc.) over the period in which they are reported as being absent; if I never observe them living at home, their data is missing. The SIPP has a marital status category "separated", meaning an individual lives permanently away from his or her spouse due to marital problems. I count these individuals as "divorced".[1]

Note that, for the sample statistics in this section, I use the SIPP weights, to account for the survey design - these statistics are therefore representative for the sub-population of married women in the US. Of the 125,074 women in my sample, I observe 9,149 transition into marriage (either from being single, widowed or divorced). The mean age at marriage is 32.2 years, 26.3 years for first marriages. Figure 2.2 depicts the age distribution of women in the month they transition into marriage (note that is for first and higher order marriages). More than eighty percent of all women are below the age of 45 when they get married.

The overall divorce hazard across the observation period for the women in my sample is 7.5%.[2] By education, the divorce hazard is highest for couples were one spouse has a high school degree while the other spouse does not (9.6%), even higher than for couples were both spouses are high school drop-outs (7.7%). Couples were one partner has a high school degree and the other a higher qualification have a probability of 8.1% to

[1] Also Charles and Stephens (2004) treat legally married couples who live in different households as divorced couples.

[2] This is higher than the sample statistic I reported earlier because it incorporates the sample weights. That is, this figure is more indicative of the incidence of divorce in the US population, while the percentage in section 2.3 was calculated directly from the sample.

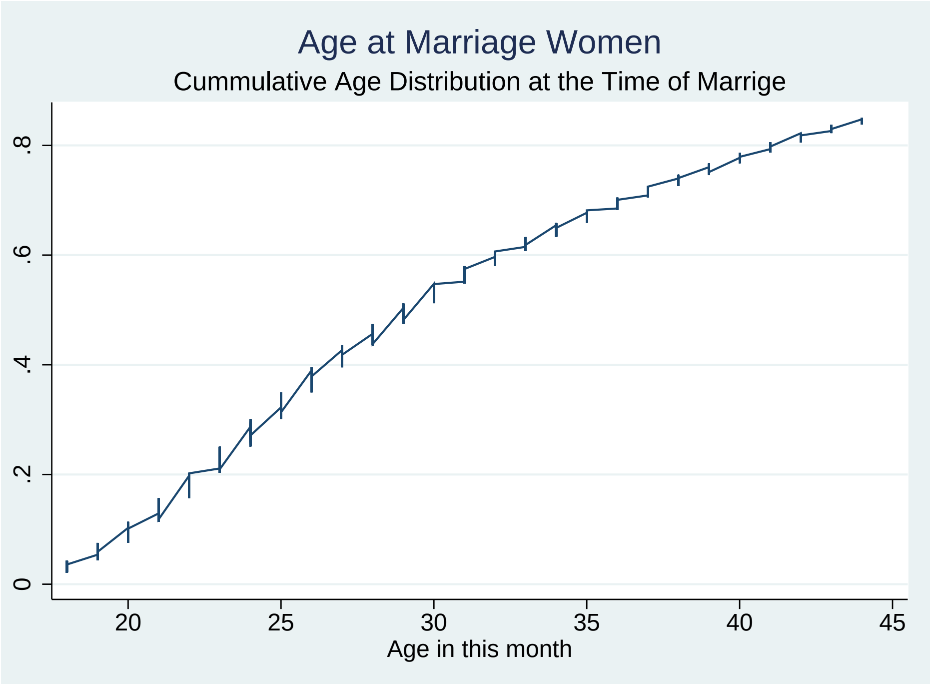

Figure 2.2: Age at Marriage

split up during the observation period, and couples were both have at least some college have the lowest divorce hazard at 5.1%. The divorce hazard according to education is therefore not linear, with college education clearly protecting against divorce.[1] The age distribution at the time of divorce is similar: women's mean age in the month of divorce is 36.4 years; around 82% of all women are below the age of 46 when they decide to end their marriage. If we also consider women who separate from their live-in partner, the mean age at the time of separation slightly decreases to 35.1 years (see figure 2.3). Note that 44% of all women in my sample are older than 45. Because of the concentration of these marital events at quite young ages, I conclude that for women who get divorced later in life, remarriage prospects are not as important. I therefore limit my analysis to women aged 46 and younger.[2] The rest of the summary statistics in this section pertains to this young sub-sample of married and cohabiting women.

[1]Using the marital history files of the 2004 SIPP, Isen and Stevenson (2010) find that individuals with some college education, but without a degree, are the most likely to divorce. Note that my summary statistics pertain to the period 1990-2004, and I only look at women 46 and younger who divorce during the sample period, while Isen and Stevenson (2010) look at the marital history files, and therefore at all divorces sample members went through at any point in the past.

[2]Coughlin and Drewianka (2011) limit their analysis to women 55 and younger.

Figure 2.3: Age at Divorce or Separation from Live-In Partner

Assortative Mating

Table 2.1 depicts the educational composition of married and cohabiting couples in the dataset. The restriction to young women (below 47 years of age) pushes the distribution of the highest educational degree to the favour of women: fewer women than men do not have a high school degree, more women do have a high school degree or some college. It is a phenomenon of the last two decades that women tend to be better educated than men, (see Goldin et al., 2006). This is however for the whole sample period, thus disregarding trends over time. The table shows clearly the tendency to assortative matching of couples according to education, with the highest proportion of couples located along the diagonal - education is one of the most important individual sorting characteristics on the marriage market (Wong, 2003).

Figure 2.4 depicts the evolution of assortative mating patterns over time. It indicates two main developments over the last seventeen years: first, later cohorts are better educated than earlier ones; the fraction of couples in which both husband and wife are college graduates has increased, while the fraction of couples formed of two individuals who do not have a high school degree decreased. Second, the fraction of couples were she is more educated than he is increased. With time, there are more couples were she has

Table 2.1: Educational Attainment of Married Couples

Wife's Education	Husband's Education: less than high school	high school	some college	college graduate	Total
less than high school	0.059	0.032	0.012	0.002	0.105
high school	0.039	0.159	0.077	0.029	0.305
some college	0.017	0.087	0.141	0.072	0.317
college	0.003	0.027	0.061	0.182	0.273
Total	0.119	0.305	0.291	0.286	1

Weighted proportion estimates, calculated from women/ month observations (takes into account qualifications acquired during the sample period), women aged 46 and younger, 1990-2007

some college education while he has a high school degree, or were she is a college graduate while he has only some college, at the expense of couples were the reverse holds. This is a consequence of women overtaking men in terms of educational attainment (Goldin et al., 2006). This trend is especially pronounced among African Americans: because the gender education gap is more pronounced within this ethnic groups, women become less selective and marry men with a lower educational attainment more often (Wong, 2003). This distributional chart is interesting because it gives an idea about the relative frequency of educational pairings in the below probit regressions.

Married vs. Cohabiting Couples

Cohabiting relationships are very different from marriages. They are shorter lived - out of the 7,421 cohabitations I observe, 3,622 (48%) end during the reference period; 1,846 (24%) end in marriage and 1,776 (23%) in separation. In contrast, only 4,170 (5.6 %) out of 74,944 marriages I observe end in divorce. Married couples are more likely to have children, 73% of married women in my sample have at least one child of their own living in their household, while only 30% of cohabiting women do.

There is selection into cohabitation: cohabiting couples are younger than married ones, with a mean age of 31.1 as compared to 35.5 (recall that these are statistics for women 46 and younger only). African Americans are more likely to cohabit than whites, see table 2.2.

The educational attainment of those living in unmarried partnerships is markedly lower than that of married couples, see figures 2.5 and 2.6. Most strikingly, only 16% of

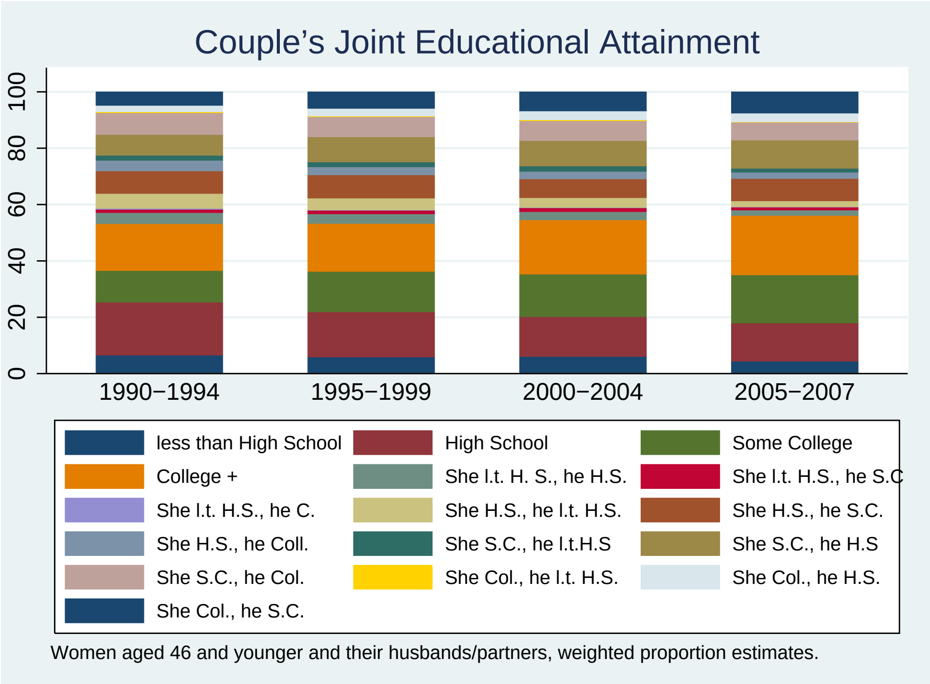

Figure 2.4: Joint educational attainment as a percentage of all couples, 1990-2007.

cohabiting men in my sample have a college degree, while 29% of married men do. This is consistent with other studies for the United States - e.g. Brien et al. (2006) use the National Longitudinal Study of the High School Class of 1972, who were followed until 1986. They also find that only about 20% of cohabitations are still intact after three years, with an end defined as either formal marriage or separation. Similarly, Stevenson and Wolfers (2007), using data from the National Survey of Family Growth, report that more than half of all couples who were cohabiting in 1997 had split up five years later, while only a quarter had married by this time.

Given this obvious differences between married and cohabiting relationships, it could be argued that I should exclude cohabitations. Because their separation risk is so much higher than for marriages, they do however provide a lot of additional variation. In the probit regressions, I control for cohabitations with a dummy variable. I also ran all probit regressions separately for a sub-sample including only married couples. My main results are robust to the exclusion of cohabitations (except for the interaction of the inequality measure with the highest educational group, see below).

Table 2.2: Racial Background of Married and Cohabiting Women

	Married Women	Cohabiting Women
White	0.74	0.72
African American	0.07	0.09
Hispanic	0.13	0.14
Other	0.06	0.05

Weighted proportion estimates, women 46 years and younger, 1990-2007.

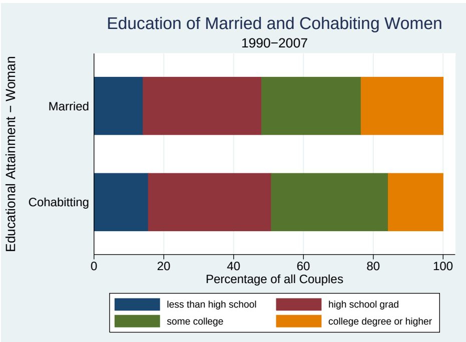

Figure 2.5: Weighted proportion estimates, women aged 46 and younger.

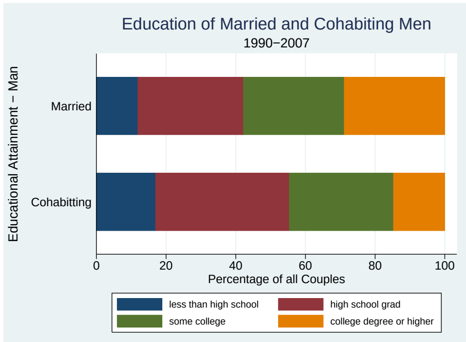

Figure 2.6: Weighted proportion estimates, partners of women aged 46 and younger.

2.6 The Effect of the Marriage Market on the Divorce Hazard

I run probit regressions on the probability that a married woman divorces or a woman with a live-in partner dissolves her relationship in any given month, according to equation (2.1). As mentioned above, I run all regressions twice, once allowing for clustering of the standard errors according to recommendations issued by the US Census Bureau, and once clustering the standard errors at the state level.[1] The clustering of the standard errors does not influence the coefficients, and the difference in standard errors between the two specifications is is very small. I report the results from the regressions using clustering according to US Census Bureau recommendations because they are more conservative (i.e. the variables of interest are significant at higher p-values). I report the results of these regressions in table B.1 in the appendix.

When modeling the state-time effect η_{jt}, I follow Gould and Paserman (2003) in their

[1]See also section B.2 for a detailed discussion of this point.

stepwise approach. My first specification only includes year fixed effects. The pure time fixed effects specification takes advantage of all the regional and time variation in the male education premium, only controlling for US-wide trends in attitudes towards marriage and relationships, changes in household production technology, housing prices, or other developments that might be correlated with the education premium and aggregate divorce rates at the same time. The results of this first regression are reported in the second column of table B.1.[1]

Here, the male education premium has an overall negative effect on the divorce hazard, that is significant at the 5% level. This is at odds with the implications of the model I develop in Hyee (2011) - I would expect the difference between the wages of university graduates and non-graduates to work through the interactions with the dummies indicating the joint educational attainment of the couple, and I would want this effect to be positive. This result is however due to the education premium picking up some unobserved heterogeneity at the state level, since the effect is not significant anymore once state fixed effects are introduced (columns three and four of table B.1). Also the fraction of men of a "marriageable age" who are college graduates is significant in this specification, but this also vanishes once state fixed effects are introduced. The same is true for the mean wage of full time working men.

My main variables of interest, the interactions of the male education premium with the dummies for the couple's joint educational attainment, are significant at the 5% level for the lower two education groups, while the interaction for couples where both have at least some college education is not significant at the 10% level. This is in line with my story: because individuals in these couples are already married to someone with a college education, they cannot expect to improve their situation by going back on the marriage market and marrying someone more educated. Therefore, changes in the returns to college education should not influence their propensity to divorce. For the other two groups, this effect is positive and significant - at the 5% level for those with at most a high school degree, and at the 2% level for the middle group of couples (one partner is high-school graduate, and the other has at least some college education). Thus, quantitatively, the interaction of the education premium has the biggest influence on couples who are in the centre of the education distribution. Because there is assortative mating in the marriage market, those with a college education are the most likely to marry a college educated spouse. Hence, the expected value of divorcing and going back to the marriage market should be the greatest for those who have a college degree, but are married to a

[1] I report the coefficients associated with the covariates in the probit regressions. Note that although these are not marginal effects, their signs indicate the direction the covariates influence the divorce hazard.

partner with only high school education.

One might worry that the education premium, varying at the state level, picks up unobserved state characteristics that influence divorce rates. I therefore estimate another regression including state and year fixed effects. State fixed effects control for omitted variables that influence divorce rates, vary between states and are constant over time. Note that this means disregarding all cross-sectional variation in divorce rates and returns to education across states. I report the results of this specification in the third column of table B.1. The overall effect of the education premium is not significant at the 10% level any more, indicating that it indeed picked up some state-inherent characteristics that influence both the returns to education and the divorce rate, corroborating my hypothesis. In this specification the proportion of women with a high school degree becomes significant at the 6% level; it has a positive effect on the divorce hazard. I am careful to interpret this result as a marriage market effect, since it could simply indicate that more educated women are more likely to leave an unsatisfying marriage because of their better economic standing. The coefficients and significance levels of the interaction of the education dummies with the education premium only change very slightly for the first two groups. For the highest educational group, the coefficient turns significant at the 10% level when controlling for state fixed effects, though.

Finally, it could be the case that changes in the male education premium are correlated with *changes* in omitted variables at the state level, that also influence divorce rates. Again, following Gould and Paserman (2003), I deal with this by introducing state specific linear time trends (in addition to state and year fixed effects). This random growth specification is conservative, since it not only throws away all between states cross sectional variation, but also all within state trends in the returns to education and divorce rates. This specification should take out all variations in the dependent variable that are due to state or time specific trends, including changes in spouse choice that vary over time or between states. All remaining variation comes from *deviations* in the education premium and the divorce rate from a state specific linear time trend. Results for this specification are listed in the fourth column of table B.1. The proportion of educated women remains significant at the 8% level. The coefficients associated with the interaction of the returns to education with the education dummies only decrease very slightly in comparison to the regression without random growth specification for the first two educational groups, and the probability scores associated with them increase only very slightly (the interaction term is significant at the 9% level for the "worst" educational group, and at the 3% level for the middle group). It is good news for my story that the p-value associated with the interaction with the highest educational group is just about 10% when state specific time trends are included.

Unfortunately though, I cannot reject the null-hypothesis, that the coefficients associated with the interaction terms of the returns to education with the education dummies are the same across educational attainment groups for all three regression specifications.

The coefficients associated with the socio-economic characteristics I control for all have the expected sign and do not change dramatically in magnitude or significance levels across the three specifications I estimate. With regards to the pure effect of the couple's educational attainment, all three educational dummies are negative. This is to be expected, since the base group for these dummies are a couple where both spouses are high school drop-outs. It is well established in the literature that better educated individuals are less likely to divorce (e.g Weiss and Willis, 1997).

As discussed above, cohabiting couples are more likely to separate than legally married couples, so we would expect the coefficient associated with the cohabitation dummy to be negative and significant. The presence of own children in the household and jointly owned property (here, home ownership) are both investments in the relationship that increase the gains to marriage as well as the cost of divorce, and have been shown to decrease the divorce hazard in previous studies (e.g. Weiss and Willis, 1997; Charles and Stephens, 2004). The presence of other kids (foster children or children who are otherwise related to the couple) increases the divorce hazard. I include two dummies for the age difference between the partners to allow for the possibility that a large age difference decreases the gains to marriage. Although the coefficients are both positive, the influence is not significant conditional on the other controls I include.

The number of times previously married has a positive impact on the divorce hazard. Most of the around 18% of the women in my sample who are in their second or higher order marriage are divorced (97%), which is not surprising given that the sample is restricted to quite young women. Thus, having experienced a divorce increases the chances to see subsequent marriages fail as well (Charles and Stephens, 2004, arrive at the same result). Becker et al. (1977) reason that individuals who were divorced in the past have either a higher variance in their traits (they experienced earnings- or other shocks in the past, that indicate that they are more likely to experience shocks in the future) or lower expected gains from marriage (because they invest less in marriage specific capital or have higher search costs) that caused their first marriage to break down. These same qualities also increase the likelihood that their second marriage, too, will be dissolved. Lundberg (2010) shows that personality traits are important in determining the risk of divorce. Most notably, individuals with a high degree of *openness to new experience* are more prone to divorce - which should not be surprising, since this personality trait is associated with a taste for variety and change. For men, extroversion is associated with a higher divorce risk, which Lundberg (2010) interprets as a lower cost to meeting new potential partners. Since personality traits are very stable in adulthood, individuals who score high in these traits are likely to divorce in higher order marriages as well.

As a robustness check, I repeated the regressions reported in table B.1 without the term interacting the couple's joint educational attainment with the male education premium, and for a common measure of overall wage inequality; I report these results in table B.2 in the Appendix. For ease of comparison I also include my base estimates, omitting the socio-economic controls that are the same as above. Consistent with the theoretical model I developed in Hyee (2011), the coefficient associated with the male education premium is not significant when the interactions are dropped - the effect indeed only affects women who have a chance to marry a college educated man in a second marriage. As a measure of overall wage inequality, I use the standard deviation of hourly wages for the marriage market relevant subgroup of men aged 18-50. The effect of overall wage inequality is somewhat stronger than the effect of the education premium, which is not surprising because there is more variation (the education premium is only a measure of between group variation). The pure effect of the standard deviation of log male earnings only disappears when state specific linear time trends are included in the specification, and the effect on the least educated couple is not significant in any specification, but the coefficients are similar in size across the two specifications.

It is interesting to see the quantitative influence of male wage inequality on the divorce risk. Table 2.6 reports the marginal effect of an increase in the male education premium on the divorce hazard - I evaluate the marginal effect at every observation (with all covariates held constant at the value for this observation), and then calculate the average over all women in the sample, as recommended by Greene (2000). That is, I calculate the *mean effect* and not the *effect at the mean*.[1] Table 2.6 reports the *difference* in the marginal effects of an increase in the male education premium for individuals who belong to the respective educational group as compared to all other individuals. These slopes should be taken with a pinch of salt because they are *changes in monthly divorce risk* in response to a change in the marriage market conditions. Since the monthly divorce risk is already very low, these effects are quantitatively small. I report them for the model specification with time and state fixed effects (column number three in table B.1). Note that it is not possible to evaluate the marginal effect of a change in the male education premium only through the *interaction term* with the educational class a couple belongs

[1] I compute these marginal effects using stata's margins command, applying derivative (dydx) option over the three educational dummies.

to - changes in the education premium influence the divorce hazard in this model both through the pure effect and through the interaction with the educational dummies.

Table 2.3: Marginal effect of a change in the education premium on the divorce hazard

	Slope
At most one spouse is a HS dropout	0.000
One is a HS graduate, the other has at least SC	0.003
Both have at least some College	-0.004

Slopes from probit estimation including time and state fixed effects, standard errors adjusted according to US Census Bureau recommendations, women aged 46 and younger.

Table 2.6 tells us that there is practically no effect on couples in which at most one partner is a high school drop out, or both have a high school degree. For the middle couple, in which one spouse is a high school graduate and the other has at least some college education, a marginal increase in the return to a college degree increases the *monthly* divorce hazard by a third of a percent. The negative influence associated with the highest educational group is due to the pure negative influence of the divorce hazard that outweighs the positive interaction with the educational dummy for this group, because this effect is very small. I also checked if the marginal effect of the education premium is constant across the range on which the education premium varies, which seems to be the case.

Coughlin and Drewianka (2011) argue that, since most women do marry at some point, we should expect the effect of the male education premium on a woman's marriage hazard to weaken with the woman's age - you cannot wait forever. Young women have more to gain by behaving strategically on the marriage market. To see if this is the case, I calculated the differential effect of the education premium on women of different ages, and indeed find that the effect of the education premium declines with age, although the differences between the age groups are very small.[1]

As a robustness check, I checked for seasonality in the divorce hazard by including month dummies (recall that the macro-economic variables are already deseasonalised using state-month interaction dummies, and the socio-economic variables are unlikely to vary monthly) in my main regressions. It turns out that there is some mild seasonality in the propensity to divorce; couples are more likely to split up in the summer and autumn than in the winter and spring. This however only very marginally influences the

[1] I did this using the at option of the margins command.

significance levels and size of the coefficients.

2.7 Conclusions

It has been shown before that young women do consider the quality of available young men in their decision to marry - if there is a lot of variation in the wages of young men, they are prepared to stay single for longer to increase their chances of finding a husband with a high earnings power. In this paper, I show that also women who are already in a relationship are influenced by the marriage market, and are more likely to separate if male wage inequality increases.

My conjecture is that the value of being married to a man without a college degree *decreases*, other things equal, if the wage returns to such a degree increase - college educated men become more attractive in comparison. Therefore, the expected value of divorcing and going back to the marriage market increases for a woman who is married to a man who does not have a college degree. Using data from the Survey of Income and Program Participation for the years 1990-2007, I show that the ratio of wages for men with and without a college degree indeed does influence a woman's propensity to divorce. Moreover, this effect is strongest for women who are most likely to marry a man with a college degree (due to assortative mating) - women who have a high school degree or some college education. The effect, although present, is statistically weaker for women with a college education or higher, who are married to man with a similar education. These women do not have as much to gain on the remarriage market, as they are already married to a highly educated spouse. This effect is robust to accounting for time trends and regional fixed effects.

The period I analyse - the 1990-2007 - was characterized by slow growth in earnings inequality as compared to the 1970s and 1980s. This weakened the positive relationship between wage inequality and age at marriage (Coughlin and Drewianka, 2011), that should be expected to be stronger than the relationship between divorce and wage inequality, due to the transaction costs of resolving a marriage. The fact that I still find a robust positive association between wage inequality and divorce is therefore encouraging.

The big caveat of this study is data availability: to my knowledge, the SIPP dataset is the only dataset available at the moment that is big enough to allow meaningful analysis of marital dissolution. While Gould and Paserman (2003) and Coughlin and Drewianka (2011) can use the much larger US census, my sample size and the shorter time period covered restrict the possibilities of this study. Gould and Paserman (2003) and Coughlin and Drewianka (2011) show that the marriage rates of very young women (below the age of thirty) are much more responsive to changes in wage inequality than the marriage rates of more mature women, which is to be expected, because younger women have a higher expected payoff from strategic behaviour on the marriage market. If there were a bigger dataset to analyse divorce, the same analysis I presented here could be meaningfully conducted for a younger sample, say, women below the age of thirty five. Further more, a larger sample size would facilitate the definition of geographically smaller marriage markets - for example at the metropolitan, instead of the state level - thus allowing for more cross-sectional variation. Because of data constraints, this is not possible at this time.

Chapter 3

Specialisation in the Bargaining Family

3.1 Introduction

Traditionally, family economics - and especially its pioneer Gary Becker - has emphasised the importance of specialisation of women and men in household and market tasks as a main function of the institution of marriage. This early work did not address the question whether or not specialisation in household production was beneficialmto the individual. Specialisation was considered advantageous for the household, because it increased total consumption, and since the household was seen as one unanimous decision maker, there was no doubt that it would benefit the individual. Likewise, there was no reason to doubt that family decision making would be efficient, either.[1]

More recent literature on family decision making calls this approach into doubt.[2] In this paper, we show that allowing for distributional conflict within a couple can generate an inefficient outcome of the family decision making process; and that specialisation in household versus market tasks does have different distributional consequences. We develop a simple two period model, in which spouses bargain over the provision level of a family public good and the division of private consumption between the spouses. The family public good is produced at home, with spouses' time as the only input, while private consumption results from labour market work. We emphasize the importance of labour market experience as a determinant of wage rates. Based on recent findings in empirical labour economics, we make an assumption about the specific functional form linking labour market experience and wage rates. This allows us to show that specialization in household and market production within the couple is efficient, even if spouses are equally productive in both spheres ex-ante. In the case of equal ex-ante productivities, it does not matter whether the husband or the wife specialises in market work. In this way, specialisation in household and market work arises as a consequence of the provision of the public good, without assuming biological differences or labour market discrimination against women. The public good causes different levels of investment in human capital within the couple, which in turn leads to spouses having different wage rates in the second period.

Provided the couple can reach a binding agreement about the distribution of their resources over the course of their whole married life, the spouse who suffers from a lower wage rate caused by the provision of the family public good is compensated by the other spouse. In this case, the outcome of the family decision making process is efficient.

If, on the other hand, binding agreements across periods are not feasible, the efficient

[1]Among the many contributions of Becker to the theory of the family, see e. g. Becker (1965, 1981).
[2]See our discussion in section 3.2.

degree of specialization may not be time-consistent. There is an asymmetry between market and household work. Working in the labour market leads to a higher wage rate in the second period while producing the household public good does not. Therefore, the public good provider suffers from a lower consumption level in the second period. This may cause an under-provision of the public good, because the spouse specialized in market work cannot credibly commit to compensate her or his partner for their lower wage rate in the second period.

The model starts with "young marriage", when the couple establishes their first joint household, and family public goods become relevant.[1] Not only every-day household work is a public good for the couple, but also the benefits of long-term investments like the rearing of children or the building of a house are enjoyed jointly by both spouses. This is what we have in mind when we talk about the production of a family public good, which requires the spouses' time as an input. Naturally, the time devoted to household production goes at the expense of other activities, most prominently the building of a professional career. The age at which most couples have children is also the age at which most market related human capital is accumulated and careers progress in the most decisive way, playing a crucial role in lifetime earnings and in later income patterns. We incorporate this trade-off by assuming learning by doing on the labour market. The more an individual works in the market and invests in his or her professional career, the more productive she/he becomes. Or, conversely, the more time an individual spends producing the household public good, the more she/he forgoes present and future income at the labour market. In line with empirical findings, we assume this effect to become weaker the longer the absence from the labour market.

In the second period, the couple is established (e.g., the children have grown up and left home). We assume that there is no household public good consumption and that both spouses devote themselves entirely to their careers.

In both periods, spouses determine the distribution of private consumption via Nash bargaining. In this solution concept, the utilities the spouses could guarantee themselves if they were unable to reach an agreement - the threat or disagreement points - are of crucial importance for the distribution of private consumption goods. We devote special attention to spouses' threat points, since there is no consensus in the literature as to what is likely to be used as a threat point in family bargaining. Two quite different specifications have been proposed so far. In the classic models of Manser and Brown

[1] While we use the term "marriage" throughout the text, the model applies to any form of cohabitation or partnership that involves a major joint project. Also other settings outside the economics of the family are imaginable, like a partnership of firms contributing to R & D as a public good in a first stage of a 2-stage-game.

(1980) and Mc Elroy and Horney (1981), spouses divorce and live as singles in the event of a breakdown of negotiations. Alternatively, it has been proposed they may stay together, but resort to non-cooperative behaviour within marriage (Lundberg and Pollak (1993) and Konrad and Lommerud (2000) are examples of this strand of literature). We compare both threat point specifications to assess their relevance. It turns out that the two different threat point specifications favour different spouses. The choice of the threat point does have distributional consequences, and it may even effect the efficiency of the household's time allocation.

The paper proceeds as follows. In the next section, we discuss the related literature. Then we present the model and its main assumptions. Section 3.4 derives the efficient Nash bargaining solution (NBS) if binding agreements across periods are feasible and discusses the two threat point specifications as well as their implications for the distribution of resources within the couple. Section 3.5 analyses the model if spouses cannot commit across time periods. We describe possible inefficient outcomes and discuss potential policy implications of the model. Section 3.6 summarizes our results and concludes.

3.2 Related Literature

The family bargaining literature was pioneered by Manser and Brown (1980) and Mc Elroy and Horney (1981). They pointed out the potential for distributional conflict within couples, and proposed that spouses resort to Nash bargaining to settle their differences.[1] In Nash bargaining models, household decision making is efficient by assumption - this is often justified by the repeated nature of interaction between spouses that should facilitate cooperation between spouses and enable them to reach efficient outcomes.

While it is arguable that families cooperate on an everyday basis, it is not clear how families should make binding contracts about intra-household distribution over long time horizons.[2] This paper contributes to a fast growing literature that questions families' ability to cooperate effectively and reach efficient outcomes regarding decisions that can influence future bargaining power, and therefore future resource allocation. If families behave non-cooperatively, investments into skills that are useful in the production of a household public good might be too low, because being more productive in the provision

[1]Another important strand of the family economics literature stresses the importance of household production and trade within the household, see Apps and Rees (1988, 1996). The "collective" model of Chiappori (1988) and many related papers do not specify a decision making process, but suggests that family decision making leads to efficient outcomes. In this paper we focus on the bargaining approach.

[2]Note that prenuptial agreements fix the distribution of resources in the case of divorce, but rarely *within* marriage.

of a public good is not necessarily an advantage in a non-cooperative setting (Buchholz and Konrad, 1995). Ott (1992) was one of the first to analyse a dynamic model of intrafamily distribution that produces an inefficient outcome. Because of learning by doing in the labour market, the bargaining outcome of one period influences relative threat point utilities in subsequent periods. Gugl (2006) analyses the effects of the taxation of couples on labour supply and intra-family distribution in a similar model (she also considers different threat point specifications).[1] In these two models, spouses work too much on the labour market in the first period to enhance their productivity (and therefore their bargaining position), in the second period; this results in a sub-efficient provision level of the public good.[2]

Another decision that is likely to influence future bargaining power is the educational choice. If one spouse has more education, and therefore a higher wage rate, than the other, efficiency demands that this spouse specialise in market work, while the other performs most of the "housework" (the production of family public goods). In Konrad and Lommerud (2000) spouses invest non-cooperatively in education *before* marriage. Then they marry and in the second period they may behave non-cooperatively or they may cooperate with the equilibrium of the non-cooperative game as the threat point. Both spouses have an incentive to inefficiently over-invest in education (i. e., their productivity in market work), because a higher wage rate improves their bargaining position in the second stage (whether directly in the private provision game or indirectly via the fall-back utility in the Nash bargaining game).[3]

In these models, excessive investment in earnings power - be it formal education or on the job training - is purely *strategic*, it is incurred to improve one's bargaining position by altering relative productivities within the couple to one's advantage. In contrast, the main reason for the inefficiency of the bargaining outcome in our model is not the different effect of household- and market skills on bargaining power, but the fact that spouses are credit constrained. Wrede (2003) develops a model similar to ours. He concentrates on couples who, at the time of raising children, have sufficient funds to ex-ante compensate the spouse who spends more time in household production - this ensures efficient time

[1] In a more recent contribution, Gugl (2009) revisits the issue of joint versus individual taxation of couples in a dynamic bargaining model, where spouses choose their labour supply non-cooperatively in the first period, and use the Nash bargaining solution only in the second period. She also examines the role of control over labour supply - i.e. if both spouses have the power to chose their own labour supply - for intra-household distribution.

[2] Lundberg (2002) also considers a model with learning by doing on the labour market, focusing on family policy. She does not explicitly model family decision making, but household utility is a weighted average of individual utilities.

[3] Vagstad (2001) proposes a similar model where the spouses do not invest in education valuable on the labour market, but in household production skills. Asymmetric household productivity is assumed.

allocation choices. Our model relaxes this assumption.

Cigno (2008) develops a dynamic model of fertility, investment in children and division of labour between spouses. He compares a Nash bargaining model with a divorce threat point to a purely non-cooperative model of the household. Cooperation is efficient, and leads to a higher degree of specialization. He also shows that the primary care-giver (who is likely to be the woman) benefits if long term contracts over the division of resources within the household are easily enforceable. If renegotiation is possible, the main care-giver is likely to be worse off, but time allocation is not affected. Aura (2007) shows that a couple's inability to commit across time can result in inefficient joint consumption and savings choices, using an infinitely repeated Nash bargaining model with a divorce threat point. Household production is absent from his model - instead, he provides a very interesting discussion of the effect of different property law regimes in the divorce threat point on the efficiency of the consumption-savings choice.

Rainer (2008) uses a framework similar to Konrad and Lommerud (2000) - to analyse how gender discrimination on the labour market influences the efficiency of married couples' time allocation and intra-household distribution. Because women have a comparative advantage in household production, it would be efficient for them to specialise in household tasks and make lower investments in their earnings power. But, since earnings capacity is an important determinant for bargaining power in the second stage, couples strategically over-invest in their earnings capacity in the first stage. Gender discrimination on the labour market can remedy this inefficiency because it makes market work less attractive for women, but this efficiency gain comes at the cost of diminished equity within the household. Our paper complements this approach by showing that inefficiency can be due to long-term commitment problems, even if husband and wife have equal productivities on the outset. Although the source of inefficiency in our model is not strategic behaviour, but credit constraints, it exhibits a similar equity/ efficiency trade-off.

All the models quoted above assume *exogenously* that spouses have differing productivities in household and market work (otherwise, specialization within the couple would not be efficient).[1] We do not need such an assumption. In contrast, our model, specialization arises *endogenously* due to the provision of the public good even if both spouses have identical productivities at the beginning of marriage.[2] Thus, our model extends the existing literature by analysing specialization between spouses that are *ex-ante* identical and leading endogenously to an asymmetric ex-post outcome. Also, we suggest

[1] Cigno (2008) assumes that each child requires a minimum time of maternal time, which almost always results in the woman being the primary care giver.

[2] For the sake of a complete analysis, we also consider the case of unequal partners.

a different source of inefficiency - contract and credit constraints - as opposed to strategic motives (influencing future threat points), that have dominated the literature so far. Furthermore, with the exception of Gugl (2006), none of these papers discuss different threat-point specifications. We show that the threat point specification does not only influence intra-household distribution (as in Gugl, 2006), but might as well influence the efficiency of the household's time allocation.

3.3 The Model

Consider a household consisting of two spouses, $i = f, m$, whose lifespan stretches over two periods. In both periods, the spouses' time endowment is fixed and normalized to 1. In period 1, which can be thought of as "young marriage", spouses f and m allocate their time between household work producing the family public good G, which can be thought of as raising children, and market work. In the second period, spouses devote all their time to market work and only consume the private good.[1] The lifetime utility function of spouse i is additively separable and is given by

$$U^i = c_1^i + v(G) + c_2^i, \qquad i = f, m, \tag{3.1}$$

where c_j^i, $i = f, m$, $j = 1, 2$ denotes the private consumption of spouse i in period j, and $v(G)$ is the utility the spouses derive from the public good G. The function $v(G)$ is monotonically increasing, concave, and twice continuously differentiable. Thus, lifetime utility is quasilinear and inter-temporally linear.[2] For the sake of simplicity there is no leisure and no discounting, therefore lifetime utility is the sum of the utilities of both periods. Further, we assume that spouses do not have access to the capital market, there is no borrowing and no saving.[3]

The public good is produced in the first period with the spouses' time as the only input according to the linear technology $G = h^f g^f + h^m g^m$, where g^i, $i = f, m$ are her

[1]Having no public good in the second period allows focusing on the commitment effect of the public good provision in the first period. Konrad and Lommerud (2000) have analyzed the case of public good provision in the second period and the corresponding strategic behaviour in the first period.

[2] This special form of utility is quite restrictive, but it is commonplace in the literature to restrict the analysis to special utility functions for the sake of analytical tractability. Lundberg and Pollak (1993) assume a Stone-Geary utility function, Konrad and Lommerud (2000) work with a quasilinear "payoff" function and Vagstad (2001) analyses the case of Cobb Douglas preferences with equal coefficients for the public and the private good. We chose this quasilinear formulation because in our Nash bargaining setting the utility possibility frontier (the locus of all Pareto efficient utility pairs) is linear and utility is easily transferable between the spouses, which greatly simplifies the formal analysis, see Bergstrom (1997).

[3] For a discussion of this assumption, see section 3.5.

and his contributions to G, and h^i, $i = f, m$ are her and his productivities in household production, respectively.[1] Throughout the paper we will assume, without loss of generality, that the wife is at least as productive in the household as the husband, $h^f \geq h^m$ (note that this involves the case of equal household productivities as a border case).[2]

The private consumption good c_j^i is purchased with the income the spouses earn on the labour market whenever they are not busy producing the family public good. On the outset, spouses have the same market productivity given by the wage rate $\underline{w}$. Private consumption in the first period is

$$c_1^f = \underline{w} \cdot (1 - g^f) + P^1, \tag{3.2}$$

$$c_1^m = \underline{w} \cdot (1 - g^m) - P^1 \tag{3.3}$$

where $1 - g^i$ is the time spent on market work, and P^1 is a transfer from husband to wife in period 1 (which of course can also be negative). In period 2, spouses devote all their time to market work and only consume the private good. Second period consumption is

$$c_2^f = w(g^f) + P^2, \tag{3.4}$$

$$c_2^m = w(g^m) - P^2, \tag{3.5}$$

where the wage rate depends on own first period labour supply and P^2 is the second period transfer.

Learning by doing on the labour market

Labour market experience acquired in period 1 increases the wage rate in period 2. Equivalently, time spent in household production in the first period decreases the market productivity in the second period, so the wage function $w(g^i)$ is decreasing. Furthermore, the (negative) marginal productivity effect of an additional time unit spent in household production (i.e. not on the labour market) decreases with the total duration of that individual's absence from the labour market, i. e., the marginal productivity effects of g^i are diminishing.

To illustrate this assumption, consider the marginal effect of one additional year of

[1] This household production technology where time inputs of husband and wife are perfect substitutes was proposed by Becker (1981), who argued that "at the beginning everyone is identical; differences in efficiency are not determined by biological or other intrinsic differences" (Becker, 1981, p. 32).

[2] We want to stress that we do not resort to any kind of exogenous or biological argument here. We want to allow for the case that one partner has a comparative advantage in household production and we consider equal productivities as the border case. The direction of the inequality is a matter of indexation only and could as well be reversed.

maternity leave on the mother's wage rate. Whether she takes one or two years off following the birth of her child has a relatively big (adverse) effect on her career, but whether she stays away from the labour market for seven or eight years does not make a big difference any more.

The assumption that the wage decreases at a decreasing rate in the time devoted to household production corresponds to the assumption that the returns to learning by doing increase at an increasing rate. It is based on several recent empirical contributions that suggest that the relationship between wages and time invested in one's earnings power (be it in education or work experience) is non-linear. Regarding education, Mincer (1997), Deschnes (2006) and Lemieux (2006b,a) all find a convex wage function of education. Lemieux (2006b) argues that especially time invested in post-secondary education increases the wage rate in an over-proportional way. With respect to work experience, Beblo and Wolf (2002) look at the effect of job leaves on wages by modelling a convex wage function, which is supported by their data. Schnberg and Ludsteck (2007) analyse the effect of several expansions in the duration of maternity leave in Germany on women's wages. They find that an expansion in job-protected leave from 2 to 6 months that took place in 1979 significantly decreased wages, while subsequent expansions from 6 to 10 months in 1986 and from 18 to 36 months in 1992 did not lower wages significantly. Although some of these papers focus on the effects of education and not on work experience, the relevant aspect in the context of our model is whether an individual invests her/his time in her/his own career and human capital (be it work experience or further education) or whether (s)he contributes to the household public good instead.

If an individual devotes all her/his time to market work, the highest possible wage in period 2 is given by a fixed, finite wage $\overline{w} := w(0)$. The lowest possible wage is denoted by $\underline{w} := w(1)$.

Thus, $w(g^i)$ is a monotonically decreasing, convex and twice continuously differentiable function, $w'(g^i) < 0$, $w''(g^i) > 0$ for $g^i \in [0, 1]$. This is a crucial assumption of our model, which we believe to be both plausible and supported by the empirical data.

Time structure

We consider a two period model with the following structure.

1. The first period is young marriage. In this phase, the couple chooses the contributions to G. We assume that the couple decides cooperatively via Nash bargaining on the size of contribution, on the spouses' labour supply and on the distribution

of the private consumption good between the partners. Spouses have two possible threat points when bargaining:

(a) Non-cooperative marriage as threat point: Spouses contribute privately to the family public good.

(b) Divorce as threat point: Spouses evaluate their utilities as being life-time singles.

2. In the second period there is no public good to be provided and both spouses devote all their time to market work, i. e., to private consumption. Again, Nash bargaining determines the distribution of private consumption between the spouses.

We will consider two versions of this model. First, as a benchmark, we look at the outcome if spouses can enter into a binding contract at the beginning of marriage that stipulates private consumption in both periods. Then, in section 3.5, we relax this assumption and assume that spouses have to renegotiate the distribution of private consumption in period 2.

3.4 Binding agreements are feasible

As a reference point for our analysis, in this section we quickly solve the model under the assumption that the couple can enter into a binding contract at the beginning of period 1, that determines both the level of the public good provision (and who provides it) and the distribution of private consumption in periods 1 and 2.

The NBS is, by construction, efficient, and lies on the boundary of the couple's utility possibility set, the Utility Possibility Frontier (UPF). Quasilinear utility implies that the UPF is linear in the relevant region where both spouses consume positive quantities of public and private goods. The couple's UPF and the NBS are depicted in Figure 3.1, where the efficient NBS is found at the tangency point of the UPF and the curve representing the Nash product.[1] The optimal provision level of the public good is unique, while the division of the private consumption good is determined by spouses' threat point utilities.

[1]The UPF is non linear in its border regions, where private consumption is zero for one spouse. If one of the spouses controls the couple's entire private consumption, he or she can further increase his or her utility by decreasing the level of public good provision below the socially optimal level. Any reduction beyond his or her individually optimal provision level decreases both utilities. This results in the concave borders of the UPF as depicted in Figure 3.1. Because both spouses consume public and private goods at the threat points and control their own income, the NBS will never lie on these borders regions.

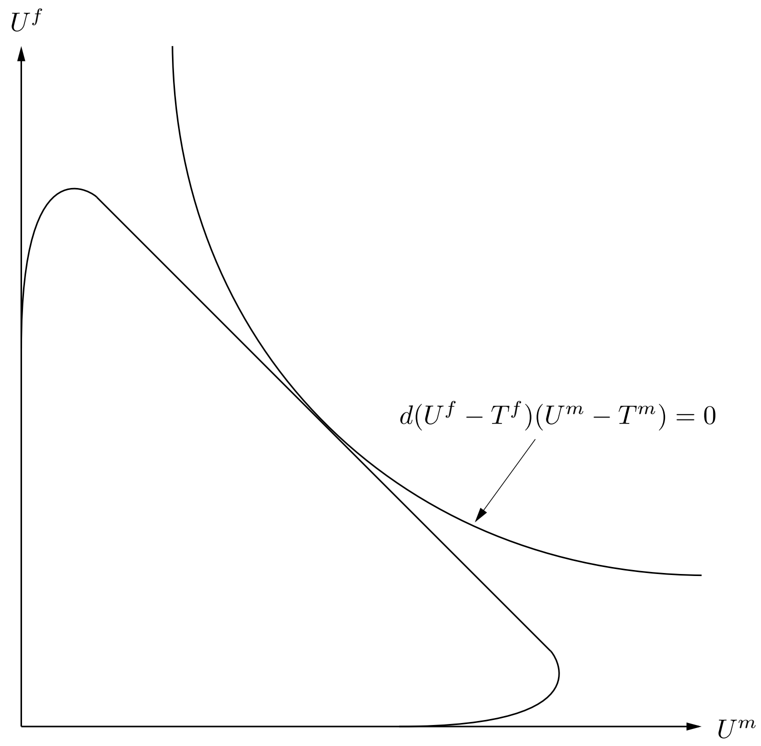

Figure 3.1: The efficient outcome

Efficient outcome

Assuming binding contracts across periods enables us to treat the two periods of the model as one. Maximising the sum of the spouses' inter-temporal utilities, with respect to their contributions g^f and g^m yields the efficient outcome:

$$\begin{aligned} U(g^f, g^m) &= U^f(g^f, g^m) + U^m(g^f, g^m) = \\ &= \underline{w} \cdot (1 - g^f) + \underline{w} \cdot (1 - g^m) + 2v(h^f g^f + h^m g^m) \\ &\quad + w(g^f) + w(g^m). \end{aligned} \tag{3.6}$$

In order to have a non-trivial problem, we assume that each spouse would consume a positive amount of both the public and the private good if (s)he were single, $0 < g^i < 1$ for $i = f, m$. Equivalently, the marginal utility of the first unit of time devoted to the public good G is sufficiently large and the marginal wage effect of the last unit of time devoted to market work is sufficiently small for both spouses $i = f, m$:

$$\begin{aligned} v'(0)h^i &> \underline{w} - w'(0) && (3.7)\\ 2 \cdot v'(h^i)h^i &< \underline{w} - w'(1). && (3.8) \end{aligned}$$

Note that the second of these Inada conditions states that, at the solution of the couple's joint maximization problem, the sum of the contributions to the public good $g^f + g^m$ is smaller than 1. This condition also implies that each spouse on her or his own would never spend all available time in household production. Additionally, we assume that $U^i(g^f, g^m), i = f, m$, are globally concave:

$$-w''(g^i) > v''(h^i g^i)(h^i)^2 \qquad \forall g^i \in [0, 1]. \tag{3.9}$$

These assumptions guarantee that the individual maximization problem does not have a trivial (corner) solution and that the second order conditions for both individual and joint utility maximization are satisfied. We say that an individual i is *fully specialized* if (s)he devotes all of her/his time in the first period to one type of work (market or household work), that is, if $g^i = 0$ or $g^i = 1$.

Proposition 11 (Efficiency). *In the efficient solution, one spouse is fully specialized in market work while the other spouse divides his or her time between market work and household production. If $h^f > h^m$, it is the husband who specializes in market work. If $h^f = h^m$ either spouse can specialize in market work.*

Proof. See Appendix.

The intuition behind this result is that, in the first period, both spouses have the same wage rate, so they face the same direct cost of providing the public good. In terms of second period consumption, though, the first unit of the public good is the most expensive. This is due to the convex wage function. Therefore, it cannot be optimal to split the time they want to devote to household production equally, since both spouses would then suffer the expensive first units of wage loss. This is true for couples with identical productivities. If, on top of that, the wife has a comparative advantage in household production, it is optimal that she becomes the sole provider of the household public good and that the husband specializes in market work.

This full specialization result also depends on the simple payoff functions assumed. One can think of many, more sophisticated payoff functions that do not lead to full specialization; e. g. a payoff function where spouses' contributions to the public good are not perfect substitutes. However, it is our aim to keep the specification as simple as possible to focus on the spouses' inability to sign a binding agreement. A more sophisticated payoff function would, in general, make an inefficient outcome even more likely.

Proposition 11 shows that specialization is efficient because it minimizes the total cost of the provision of the public good. Although it does not matter which spouse specializes if spouses are equally productive, for notational convenience and without loss of generality we will assume that the wife is the public good provider, i. e., $G^* = h^f g^{f*}, g^{m*} = 0$. Maximizing the couple's joint utility (3.6) with respect g^f to gives us the first order condition for the efficient provision level of the public good

$$2 \cdot h^f v'(h^f g^{f*}) = 2 \cdot h^f v'(G) = \underline{w} - w'(g^{f*}). \tag{3.10}$$

The distribution of private consumption in the NBS is determined by the spouses' relative threat point utilities, denote them by T^f and T^m. The higher a spouse's utility in the event of disagreement, the larger the share of resources that spouse can claim. On the linear region of the UPF, the socially optimal amount of the public good is provided, and only the distribution of the private consumption good varies. In this region, spouses bargain over the partition of a "gains from marriage cake" of fixed size. The NBS guarantees each spouse their threat point utility, and splits the remaining surplus equally among them (see, e. g., Muthoo, 1999, p. 25). Formally, the NBS (U^{f*}, U^{m*}) is given by

$$U^{f*} = T^f + \frac{U^* - T^f - T^m}{2} \quad \text{and} \quad U^{m*} = T^m + \frac{U^* - T^f - T^m}{2}. \tag{3.11}$$

Unlike the husband, the wife works in household production, so she bears the resulting cost alone. At the NBS, she has to receive a transfer payment to ensure that she reaches the utility level guaranteed to her in (3.11). In the first period, she receives a transfer P^1 to make up for her direct income loss, while in the second period, a payment P^2 compensates her for her lower wage rate. In the following, let $\Delta U^{f-m} := U^f - U^m$ denote the *utility difference* between wife and husband and $\Delta T^{f-m} := T^f - T^m$ denote the difference between the threat point utilities of wife and husband, which we also call the wife's *utility edge* at the threat point. The transfers are calculated by subtracting the wife's utility level at the optimal household production level g^{f*} without the transfer,

$U(g^{f*})$, from the utility level she reaches in the NBS, U^{f*} (as given in (3.11)).[1]

$$\begin{aligned} P^1 + P^2 &= \frac{1}{2}(U^* + \Delta T^{f-m}) - U^f(g^{f*}) = \frac{1}{2}(U^f(g^{f*}) + U^m(g^{f*}) + \Delta T^{f-m}) - U^f(g^{f*}) \\ &= \frac{1}{2}(U^m(g^{f*}) - U^f(g^{f*}) + T^f - T^m) = \frac{1}{2}(-\Delta U^{f-m} + \Delta T^{f-m}), \end{aligned} \tag{3.12}$$

where in expression (3.12), ΔU^{f-m} is evaluated at the efficient level of g^{f*}.

In the following, we will lay out in detail the two threat point specifications we consider, non-cooperative marriage (NC) and divorce (D), and calculate the transfers corresponding to each threat point. As will become clear, the two specifications favour different spouses, as Table 3.1 below shows.[2]

Non-cooperative marriage as threat point

In the non-cooperative marriage threat point the couple lives together without coordinating their actions. They play a non-cooperative private-provision of a public good game - each spouse maximizes his/her utility, taking the behaviour of their partner as given, there are no transfers. This game has a Cournot-Nash equilibrium. Spouses maximize their individual utilities

$$U^f(g^f, g^m)|_{NC} = \underline{w} \cdot (1 - g^f_{NC}) + v(h^f g^f_{NC} + h^m g^m_{NC}) + w(g^f_{NC}) \tag{3.13}$$
$$U^m(g^f, g^m)|_{NC} = \underline{w} \cdot (1 - g^m_{NC}) + v(h^f g^f_{NC} + h^m g^m_{NC}) + w(g^m_{NC}) \tag{3.14}$$

The FOCs implicitly describing the reaction functions are

$$v'(h^f g^f_{NC} + \overline{h^m g^m_{NC}}) \leq \frac{1}{h^f}(\underline{w} - w'(g^f_{NC})), \tag{3.15}$$
$$v'(\overline{h^f g^f_{NC}} + h^m g^m_{NC}) \leq \frac{1}{h^m}(\underline{w} - w'(g^m_{NC})), \tag{3.16}$$

with equality if $g^i > 0$. The left hand side (LHS) is the marginal utility of an additional unit of the public good, while the right hand side (RHS) represents the marginal cost of that unit in forgone units of private consumption. Spouses not only take the direct cost of their home time into account ($\underline{w}$ on the RHS), but also the lower wage rate a marginal unit of household work brings about in the second period ($w'(g^i_{NC})$ on the RHS).

[1] Remember that g^{f*} denotes the efficient contribution to the public good and that U^{f*} denotes not only the efficient outcome, but additionally the NBS. So, if the wife provides the public good, $U(g^{f*}) < U^{f*}$ because of the transfer.

[2] Note that the threat point is exogenously given in our setting, and cannot be chosen by the spouses.

Lemma 1 (Non-cooperative marriage as threat point)**.** *For equal household productivities $h^f = h^m$, the contributions to the household public good are equal, $g^f_{NC} = g^m_{NC}$. If the wife is more productive in household production than the husband, $h^f > h^m$, she is the only contributor and he free-rides on her public good provision, $h^f g^f_{NC} = G_{NC}, g^m_{NC} = 0$. Moreover, the wife spends less time in household production in the non-cooperative threat point than she does at the efficient outcome, $g^f_{NC} < g^{f*}$.*

Proof. See Appendix.

Asymmetric productivities $h^f > h^m$. The wife's provision level of the public good at the non cooperative threat point g^f_{NC} is determined by (3.15) holding with equality, while the husband's contribution is zero. Therefore, the husband is at least as well off as the wife in the non-cooperative threat point. With P^1_{NC}, the husband compensates the wife for half of the time she works more in the cooperative outcome than she would have done in the absence of an agreement. P^2_{NC} compensates her for half of her associated wage loss in Period 2.

Equal productivities $h^f = h^m$. In this case, both spouses spend the same amount of time in household production at the non-cooperative threat point. Hence, both have the same level of threat point utility, and so their utility at the bargaining outcome is equal - the costs of the public good provision is shared in a "fair" way. The wife receives a payment of

$$P^1_{NC} = \frac{1}{2}\underline{w} \cdot g^{f*} \tag{3.17}$$

$$P^2_{NC} = \frac{1}{2}(w(0) - w(g^{f*})). \tag{3.18}$$

Divorce as threat point

In the event of a divorce, spouses live as singles in both periods. There are no transfers, and the public good becomes a private good. The wife maximizes her single utility as in

$$U^f(g^f)|_D = \underline{w} \cdot (1 - g^f_D) + v(h^f g^f_D) + w(g^f_D). \tag{3.19}$$

Her first order condition reads

$$h^f v'(h^f g^f_D) = \underline{w} - w'(g^f_D). \tag{3.20}$$

and analogously his first order condition is

$$h^m v'(h^m g^m_D) = \underline{w} - w'(g^m_D). \tag{3.21}$$

Lemma 2 (Divorce as threat point)**.** *For equal household productivities $h^f = h^m$, both spouses devote the same amount of time to the public good, $g_D^f = g_D^m$, but their contributions are duplicated because the good is now private. If the wife is more productive in the household than her husband $h^f > h^m$, she consumes more of the public good than he does, $h^f g_D^f > h^m g_D^m$. Moreover, the wife's contribution to the public good is the same in the divorce as in the non-cooperative marriage threat point, therefore it is below the socially optimal level, $g_D^f = g_{NC}^f < g^{f*}$.*

Proof. See Appendix.

Asymmetric productivities $h^f > h^m$. The wife's utility edge $\Delta T_D^{f-m} = T_D^f - T_D^m$ is given by

$$\begin{aligned}\Delta T_D^{f-m} &= \Big(\underline{w}\cdot(1-g_D^f) + v(h^f g_D^f) + w(g_D^f)\Big) \\ &\quad - (\underline{w}\cdot(1-g_D^m) + v(h^m g_D^m) + w(g_D^m)) \\ &= \underbrace{\underline{w}\cdot(g_D^m - g_D^f)}_{?} + \underbrace{(v(h^f g_D^f) - v(h^m g_D^m))}_{>0} + \underbrace{(w(g_D^f) - w(g_D^m))}_{?} > 0. \end{aligned} \tag{3.22}$$

The middle term is positive - because of her higher household productivity, the wife consumes more *effective* units $h^f g_D^f$ of the public good at the divorce threat point than the husband does. The signs of the first and the last term depend on who devotes more time to household production at the divorce threat point. From our assumptions about $v(G)$ and h^f/h^m, we cannot unambiguously determine the signs of the first and the last term. Still, the wife's utility edge ΔT^{f-m} is strictly positive, because she is better endowed than the husband. The transfer payments from husband to wife at the NBS are listed in Table 3.1. In the divorce threat point, the wife's higher household productivity is an advantage, her better overall endowment enables her to claim a higher share of marital resources in the NBS.

Equal productivities $h^f = h^m$. In this situation we obtain $g_D^f = g_D^m$, and therefore $v(h^f g_D^f) = v(h^m g_D^m)$, and the utility edge is zero. For a symmetric couple, the transfer payments are the same as if non-cooperative marriage were the threat point, given by equations (3.17) and (3.18).

Comparison of the two threat point specifications

Table 3.1 summarizes the transfer payments for both threat point specifications. With respect to the distributional implication of the threat point choice, Gugl (2006) arrives at similar results; but in our model the threat point choice also has allocative consequences

Table 3.1: Comparison of transfers P_i^1 and P_i^2 for both threat point specifications $i = NC, D$

	P_i^1	P_i^2
NC	$\frac{1}{2}\underline{w} \cdot (g^{f*} - g^f_{NC})$	$\frac{1}{2}(w(g^f_{NC}) - w(g^{f*}))$
D	$\frac{1}{2}[\underline{w} \cdot (g^{f*} - g^f_D + g^m_D) + (v(h^f g^f_D) - v(h^m g^m_D))]$	$\frac{1}{2}[(w(0) - w(g^m_D) + w(g^f_D) - w(g^{f*}))]$

(see below).

Asymmetric productivities $h^f > h^m$. In the non-cooperative marriage threat point, the wife's comparative advantage in household production allows the husband to free-ride on her public good provision; therefore, his threat point utility is higher than hers.[1] In the divorce threat point, on the other hand, the wife has a higher utility (since she is equally productive in market work, but more productive at producing the public good).

Equal productivities $h^f = h^m$. If the spouses are equally endowed, they make the same threat point contributions to the public good (their first order conditions coincide) regardless of the threat point specification.

Thus, if a couple with unequal household productivities were given the option to choose between the two threat point specifications, the husband would opt for non-cooperative marriage, while the wife would prefer divorce. A symmetric couple would be indifferent between the two threat point specifications. We summarize our results in the following

Proposition 12 (Efficiency under binding agreements)**.** *Under binding agreements across periods, there is full specialization within the couple. Efficiency is reached via monetary transfers, the sizes of which depend on the threat point specification. For both threat point specifications, the first and the second period transfer payments do not violate the husband's budget constraints. A wife with a comparative advantage in household production is better off (and the husband is correspondingly worse off) if the threat point is divorce than if it is non-cooperative marriage. With equal productivities, the choice of the threat point does not matter for intra-household distribution.*

Proof. See Appendix.

[1] While she has the same utility in both threat point specifications - her FOCs (3.15) and (3.20) coincide and $g^f_{NC} = g^f_D$ - he has a strictly higher utility in non-cooperative marriage than in divorce.

3.5 Binding agreements are not feasible

In a more realistic version of our model, we suppose that the couple can commit to labour supply and monetary transfers only *within* but not *across* periods. That is, at the beginning of marriage, only monetary transfers in the first period can be credibly assured, whilst payments in the second period are determined at the beginning of period 2. This reflects the fact that transfers within marriage typically cannot be legally enforced.

In the model without binding agreements, the spouses play two successive Nash bargaining games, one in each period. The outcome of the game in the second period depends on the NBS of the first period, because second period wage rates depend on first period labour supply. Since the spouses anticipate that their agreement in the first period will influence their agreement in the second period through their wage rates, this game combines cooperative and non-cooperative elements. Ott (1992) solves this problem by first deriving a "conditional solution" for the second period for given wage rates and then using the resulting indirect utility functions to find the NBS in the first period. We use a more direct approach. We start by determining the transfer in the second period, and let the couple then bargain on a subset of the original utility possibility set, that only contains utility pairs that can be reached given the size of the second period transfer.

The second period

In the second period, there is no public good, no gains to specialization and therefore no surplus to be divided. The second period payoffs of husband and wife for given contributions g^f and g^m in the first period are:

$$U^f(g^f, g^m, P^2)|_{t=2} = w(g^f) + P^2 \tag{3.23}$$
$$U^m(g^f, g^m, P^2)|_{t=2} = w(g^m) - P^2, \tag{3.24}$$

where P^2 denotes the transfer payment from the husband to the wife in the second period.

Spouses' threat points are also determined by their first period contributions g^f and g^m. Note that in the second period, the distinction between the non-cooperative and the divorce threat point becomes obsolete, since there is no public good provision. In the threat point, each spouse simply controls his or her labour market income, there are no transfers:

$$T^f(g^f)|_{t=2} = w(g^f) \tag{3.25}$$
$$T^m(g^m)|_{t=2} = w(g^m). \tag{3.26}$$

From the maximization of the Nash product in the second period with respect to P^2

$$\left(w(g^f) + P^2 - w(g^f)\right)\left(w(g^m) - P^2 - w(g^m)\right) \tag{3.27}$$

it follows that the second period transfer without binding agreements is zero. In the absence of a public good, the husband has no reason to share his private consumption with his wife. If the second period transfer cannot be legally enforced, the wife will not trust in her husband making such a payment, and she will change her actions in the first period accordingly.

The first period

Let P^1 denote the transfer payment from the husband to the wife in the first period. Given that $P^2 = 0$ by the previous section, the sum of the spouses' payoffs over both periods are given by:

$$U^f(g^f, g^m, P^1) = \underline{w} \cdot (1 - g^f) + v(h^f g^f + h^m g^m) + P^1 + w(g^f), \tag{3.28}$$

$$U^m(g^f, g^m, P^1) = \underline{w} \cdot (1 - g^m) + v(h^f g^f + h^m g^m) - P^1 + w(g^m). \tag{3.29}$$

The constraint $P^2 = 0$ alters the couple's UPF. The UPF of the original problem (as illustrated in Figure 3.1) is a straight line wherever both spouses consume a strictly positive amount of the private good. Along this line, the sum of spouses' utilities is constant and given by:

$$2v(h^f g^{f*}) + \underline{w} \cdot (2 - g^{f*}) + w(0) + w(g^{f*}). \tag{3.30}$$

Any movement along this line only redistributes private consumption between the spouses while the provision level of the public good remains constant. At the north end of this line, the wife gets all the private consumption, while at the south end the husband does. The condition $P^2 = 0$ means that this redistribution is not possible for income earned in the second period. Thus, the linear part of the UPF is shortened to the line between the point where the wife controls all *first period* labour income and the husband only consumes the public good, and the point where the distribution is tilted to the other extreme and the husband gets all first period consumption. Figure 3.2 illustrates this modified UPF for the segment in which the wife controls all first period consumption.[1]

[1] The upper part of the modified UPF is not depicted because our assumption that the wife provides the public good renders it impossible that the NBS could lie on this segment.

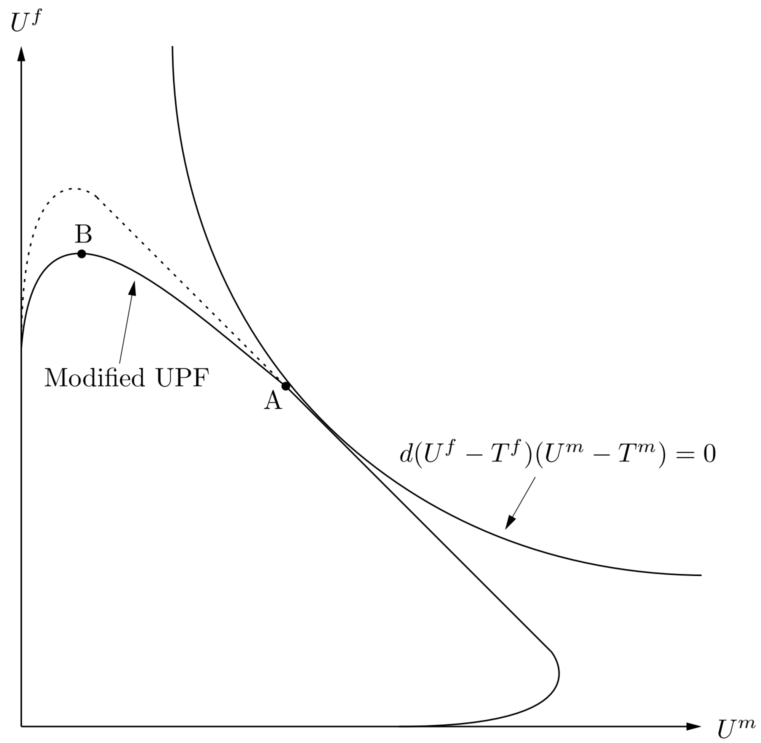

Figure 3.2: The modified UPF

The modified UPF starts at point A where the wife has the highest utility she can obtain while providing the socially optimal level of the public good, $\widehat{U^f} = v(h^f g^{f*}) + \underline{w} \cdot (2 - g^{f*}) + w(g^{f*})$. Because of the constraint, the only way to increase her utility at that point is to reduce her level of public good provision, boosting her private consumption. Reducing g^f below g^{f*} increases her utility up to point B where her contribution equals her individual optimum g^f_D, $\overline{U^f} = v(h^f g^f_D) + \underline{w} \cdot (2 - g^f_D) + w(g^f_D)$. At point B, the wife receives all the couple's private consumption in the first period, and the consumption earned by herself in the second period. Because she provides less than the socially optimal level of the public good, the UPF of the model without binding agreements lies below the original UPF for all $U^f \geq \widehat{U^f}$. It is non-linear because in this segment of the UPF, utility can only be redistributed between the spouses by varying g^f (because the wife already controls the couple's entire first period consumption, and second period consumption cannot be redistributed), and the U^i are strictly concave in g^f. The liquidity constraint preventing second period income from being distributed means that the concave region of the UPF is enlarged compared to the original problem.

Formally, the new segment of the UPF where the liquidity constraint is binding can be described as follows. For all values of g^f such that $g^f \in [g^f_D, g^{f*}]$, spouses' utilities along the UPF are given by

$$U^f = v(h^f g^f) + \underline{w} \cdot (2 - g^f) + w(g^f), \tag{3.31}$$

$$U^m = v(h^f g^f) + w(0), \tag{3.32}$$

so the wife controls the couple's entire first period labour income, and each spouse controls the second period labour income earned by themselves. The maximum utility the wife can obtain given that $P^2 = 0$ is at the maximum of this segment of the UPF, at point B. The wife's lowest utility on this segment of the UPF is the point where she provides the socially optimal level of the public good $\widehat{U^f} = v(h^f g^{f*}) + \underline{w} \cdot (2 - g^{f*}) + w(g^{f*})$.

Since the wife controls the couple's entire first period consumption in this segment of the UPF, spouses' utility only depends on the provision level of the public good. Define the set of all utility levels the husband can obtain in this region,

$$\Omega = \left\{ u^m : U^m(g^f) = v(h^f g^f) + w(0),\ g^f \in [g^f_D, g^{f*}] \right\}. \tag{3.33}$$

Because $U^m(g^f)$ is strictly increasing in Ω, its inverse $U^{m^{-1}}(u^m) = g^f(u^m)$ exists. This allows us to write the wife's utility, $U^f(g^f)$ as a function of her husband's, $f(u^m) \equiv U^f(g^f(u^m)), u^m \in \Omega$.

Lemma 3. *The function $f(u^m)$ is strictly decreasing and strictly concave for all $u^m \in \Omega$.*

Proof. See Appendix.

The intuition behind this result is simple. From (3.31) it follows that the husband's utility increases in g^f. The wife's utility must be decreasing for $g^f > g^f_D$ because $U(g^f)$ is concave and g^f_D is its maximum. Hence, $f(u^m)$ must be a decreasing and strictly concave function of u^m (between points A and B).

The difference between the model with and without binding agreements is that the straight segment of the UPF is shorter in the latter model, because only first period labour income can be freely distributed between spouses. If the NBS of the model with binding agreements still lies on the straight segment of the UPF of the model without binding agreements, the NBS remains unchanged if the assumption of binding agreements is abolished. Put differently, if in the model with binding agreements the transfers P^1

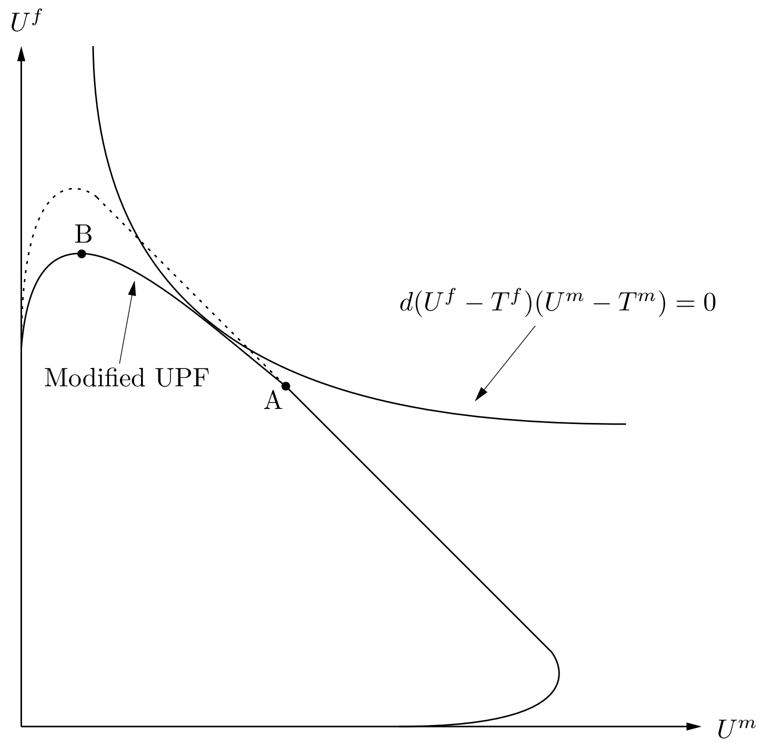

Figure 3.3: Inefficient outcome due to the liquidity constraint

and P^2 satisfy the condition

$$P^1 + P^2 \leq \underline{w}, \tag{3.34}$$

the NBS of the model without binding agreements is the same as in the model with binding agreements. If this the case, the husband is rich enough in the first period to compensate the wife not only for her direct wage loss, but also for her lower wage rate in the second period. He can afford to compensate his wife in advance and thereby sidesteps the commitment problem. Therefore, the level of public good provision is also efficient. This situation is depicted in Figure 3.2.

If, on the other hand, the transfers of the model with binding agreements exceed the husband's first period budget, i.e. $P^1 + P^2 > \underline{w}$, the original NBS cannot be reached in the model without binding agreements and the outcome is not efficient as illustrated in Figure 3.3.

The Nash product is

$$(U^f(g^f, g^m, P^1) - T_i^f)(U^m(g^f, g^m, P^1) - T_i^m), \quad i \in D, NC, \tag{3.35}$$

where T_i^f and T_i^m denote the threat point utilities for the divorce and non-cooperative threat point as determined in Sections 3.4 and 3.4. To find the NBS, we maximize the Nash product (3.35) subject to the constraints that the transfer P^1 in the first period must be feasible, $P^1 \leq \underline{w} \cdot (1 - g^m)$, and that the transfer P^2 in the second period is zero, $P^2 = 0$, as demanded by subgame perfection. If the constraint $P^2 = 0$ is binding, the new NBS must lie on the new segment of the UPF and can be found by maximizing (3.35) on $f(u^m)$. We summarize our results in the following

Proposition 13 (Binding agreements not feasible)**.** *If the couple cannot commit to a transfer in the second period at the beginning of period 1, there will be no monetary transfers in period 2. Two cases can be distinguished:*

1. *The payments determined in section 3.4 satisfy the condition $P^1 + P^2 \leq \underline{w}$. The husband fully compensates the wife in the first period, and the outcome of the model is unaffected by the absence of binding agreements.*

2. *The husband cannot afford to fully compensate the wife in period 1, the payments determined in section 3.4 are such that $P^1 + P^2 > \underline{w}$. The wife receives the couple's entire first period consumption. The first order condition for the wife's public good provision when binding agreements are not feasible, g^f_{NB}, is given by:*

$$\underline{w} - w'(g^f_{NB}) = \left(1 + \frac{U^f(g^f_{NB}) - T^f}{U^m(g^f_{NB}) - T^m}\right) h^f v'(h^f g^f_{NB}). \tag{3.36}$$

In this case, the wife's contribution to the public good, g^f_{NB} is increasing in the husband's threat point utility and decreasing in the wife's.

Proof. See Appendix.

If the constraint $P^2 = 0$ is binding, spouses' threat point utilities not only influence the distribution of resources within the couple, but also the efficiency of the public good provision. Changes in his and her threat point utility push g^f_{NB} in different directions. To see why, note that in the NBS, the wife's utility must increase if her threat point utility goes up. Since the wife's utility is decreasing in g^f on $f(u^m)$, it is clear that g^f_{NB} must go down with an increase in the wife's threat point. Because the wife's utility is

Table 3.2: Comparison of first order conditions

Situation	FOC
Efficiency	$\underline{w} - w'(g^{f*}) = 2 \cdot h^f v'(h^f g^{f*})$
Threat point D or NC	$\underline{w} - w'(g^f_D) = h^f v'(h^f g^f_D)$
No binding agreements	$\underline{w} - w'(g^f_{NB}) = \left(1 + \dfrac{U^f(g^f_{NB}) - T^f}{U^m(g^f_{NB}) - T^m}\right) h^f v'(h^f g^f_{NB})$

at least as high in the divorce threat point as it is in the non-cooperative threat point (strictly higher if $h^f > h^m$), g^f_{NB} is at least as large if non-cooperative marriage is the the threat point in bargaining as it is if spouses use divorce as the disagreement point. This is an efficiency-equity trade-off: Because the wife's contribution to the public good is higher if non-cooperative marriage is the threat point, the inefficiency will be greater if divorce is the threat point in bargaining - but intra-household distribution will be more equal with divorce as the relevant threat point.

This inefficiency is entirely due to the lack of a commitment device and is robust to the specification of the payoff function (in contrast to the full specialization efficiency result of Section 3.4). In fact, assuming a more sophisticated payoff function would in most cases increase the probability of an inefficient outcome.

Corollary 1. *If binding agreements are not feasible and the constraint $P^2 = 0$ is binding, the wife's contribution to the public good g^f_{NB} lies between her individual optimum g^f_D and the couple's joint optimum g^{f*}:*

$$g^f_D < g^f_{NB} < g^{f*}. \tag{3.37}$$

Her individually optimal contribution g^f_{NB} must lie in this interval because we found it by maximizing the Nash product on $f(u^m)$ which is defined on this interval. The first inequality stems from the fact that the wife would contribute g^f_D without a transfer of $\underline{w}$ from her husband, the second is due to the concavity of $f(u^m)$ and the fact that $P^2 = 0$ is binding.

Policy implications

The inefficiently low provision of the family public good in our model arises because the spouse specialized on a labour market career (in our model the husband) cannot credibly commit to compensate his or her partner for foregone career opportunities later in life.

The most direct way to eliminate this inefficiency would therefore ask the husband to sign a binding contract at the beginning of marriage and therein pledge himself to compensate his wife later. If that were possible, our model would predict an efficient provision level of the public good. Unfortunately, such contracts are generally not legally enforceable. In this section, we quickly review other policies that could mitigate the inefficiency. If we imagine the family public good to be the quantity and quality of children, it might also be in the government's interest to step in.

Borrowing and saving

One way for the husband to avoid the commitment problem is to "pay" his wife up front to compensate her for her loss of second period earnings in the first period. This is what he does in our model if his first period income is big enough for such a payment. Empirically, we observe substantial returns to labour market experience. Given the importance of seniority as a determinant of the hourly wage rate, it seems unlikely that a young man should be able compensate his wife for a lower wage rate (that she has to suffer throughout her entire working life) *before* starting a family.

He could however try to obtain the necessary funds on the capital market. We believe that it would be very difficult if not impossible for the average husband to take out a loan of the necessary magnitude to compensate his wife ex ante, even more so if he has young children and needs credit for other things, like buying a house. Another theoretical possibility would be for the husband to issue a debt certificate to his wife at the beginning of marriage, payable at a later date. This would allow him to avoid the capital market, borrowing from his wife instead. However, the signing of debt certificates in new couples is nearly unheard of. Also, this would create a new moral hazard incentive problem both for the wife (an unconditional payment is agreed for future services) and the husband (he agrees to share future earnings that depend on effort). Therefore we think that ruling out borrowing and saving in our model aptly describes the situation of young couples.

Divorce law and alimony

While the distribution of resources *within* marriage is generally not regulated, monetary transfers after a divorce are stipulated by law in most industrialized countries. Indeed, the existence of divorce legislation that incorporates alimony payments contingent on the time spent on child rearing suggests that the law acknowledges the inadmissibility of binding agreements within marriage over long periods of time. It assures compensation for foregone labour market earnings in the event of divorce that can not be guaranteed in an intact marriage.

Since divorce law determines the distribution of resources only when divorced, it influences our model only if the threat point is assumed to be divorce. With an alimony payment P_2^D assured to her by law, the wife's threat point utility in the second period rises from $w(g^f)$ to $w(g^f) + P_2^D$, while the husband's is diminished by the same amount. By plugging this into the objective function (3.27) it can easily be seen that the second period transfer without binding agreements is the compensation that would be due to the wife in the event of divorce, P_2^D. This extends the part of the UPF where the socially optimal amount of the public is produced, and hence increases the probability that the NBS lies on it. Ideally, the legal alimony payment should depend on the time spent out of the labour market to bring it as close as possible to the original P^2 that is probably unknown to policy makers, but can be estimated. Also, divorce legislation should not be changed quickly, so individuals can rely on future payments. Observe that in the context of our model, alimony legislation also benefits the husbands (at least ex-ante).

Public child care

The inefficiency within our model originates in the couple's inability to effectively exploit the gains to specialization, that household production and learning by doing on the labour market offer them. Instead of trying to eliminate the lack of commitment, policy makers could also try to get rid of the need for specialization *within* families and promote specialization *between* households instead, since child care professionals do not suffer from foregone labour market experience.[1] The public provision of child care eliminates the need for specialization within couples and thereby avoids its harmful effect on the spouse who falls short of acquiring labour market experience. Many industrialized countries heavily subsidize childcare facilities, that is, many governments provide child care as a benefit in kind. Translated into our framework, this amounts to an exogenous increase in G. Because of quasilinear utility, the couple withdraws their private contribution in response to the public provision of G in order to maintain the level $h^f g^f_{NB}$. All private contributions have to be crowded out before the total amount of G begins to rise, but a sufficiently generous subsidy to child care facilities can indeed improve efficiency within our framework.

[1] In fact, we would expect the emergence of private markets for child care. But market provided child care has to use taxed labour while family provided care is tax free. Which one is cheaper overall depends on the tax system and the importance of learning by doing (which is likely to differ between individuals). We think that tax wedges are important enough in most industrialized countries to inhibit the emergence of legal and completely unsubsidised markets for childcare, that offer prices affordable to all families (for a similar argument, see Konrad and Lommerud, 1995).

Because it enables young mothers to focus more on their careers, public provision of child care reduces not only direct, but also indirect costs of children, and can therefore stimulate fertility.[1]

With respect to intra-household distribution, the public provision of child care is to the advantage of the wife in the non-cooperative marriage threat point. It crowds out her contribution, enabling her to work more on the labour market like her husband. So, the introduction of free public child care facilities tilts intra- household distribution to the wife's favour, if the threat point is non-cooperative marriage. With a divorce threat point, both spouses equally benefit from free child care in the threat point, so intra-household distribution in the first period remains unchanged. The wife of course benefits in both threat point scenarios from her higher wage rate in the second period.

3.6 Conclusions

This paper highlights that, as in many other areas of economics, commitment problems do exist within the household and that they may cause inefficient outcomes. Following sensible assumptions about the effect of career interruptions on wage rates, we illustrate with a simple two period model that it is efficient that only one spouse contributes to a family public good like child care, while the other spouse concentrates on her/his career. This is also true if husband and wife are ex-ante equally productive in household and market work. Specialization arises *endogenously* as a consequence of the provision of the family public good in our model, and not in its strategic anticipation or because of an exogenous productivity asymmetry, as in most models in the literature.

This specialization within the family can result in inefficient household allocations: due to the absence of commitment devices, too little of the joint household public good may be provided. If the spouse specialized in market work (who is typically the husband) can credibly commit her/himself to share the fruits of her/his labour market experience with their partner later in life, the couple achieves the efficient provision level of the public good. But, if such an inter-temporal commitment is not feasible, the wife withdraws part of her contribution to the public good below the socially optimal level. She anticipates that, once there is no more public good production (e. g. because children have grown up and left home) the husband has no reason to make any payments to her. This inefficiency is a direct consequence of the liquidity constraint faced by the couple, and is not caused

[1]Indeed, there is anecdotal evidence that countries that generously provide child care like France and Sweden have higher birth rates than countries that concentrate on monetary transfers to support families, like Germany and Austria.

by the spouses trying to manipulate their threat points in later stages.

We devote special attention to the specification of the threat point that is used in the NBS, since there is yet no consensus in the literature on what is a sensible threat point in a family bargaining setting. We find that the choice of the threat point does have important implications for the distribution of resources within the couple. If the threat point is non-cooperative behaviour within marriage, the husband can still enjoy the wife's public good provision, which is impossible if the couple is divorced. Hence, the spouse who has the comparative advantage in public good provision benefits from a switch of the threat point from non-cooperative marriage to divorce. Which threat point is more likely to be used in marital bargaining can only be determined by empirical studies that can clearly discriminate between the two; unfortunately, to date we are not aware of such a study. However, divorce is unlikely to be the threat point in marital bargaining if terminating a marriage is not really an option in the social environment of a couple. As divorce has become more common in the Western world, wives are more and more able to credibly threaten with divorce in marital disputes, thereby improving their position within marriage.

Appendix

Appendix A

Education in a Marriage Market Model without Commitment

A.1 Structure of the Game

1. Nodes starting with matching are denoted by n_m. At these nodes nature randomly assigns a partner of the opposite sex to each single individual on the marriage market. Subgames starting at this node are homomorphic to the whole game. Nodes of this type are followed by nodes of the type n_p.

2. At nodes of the type n_p, nature randomly determines the first proposer in each new match, both partners face the same probability of being selected (this happens independently for all couples). Nodes of type n_p are followed by nodes of the type n_{ij}^f and n_{ij}^m.

3. Nodes of the type n_{ij}^f start an alternating offers bargaining game for a couple with a female of type i and a male of type j, in which the woman is the first proposer. Her action space consists of all possible fractions of marital output that she could claim for herself; she picks $\mu_j^i \in [0, 1]$. This node is followed by a node $n_{ij}^{\overline{f}}$.

4. The man reacts to the woman's offer at nodes $n_{ij}^{\overline{f}}$. His possible actions are "accept" (leading to a terminal node n_T^f), "reject and make a counteroffer" (leading to a node n_{ij}^m) or "divorce" leading to a matching node n_m. After this move, the period ends.

5. Nodes that start an alternating offers bargaining game, in which the husband is the first proposer are denoted by n_{ij}^m. His action is to propose the fraction of marital resources that would accrue to his wife, $\widetilde{\mu_j^i} \in [0, 1]$. This node leads to a node $n_{ij}^{\overline{m}}$.

6. At nodes $n_{ij}^{\overline{m}}$ the wife responds to a proposal by her husband. Like his, her actions are "accept" (which leads to a terminal node n_T^m), "reject and make a counteroffer" (leading to a node of type n_{ij}^f) or "divorce" (leading to a node n_m).

7. Terminal nodes n_T^f follow the acceptance of an offer in a subgame where the wife makes the first offer. As mentioned above, I assume that after an offer has been accepted, spouses stick to the proposed output distribution forever after.

8. Terminal nodes n_T^m follow the acceptance of an offer in subgames where the husband makes the first offer. Again, once such a node is reached, spouses enjoy the utilities they once agreed upon forever after.

A.2 Solving the Game

Before I begin solving the game, I have to fix some notation. I denote the present expected lifetime value for an individual $i, i \in \{f_e, f_u, m_e, m_u\}$ of being matched to an individual of educational class $j, j \in \{e, u\}$ by V_j^i if the woman is the proposer in the current match. At each node at which it is the woman's turn to make an offer,

- $V_e^{f_e}$ denotes an educated woman's value of being married to an educated man,
- $V_u^{f_e}$ denotes an educated woman's value of being married to an uneducated man,
- $V_u^{f_u}$ is an uneducated woman's value of being married to an uneducated man,
- $V_e^{f_u}$ is an uneducated woman's value of being married to an educated man.

Exchanging the superscript w by m gives the relevant values for men. In the twin game, in which the husband makes the first offer, I denote the present value of being in each particular marriage by $\widetilde{V_j^i}$, with $i \in \{f_e, f_u, m_e, m_u\}$ and $j \in \{e, u\}$. Thus, $\widetilde{V_u^{m_e}}$ is an educated man's value of being married to an uneducated woman in the game in which he makes the first offer, and so on.

The share of the marital output, that accrues to the wife in case of agreement in any given period is denoted by μ if she is the proposer and $\widetilde{\mu}$ if he is the proposer. Hence $V_e^{f_e} = \frac{1}{1-\delta} \cdot \mu_e^e \cdot 2r$ if an educated woman agrees in a marriage to an educated man and she gets to make the offer, while $V_u^{f_e} = \frac{1}{1-\delta} \cdot \mu_u^e \cdot (r+1)$ is her payoff if she is married to an uneducated man and she is the proposer. Conversely, if she is the responder, the values are $\widetilde{V_e^{f_e}} = \frac{1}{1-\delta} \cdot \widetilde{\mu_e^e} \cdot 2r$ and $\widetilde{V_u^{f_e}} = \frac{1}{1-\delta} \cdot \widetilde{\mu_u^e} \cdot (r+1)$.

Suppose a woman $i \in \{f_e, f_u\}$ finds her match dissolved at the end of the current period. Then, she has a single payoff of 0 in the current period, and will be matched to another man at the beginning of the next period. Her continuation value in the current period of getting married to a man of educational class $j \in \{e, u\}$ in the next period is $\frac{\delta}{2}\left(V_j^i + \widetilde{V_j^i}\right)$. The probability of being matched to a man of class j depends on the frequency of j's in the male population. Assuming risk neutrality, her continuation value of getting divorced in the current period is

$$D^{f_i} = \frac{\delta}{2} \cdot \left(q \cdot \left(V_e^{f_i} + \widetilde{V_e^{f_i}}\right) + (1-q) \cdot \left(V_u^{f_i} + \widetilde{V_u^{f_i}}\right)\right), \quad i \in \{e, u\} \tag{A.1}$$

while her husband's continuation value of getting divorced in this period is

$$D^{m_i} = \frac{\delta}{2} \cdot \left(p \cdot \left(V_e^{m_i} + \widetilde{V_e^{m_i}}\right) + (1-p) \cdot \left(V_u^{m_i} + \widetilde{V_u^{m_i}}\right)\right), \quad i \in \{e, u\} \tag{A.2}$$

The outside option influences the bargaining outcome for a couple only if at least one of the following inequalities hold (Binmore et al. (1989)):

$$D^i > \delta \widetilde{V_j^i} \quad i \in \{m_e, m_u\}, \quad j \in \{e, u\} \tag{A.3}$$

$$D^i > \delta V_j^i \quad i \in \{f_e, f_u\}, \quad j \in \{e, u\}. \tag{A.4}$$

If neither of these inequalities holds, the outcome of the bargaining game is the standard Rubinstein solution; if one of them holds, the spouse with the credible divorce threat gets the value of his or her outside option, while the other spouse receives the residual; and if both inequalities hold there are no gains to cooperation within this match, and it dissolves immediately.

Therefore, in every symmetric subgame perfect equilibrium in stationary strategies, the following equations have to hold:

For a couple of two educated individuals

$$\begin{aligned}
V_e^{f_e} &= \frac{1}{1-\delta} \cdot 2r - \max\left\{ D^{m_e}, \delta \widetilde{V_e^{m_e}} \right\} \\
V_e^{m_e} &= \max\left\{ D^{m_e}, \delta \widetilde{V_e^{m_e}} \right\} \\
\widetilde{V_e^{f_e}} &= \max\left\{ D^{f_e}, \delta V_e^{f_e} \right\} \\
\widetilde{V_e^{m_e}} &= \frac{1}{1-\delta} \cdot 2r - \max\left\{ D^{f_e}, \delta V_e^{f_e} \right\}
\end{aligned} \tag{A.5}$$

For a couple of two uneducated individuals

$$\begin{aligned}
V_u^{f_u} &= \frac{1}{1-\delta} \cdot 2 - \max\left\{ D^{m_u}, \delta \widetilde{V_u^{m_u}} \right\} \\
V_u^{m_u} &= \max\left\{ D^{m_u}, \delta \widetilde{V_u^{m_u}} \right\} \\
\widetilde{V_u^{f_u}} &= \max\left\{ D^{f_u}, \delta V_u^{f_u} \right\} \\
\widetilde{V_u^{m_u}} &= \frac{1}{1-\delta} \cdot 2 - \max\left\{ D^{f_u}, \delta V_u^{f_u} \right\}
\end{aligned} \tag{A.6}$$

For a mixed couple with an educated wife

$$\begin{aligned}
V_u^{f_e} &= \frac{1}{1-\delta}\cdot(r+1) - \max\left\{D^{m_u}, \delta\widetilde{V_e^{m_u}}\right\} \\
V_e^{m_u} &= \max\left\{D^{m_u}, \delta\widetilde{V_e^{m_u}}\right\} \\
\widetilde{V_u^{f_e}} &= \max\left\{D^{f_e}, \delta V_u^{f_e}\right\} \\
\widetilde{V_e^{m_e}} &= \frac{1}{1-\delta}\cdot(r+1) - \max\left\{D^{f_e}, \delta V_u^{f_e}\right\}
\end{aligned} \tag{A.7}$$

Finally, for a mixed couple with an educated husband

$$\begin{aligned}
V_e^{f_u} &= \frac{1}{1-\delta}\cdot(r+1) - \max\left\{D^{m_e}, \delta\widetilde{V_u^{m_e}}\right\} \\
V_u^{m_e} &= \max\left\{D^{m_e}, \delta\widetilde{V_u^{m_e}}\right\} \\
\widetilde{V_e^{f_u}} &= \max\left\{D^{f_u}, \delta V_e^{f_u}\right\} \\
\widetilde{V_e^{m_e}} &= \frac{1}{1-\delta}\cdot(r+1) - \max\left\{D^{f_u}, \delta V_e^{f_u}\right\}
\end{aligned} \tag{A.8}$$

This leads to the following inequalities:

$$\begin{aligned}
\delta\widetilde{V_e^{m_e}} &\gtreqless D^{m_e} && \text{and} \\
\delta V_e^{f_e} &\gtreqless D^{f_e} && \text{for a couple of two educated individuals,} \\
\delta\widetilde{V_u^{m_u}} &\gtreqless D^{m_u} && \text{and} \\
\delta V_u^{f_u} &\gtreqless D^{f_u} && \text{for a couple of two uneducated individuals,} \\
\delta\widetilde{V_e^{m_u}} &\gtreqless D^{m_u} && \text{and} \\
\delta V_u^{f_e} &\gtreqless D^{f_e} && \text{for a mixed couple with an educated wife,} \\
\delta\widetilde{V_u^{m_e}} &\gtreqless D^{m_e} && \text{and} \\
\delta V_e^{f_u} &\gtreqless D^{f_u} && \text{for a mixed couple with an educated husband.}
\end{aligned} \tag{A.9}$$

I write m:b and m:nb if the outside option for the husband in one particular marriage is binding ($\delta\widetilde{V_j^{m_i}} < D^{m_i}$) or non-binding ($\delta\widetilde{V_j^{m_i}} \geq D^{m_i}$), respectively, f:b and f:nb means the same for the wife. Hence, if m:b holds for a given couple, this means that the husband can credibly threaten with a divorce, while if f:b holds the wife has a credible divorce threat. Within each couple, there are four combinations of these inequalities, with four couples we arrive at 256 cases, each of which is a potential equilibrium.

The majority of these cases - 175 - are disqualified as equilibria for the game because at least one type of agent has a credible divorce threat in both types of couples - e.g. the case postulates that uneducated women can credibly threaten with divorce when married to an educated *and* an uneducated man. If this were indeed the case, from equations (A.1), (A.2), (A.4) and (A.3) we would have

$$\frac{\delta}{2} \cdot \left(q \cdot \left(V_e^{f_u} + \widetilde{V_e^{f_u}} \right) + (1-q) \cdot \left(V_u^{f_u} + \widetilde{V_u^{f_u}} \right) \right) \quad > \quad \delta \cdot V_e^{f_u} \quad \text{and} \tag{A.10}$$

$$\frac{\delta}{2} \cdot \left(q \cdot \left(V_e^{f_u} + \widetilde{V_e^{f_u}} \right) + (1-q) \cdot \left(V_u^{f_u} + \widetilde{V_u^{f_u}} \right) \right) \quad > \quad \delta \cdot V_u^{f_u}. \tag{A.11}$$

Conditions (A.10) and (A.11) can only hold simultaneously if at least in one couple, the value of being the responder is greater than the value of being the first proposer in the alternating offers game (that is, $\widetilde{V_j^{f_u}} > V_j^{f_u}$ for at least one $j \in \{e, u\}$). As stated above, if both partners have a binding outside option, the match dissolves immediately (any offer that will be rejected is made, and a divorce follows a rejection). If only the woman has a binding divorce threat, we know that her value of being a responder, regardless of the type of her spouse is $\widetilde{V_j^{f_u}} = D^{f_u}$; her equilibrium value of being the proposer, when married to an educated man is $V_e^{f_u} = (r+1) + \delta D^{f_u}$ (see Binmore et al., 1989). This is equivalent to claiming the entire output of the couple for herself in the first period, and demanding her outside option utility from the next period onward. Then, $\widetilde{V_e^{f_u}} > V_e^{f_u}$ can only hold if $D^{f_u} > \frac{r+1}{1-\delta}$, which is the present value of the entirety of the biggest output an uneducated woman can produce with any man, $\frac{r+1}{1-\delta}$, starting from this period - since she can only go back to the marriage market with a delay of one period, this can never be the case (also if she were matched to an educated man with probability one, and could claim the entire output in this match). By the same argument, $\widetilde{V_u^{f_u}} > V_u^{f_u}$ can only hold if $D^{f_u} > \frac{2}{1-\delta}$. If this is the case, the woman's outside option is bigger than the entire marital product of this couple starting from the present period - $\widetilde{V_u^{f_u}}$ is therefore not feasible in this match, and the inequality can therefore not hold. The same reasoning applies to all other types of individuals.

This leaves me with 81 potential equilibria. Which each of these, I have to check if there is a nonempty parameter area on which they can exist (which is not the case for 72 of them). These calculations are long and cumbersome and therefore omitted (available upon request).

A.3 Equilibria

Here I state the existence conditions for each equilibrium discussed in section 1.4. Each condition corresponds to a binding or non-binding divorce threat for an individual of education class $i \in \{e, u\}$ married to an individual of class $j \in \{e, u\}$. I indicate this by marking each condition by the type of couple - uu is for two uneducated individuals, eu for a mixed couple were the woman is educated and ue for a mixed couple were the man is educated - and whether the man has a binding divorce threat $(m : b)$ or the woman $(f : b)$. Conversely, if an individual does not have a binding outside option, I write $m : nb$ and $f : nb$ respectively. I omit the conditions for the couple consisting of an educated man and woman, since they always hold on the entire parameter space.

Proving that these equilibria are subgame perfect is straightforward and requires checking that the strategies are optimal at each node. Because there are four different types of couples, the proofs are long. I prove subgame perfection here for the *forever after* equilibrium, the proofs for the other equilibria are completely analogous and therefore omitted.

Proposition 2 that states that for infinitely patient individuals, the unique SSPE is the *market equilibrium* on the entire parameter space, can be seen directly by taking limits with respect to δ for all existence conditions for the below equilibria. Conversely, from the existence conditions for *market equilibrium*, it is apparent that it exists on the entire parameter space for $\delta = 1$, and that the parameter space it requires for $\delta < 1$ is empty. As above, showing subgame perfection is shown as I do for the *forever after* equilibrium, and therefore omitted.

Forever after

This equilibrium exists if

$$\begin{aligned}
\frac{2}{(r+1)} &\geq \frac{p(\delta+1)}{(p-\delta+p\delta+1)} && \text{uu-m:nb} \\
\frac{2}{(r+1)} &\geq \frac{q(\delta+1)}{(q-\delta+q\delta+1)} && \text{uu-f:nb} \\
\frac{2}{(r+1)} &\leq \frac{-(p+p\delta-2)}{-(\delta+1)(p-1)} && \text{eu-m:nb} \\
\frac{2r}{(r+1)} &\leq \frac{(q-\delta+q\delta+1)}{q(\delta+1)} && \text{eu-f:nb} \\
\frac{2r}{(r+1)} &\leq \frac{(p-\delta+p\delta+1)}{p(\delta+1)} && \text{ue-m:nb} \\
\frac{2}{(r+1)} &\leq \frac{-(q+q\delta-2)}{-(\delta+1)(q-1)} && \text{ue-f:nb.}
\end{aligned} \tag{A.12}$$

If the woman is the first proposer, the corresponding shares are

$$\begin{aligned}
\mu_e^e &= \frac{1}{\delta+1} \\
\mu_u^u &= \frac{1}{\delta+1} \\
\mu_u^e &= \frac{1}{\delta+1} \\
\mu_e^u &= \frac{1}{\delta+1}.
\end{aligned} \tag{A.13}$$

Result 1. Forever-after *is the unique SSPE in stationary strategies for all combinations of parameter values that satisfy the conditions (A.12), with equilibrium shares (A.13).*

Proof. Consider the following strategies:

- Educated women: Regardless of the type of the husband, always offer $\mu_j^e = \frac{1}{1+\delta}$, $j \in \{e, u\}$, accept any offer $\widetilde{\mu_j^{e}}' \geq \frac{\delta}{1+\delta}$, reject any other offer. Always make a counteroffer after rejecting an offer.
- Educated men: Regardless of the type of the wife, always offer $\widetilde{\mu_e^j} = \frac{\delta}{1+\delta}$, accept any offer $\mu_e^{j'} \leq \frac{1}{1+\delta}$, $j \in \{e, u\}$, reject any other offer. Always make a counteroffer after rejecting an offer.

- Uneducated women: Regardless of the type of the husband, always offer $\mu_j^u = \frac{1}{1+\delta}$, $j \in \{e,u\}$, accept any offer $\widetilde{\mu_j^u}' \geq \frac{\delta}{1+\delta}$, reject any other offer. Always choose to make a counteroffer after rejecting an offer.
- Uneducated men: Regardless of the type of the wife, always offer $\widetilde{\mu_u^j} = \frac{\delta}{1+\delta}$, $j \in \{e,u\}$, accept any offer $\mu_u^{j\prime} \leq \frac{1}{1+\delta}$, $j \in \{e,u\}$, reject any other offer. Always make a counteroffer after rejecting an offer.

These strategies are stationary and symmetric. Uniqueness follows from the fact that I excluded all other possible equilibria. Therefore, I only have to prove subgame perfection. I will show that this strategy profile is a SPE in every subgame, for every type of couple, working backwards through the game.

For notational convenience, note that under the equilibrium strategy profile, the outside option utilities for men and women of each type (according to equations (A.1), (A.2) and A.13)) are:

$$D^{f_e} = \frac{\delta}{2(1-\delta)}(1+r+qr-q) \tag{A.14}$$

$$D^{m_e} = \frac{\delta}{2(1-\delta)}(1+r+pr-p) \tag{A.15}$$

$$D^{f_u} = \frac{\delta}{2(1-\delta)}(2-q+qr) \tag{A.16}$$

$$D^{m_u} = \frac{\delta}{2(1-\delta)}(2-p+pr) \tag{A.17}$$

Husband and wife are educated. I start with the subgame in which the husband makes the first offer. At the end of any period in which a woman rejects an offer, her expected present value from making a counter offer under the equilibrium strategy profile is $\frac{\delta}{1-\delta^2} \cdot 2r$, while her expected present value from divorcing and going back to the marriage market is given by (A.14). Making a counteroffer instead of divorcing is optimal iff $D^{f_e} \leq \frac{\delta}{1-\delta^2} \cdot 2r$, which is true as long as

$$\begin{aligned} \frac{\delta}{2(1-\delta)}(1+r+qr-q) &\leq \frac{\delta}{1-\delta^2} \cdot 2r \Leftrightarrow \\ (1-\delta)(1-q) - r(-q+\delta+q\delta+3) &\leq 0, \end{aligned}$$

which clearly is the case (given that q and δ are smaller than 1, and r is bigger than one). Moving up one node, it is optimal for any educated woman to accept $\widetilde{\mu_j^e}' \geq \frac{\delta}{1+\delta}$(as opposed to waiting a period and making a counter-offer of $\mu_j^e = \frac{1}{1+\delta}$ in accordance with the strategy profile) as long as

$$\frac{1}{1-\delta}\widetilde{\mu_j^{e}}' \cdot 2r \geq \frac{\delta}{1-\delta}\frac{1}{1+\delta} \cdot 2r \Leftrightarrow \widetilde{\mu_j^{e}}' \geq \frac{\delta}{1+\delta}.$$

Replacing the $\geq$ with a $<$ in this same condition shows that it is optimal for her to reject any offer $\widetilde{\mu_j^{e}}' < \frac{\delta}{1+\delta}$, and make a counteroffer in the next period instead. It is straightforward that an educated man would never offer $\widetilde{\mu_j^{e}}' > \frac{\delta}{1+\delta}$, because $\widetilde{\mu_e^{j}} = \frac{\delta}{1+\delta}$ will be accepted by his wife in equilibrium, and making a bigger offer would decrease his payoff. As established, offering $\widetilde{\mu_j^{e}}' < \frac{\delta}{1+\delta}$ will lead to a period's delay and subsequent counteroffer by the woman, which according to her strategy will be $\mu_e^e = \frac{1}{1+\delta}$. Therefore, offering $\widetilde{\mu_e^{j}} = \frac{\delta}{1+\delta}$ is optimal if $\frac{\delta}{1-\delta}\frac{\delta}{1+\delta} \cdot 2r \leq \frac{1}{1-\delta}\frac{1}{1+\delta} \cdot 2r$, which is obviously the case. Turning to the twin game in which the wife makes the first offer, in any period in which the husband rejected an offer, it is optimal for him to make a counteroffer instead of divorcing and going back to the marriage market if $D^{m_e} \geq \frac{\delta}{1-\delta} \cdot \widetilde{\mu_e^{j}} \cdot 2r$, which is the present value of his expected payoff from making a counteroffer in the next period, under this strategy profile. According to (A.15), this holds as long as

$$\begin{aligned} \frac{\delta}{1-\delta}\frac{1}{1+\delta} \cdot 2r &\geq \frac{\delta}{2(1-\delta)}\left(1+r+pr-p\right) \Leftrightarrow \\ \left(\delta+1\right)\left(1-p\right) - r\left(-p-\delta-p\delta+3\right) &\leq 0, \end{aligned}$$

which is true (again, because p and δ are smaller than 1, and r is bigger than one). Moving up one node, it is optimal for the husband to accept an offer $\mu_e^{j\prime}$ instead of waiting for the next period to make a counteroffer if

$$\frac{1}{1-\delta}\left(1-\mu_e^{j\prime}\right) \cdot 2r \geq \frac{\delta}{1-\delta}\frac{1}{1+\delta} \cdot 2r \Leftrightarrow \frac{1}{1+\delta} \geq \mu_e^{j\prime},$$

which is in accordance with his strategy profile. Again, replacing the $\geq$ with a $<$ shows that it is optimal to reject any offer $\mu_e^{j\prime} > \frac{1}{1+\delta}$. Moving up one node, it can not be optimal for an educated woman to offer $\mu_e^{j\prime} < \frac{1}{1+\delta}$, since $\mu_e^j = \frac{1}{1+\delta}$ will be accepted in equilibrium and gives her a bigger payoff. Hence, I only have to show that it is optimal for her to offer $\mu_e^j = \frac{1}{1+\delta}$.Offering $\mu_e^{j\prime} > \frac{1}{1+\delta}$ will be rejected by her husband and lead to him making a

coutneroffer in the next period, which, as I have shown above, she will accept. Therefore, offering $\mu_e^j = \frac{1}{1+\delta}$ is optimal if $\frac{\delta}{1-\delta}\frac{\delta}{1+\delta} \cdot 2r \leq \frac{1}{1-\delta}\frac{1}{1+\delta} \cdot 2r$ which is true. This establishes that *forever after* is an equilibrium for couples were both partners are educated.

Neither husband nor wife are educated. Again, I start with the subgame in which the husband makes the first offer. At the end of any period in which the woman rejected an offer, it is optimal for her to wait for the next period to make a counteroffer if the present expected value of doing so under the equilibrium strategy profile exceeds her outside option utility given by (A.16). This is the case if

$$\begin{aligned} \frac{\delta}{1-\delta}\frac{1}{1+\delta}\cdot 2 &\geq \frac{\delta}{2(1-\delta)}\left(2-q+qr\right) \Leftrightarrow \\ q-2\delta-qr+q\delta-qr\delta+2 &\geq 0, \end{aligned}$$

which is equivalent to the second line of condition (A.12). Moving up one node, it is optimal for her to accept her husband's offer of $\widetilde{\mu_u^u}'$ instead of making a counteroffer of $\mu_u^u = \frac{1}{1+\delta}$ in the next period (which will be accepted in equilibrium) if

$$\frac{1}{1-\delta}\cdot\widetilde{\mu_j^u}'\cdot 2 \geq \frac{\delta}{1-\delta}\cdot\frac{1}{1+\delta}\cdot 2 \Leftrightarrow \widetilde{\mu_u^u}' \geq \frac{\delta}{1+\delta}.$$

Moving further up the game, again, we note that offering more than $\widetilde{\mu_u^u} = \frac{\delta}{1+\delta}$ cannot be optimal for the man, since $\widetilde{\mu_u^u}$ is accepted in equilibrium and yields a higher payoff. Offering $\widetilde{\mu_u^u}' < \frac{\delta}{1+\delta}$ will be rejected and lead to a counteroffer in the next period, which will be accepted. Therefore it is optimal for the husband to offer $\widetilde{\mu_u^u}$ if $\frac{\delta}{1-\delta}\frac{\delta}{1+\delta}\cdot 2 \leq \frac{1}{1-\delta}\frac{1}{1+\delta}\cdot 2$, which is clearly the case. Concerning the twin game in which the woman makes the first offer, an uneducated man will find it optimal to make a counteroffer instead of divorcing after rejecting an offer if his outside option utility as given by (A.17) does not exceed the present value of his expected payoff from offering $\widetilde{\mu_u^u} = \frac{\delta}{1+\delta}$, which will be accepted in equilibrium. Therefore, after rejecting an offer, it is a best response to make a counteroffer instead of divorcing as long as

$$\begin{aligned} \frac{\delta}{2(1-\delta)}\left(2-p+pr\right) &\leq \frac{\delta}{1-\delta}\cdot\frac{1}{1+\delta}\cdot 2 \Leftrightarrow \\ 0 &\leq p-2\delta-pr+p\delta-pr\delta+2, \end{aligned}$$

which is equivalent to the first line of condition (A.12). Moving up one node, accepting any offer ${\mu_u^j}' \leq \frac{1}{1+\delta}$ is optimal if

$$\frac{1}{1-\delta}\cdot\left(1-\mu_u^{u\prime}\right)\cdot 2 \geq \frac{\delta}{1-\delta}\cdot\frac{1}{1+\delta}\cdot 2 \Leftrightarrow \frac{1}{1+\delta} \geq \mu_u^{u\prime},$$

which is in line with the equilibrium strategy profile. Moving further up, again we observe that it cannot be optimal for the wife to offer ${\mu_u^j}' < \frac{1}{1+\delta}$. Offering ${\mu_u^j}' > \frac{1}{1+\delta}$ will lead to a rejection, a period's delay and a payoff share of $\widetilde{\mu_u^u} = \frac{\delta}{1+\delta}$ for the woman in every period. Hence, offering $\mu_u^u = \frac{1}{1+\delta}$ is a best response if $\frac{\delta}{1-\delta}\frac{\delta}{1+\delta} \cdot 2 \leq \frac{1}{1-\delta}\frac{1}{1+\delta} \cdot 2$, which is obviously the case. This establishes that *forever after* is an equilibrium for the subgame in which two uneducated individuals are matched into a couple.

Mixed couple: educated wife, uneducated husband. Again, first consider the subgame that starts with a man proposing a share of household resources. At the end of any period in which an educated woman rejected an offer, it is a best response for her to wait for the next period and propose $\mu_u^e = \frac{1}{1+\delta}$ (which will be accepted in equilibrium) if

$$\begin{aligned}\frac{\delta}{1-\delta}\frac{1}{1+\delta}(r+1) &\geq \frac{\delta}{2(1-\delta)}(1+r+qr-q) \Leftrightarrow \\ \delta - r - q - q\delta + r\delta + qr + qr\delta - 1 &\leq 0.\end{aligned}$$

This is equivalent to the fourth line of condition (A.12). Moving up one node, accepting an offer is optimal if it yields a higher continuation value than rejecting and getting a share of $\mu_u^e = \frac{1}{1+\delta}$ from the next period onwards,

$$\frac{1}{1-\delta} \cdot \widetilde{\mu_u^e}' \cdot (r+1) \geq \frac{\delta}{1-\delta} \cdot \frac{1}{1+\delta} \cdot (r+1) \Leftrightarrow \widetilde{\mu_u^e}' \geq \frac{\delta}{1+\delta}$$

in accordance with the equilibrium strategy profile. Again, on the preceeding node, the man will never offer $\widetilde{\mu_u^e}' > \frac{\delta}{1+\delta}$. Making an offer $\widetilde{\mu_u^e}' < \frac{\delta}{1+\delta}$ will lead to a rejection and to a utility flow of $\frac{\delta}{1+\delta}(r+1)$ for the husband from the next period onwards. Hence, offering $\widetilde{\mu_u^e} = \frac{\delta}{1+\delta}$ is optimal if $\frac{\delta}{1-\delta}\frac{\delta}{1+\delta} \cdot (r+1) \leq \frac{1}{1-\delta}\frac{1}{1+\delta} \cdot (r+1)$, which is clearly true, establishing that the strategy profile is an equilibrium for this subgame. Moving to the twin game in which the woman is the first proposer, it is optimal for the man to make a counteroffer of $\widetilde{\mu_u^e} = \frac{\delta}{1+\delta}$ instead of divorcing as long as

$$\begin{aligned}\frac{\delta}{2(1-\delta)}(2-p+pr) &\leq \frac{\delta}{1-\delta}\frac{1}{1+\delta} \cdot (r+1) \Leftrightarrow \\ 2\delta - 2r - p - p\delta + pr + pr\delta &\leq 0\end{aligned}$$

which is equivalent to line three of condition (A.12). Moving up one node, accepting $\mu_u^{e\prime}$ dominates rejecting and making a counteroffer if

$$\frac{1}{1-\delta} \cdot \left(1 - \mu_u^{e\prime}\right) \cdot (r+1) \geq \frac{\delta}{1-\delta} \cdot \frac{1}{1+\delta} \cdot (r+1) \Leftrightarrow \frac{1}{1+\delta} \geq \mu_u^{e\prime}.$$

Moving further up the game, offering $\frac{1}{1+\delta} < \mu_u^{e\prime}$ can never be a best response for the woman. Any offer $\mu_u^{e\prime} > \frac{1}{1+\delta}$ will be rejected, and the couple will settle on $\widetilde{\mu_u^{e}}' = \frac{\delta}{1+\delta}$ in the next period. Hence, it is optimal for the woman to offer $\mu_u^e = \frac{1}{1+\delta}$ if $\frac{1}{1-\delta}\frac{1}{1+\delta}\cdot(r+1) \geq \frac{\delta}{1-\delta}\frac{\delta}{1+\delta}\cdot(r+1)$ which is the case. This establishes that *forever after* is an equilibrium for couples were she is educated while he is not.

Mixed couple: uneducated wife, educated husband. As before, let us start with the subgame in which the man makes the first offer. It is optimal for a woman to make a counteroffer, as opposed to divorce her husband given the strategy profile detailed in result 1, if

$$\begin{aligned}\frac{\delta}{1-\delta}\frac{1}{1+\delta}(r+1) &\geq \frac{\delta}{2(1-\delta)}(2-q+qr) \Leftrightarrow \\ 0 &\geq 2\delta - 2r - q - q\delta + qr + qr\delta,\end{aligned}$$

which is equivalent to the last line of condition (A.12). Accepting an offer $\widetilde{\mu_e^{u}}'$ is a best response if

$$\frac{1}{1-\delta}\cdot\widetilde{\mu_e^{u}}'\cdot(r+1) \geq \frac{\delta}{1-\delta}\cdot\frac{1}{1+\delta}\cdot(r+1) \Leftrightarrow \widetilde{\mu_e^{u}}' \geq \frac{\delta}{1+\delta}.$$

Again, no educated man would ever offer $\widetilde{\mu_e^{u}}' \geq \frac{\delta}{1+\delta}$ since $\widetilde{\mu_e^{u}} = \frac{\delta}{1+\delta}$ is accepted in equilibrium. Therefore, I only have to show that it is a best response to offer $\widetilde{\mu_e^{u}} = \frac{\delta}{1+\delta}$ as opposed to $\widetilde{\mu_e^{u}}' \leq \frac{\delta}{1+\delta}$ which would be rejected and result in a counteroffer by the woman in the next period. $\widetilde{\mu_e^{u}} = \frac{\delta}{1+\delta}$ is a best response if $\frac{\delta}{1-\delta}\frac{\delta}{1+\delta}\cdot(r+1) \leq \frac{1}{1-\delta}\frac{1}{1+\delta}\cdot(r+1)$, which is clearly the case, showing that *forever after* is an equilibrium for this subgame. Now for the twin game in which the woman is the first proposer, an educated man will find optimal to make a counteroffer to his current partner instead of going back to the marriage market after rejecting an offer if

$$\begin{aligned}\frac{\delta}{2(1-\delta)}(1+r+pr-p) &\leq \frac{\delta}{1-\delta}\frac{1}{1+\delta}\cdot(r+1) \Leftrightarrow \\ \delta - r - p - p\delta + r\delta + pr + pr\delta - 1 &\leq 0,\end{aligned}$$

which is equivalent to the penultimate line in condition (A.12). Moving up one node, an uneducated man will find it optimal to accept any offer $\mu_e^{u\prime}$ that yields the same value as waiting for the next period to make a counteroffer, that is any $\mu_e^{u\prime}$ satisfying

$$\frac{1}{1-\delta}\cdot\left(1-\mu_u^{e\prime}\right)\cdot(r+1) \geq \frac{\delta}{1-\delta}\cdot\frac{1}{1+\delta}\cdot(r+1) \Leftrightarrow \frac{1}{1+\delta} \geq \mu_u^{e\prime}.$$

Moving one node further up the game, I only need to show that is is optimal for the woman to propose $\mu_e^u = \frac{1}{1+\delta}$ which will be accepted in equilibrium. Again, offering $\mu_e^{u\prime} < \frac{1}{1+\delta}$ cannot be optimal. Offering $\mu_e^{u\prime} > \frac{1}{1+\delta}$ will lead to a utility flow of $\frac{\delta}{1+\delta}(r+1)$ from the next period onwards. Therefore, offering $\mu_e^u = \frac{1}{1+\delta}$ is optimal if $\frac{1}{1-\delta}\frac{1}{1+\delta} \cdot (r+1) \geq \frac{\delta}{1-\delta}\frac{\delta}{1+\delta} \cdot (r+1)$ which is the case. This establishes subgame perfection of the above strategy profile for parameter values satisfying the conditions detailed in (A.12) for all types of couples.

□

Holding out for someone better

This equilibrium exists if

$$
\begin{aligned}
\frac{2}{r+1} &< \frac{\left(2p - p\delta + q\delta - p\delta^2 - q\delta^2 + 2pq\delta + 2pq\delta^2\right)}{2\left(-\delta + q\delta + 1\right)\left(p - \delta + p\delta + 1\right)} \quad \text{uu-m:b} \\
\frac{2}{r+1} &< \frac{\left(2q - q\delta + p\delta - q\delta^2 - p\delta^2 + 2pq\delta + 2pq\delta^2\right)}{2\left(-\delta + p\delta + 1\right)\left(q - \delta + q\delta + 1\right)} \quad \text{uu-f:b} \\
\frac{2}{r+1} &\leq \frac{\left(2p + 4\delta - p\delta - 3q\delta - p\delta^2 - q\delta^2 + 2pq\delta + 2pq\delta^2 - 4\right)}{2\left(\delta + 1\right)\left(-\delta + q\delta + 1\right)\left(p - 1\right)} \quad \text{eu-m:nb} \\
\frac{2r}{r+1} &\leq \frac{\left(q - \delta + q\delta + 1\right)}{q\left(\delta + 1\right)} \quad \text{eu-f:nb} \\
\frac{2r}{r+1} &\leq \frac{\left(p - \delta + p\delta + 1\right)}{p\left(\delta + 1\right)} \quad \text{ue-m:nb} \\
\frac{2}{r+1} &\geq \frac{\left(2q + 4\delta - 3p\delta - q\delta - p\delta^2 - q\delta^2 + 2pq\delta + 2pq\delta^2 - 4\right)}{2\left(\delta + 1\right)\left(q - 1\right)\left(-\delta + p\delta + 1\right)} \quad \text{ue-f:nb.}
\end{aligned}
$$

If the woman is the first proposer, the corresponding shares are

$$
\begin{aligned}
\mu_e^e &= \frac{1}{\delta + 1} \\
\mu_u^u &= \frac{\left(\delta - 2\right)\left(4\delta - 3p\delta - 4\right) + q\delta\left(-3\delta + 2p\delta + 4\right) - r\delta\left(2p - p\delta - q\delta + 2pq\delta\right)}{4\left(-2\delta + p\delta + q\delta + 2\right)} \\
\mu_u^e &= \frac{1}{\delta + 1} \\
\mu_e^u &= \frac{1}{\delta + 1}
\end{aligned}
$$

Out of your league

This equilibrium exists if:

$$
\begin{gathered}
2\left(-\delta + p\delta - \delta^2 + p\delta^2 + 2\right)(p - \delta + p\delta + 1)(-\delta + q\delta + 1) \\
+2rpq\delta(\delta+1)^2(-\delta + p\delta + 1) < \\
(r+1)(\delta+1)\begin{pmatrix} 2p - p^2\delta^3 - 3p\delta + q\delta + p^2\delta + p\delta^3 - 2q\delta^2 \\ +q\delta^3 + 2p^2q\delta^2 + 2p^2q\delta^3 + 3pq\delta - 3pq\delta^3 \end{pmatrix} \text{ uu-m:b}
\end{gathered}
$$

$$
\begin{gathered}
2\left(-\delta + q\delta - \delta^2 + q\delta^2 + 2\right)(q - \delta + q\delta + 1)(-\delta + p\delta + 1) \\
+2rpq\delta(\delta+1)^2(-\delta + q\delta + 1) < \\
(r+1)(\delta+1)\begin{pmatrix} 2q - q^2\delta^3 + p\delta - 3q\delta - 2p\delta^2 + p\delta^3 + q^2\delta \\ +q\delta^3 + 2pq^2\delta^2 + 2pq^2\delta^3 + 3pq\delta - 3pq\delta^3 \end{pmatrix} \text{ uu-f:b}
\end{gathered}
$$

$$
\frac{(q - \delta + q\delta + 1)}{q(\delta+1)} < \frac{2r}{(r+1)} \text{ eu-m:nb}
$$

$$
\frac{(p - \delta + p\delta + 1)}{p(\delta+1)} < \frac{2r}{(r+1)} \text{ eu-f:nb}
$$

$$
\begin{gathered}
2rq\delta\begin{pmatrix} 2p + 6\delta + p^2\delta^2 - 2p^2\delta^3 - p^2\delta^4 - 5p\delta - 2q\delta - 2\delta^3 \\ -2p\delta^2 + 2p^2\delta + 4p\delta^3 + p\delta^4 + q\delta^2 + q\delta^3 + p^2q\delta^2 \\ +2p^2q\delta^3 + p^2q\delta^4 + pq\delta - pq\delta^2 - 3pq\delta^3 - pq\delta^4 - 4 \end{pmatrix} \\
+2\left(-\delta + q\delta - \delta^2 + q\delta^2 + 2\right)(-\delta + q\delta + 1)(p-1)\left(-\delta + p\delta - \delta^2 + p\delta^2 + 2\right) \geq \\
(r+1)\begin{pmatrix} 4p + 20\delta - p^2\delta^2 - 3p^2\delta^3 + p^2\delta^4 - 5q^2\delta^2 + p^2\delta^5 \\ +q^2\delta^3 + 3q^2\delta^4 + 19q\delta^2 - p\delta^5 + 3q\delta^3 + q^2\delta^5 - 12p\delta - 14q\delta \\ -12\delta^2 - 4\delta^3 + 4\delta^4 + 5p\delta^2 + 2p^2\delta + 9p\delta^3 - 5p\delta^4 - 7q\delta^4 \\ -q\delta^5 + 3pq^2\delta^2 + 5p^2q\delta^2 - pq^2\delta^3 + 3p^2q\delta^3 - 7pq^2\delta^4 \\ -5p^2q\delta^4 - 3pq^2\delta^5 - 3p^2q\delta^5 + 8pq\delta + 2p^2q^2\delta^3 + 4p^2q^2\delta^4 \\ +2p^2q^2\delta^5 - 14pq\delta^2 - 10pq\delta^3 + 12pq\delta^4 + 4pq\delta^5 - 8 \end{pmatrix} \text{ ue-m:b}
\end{gathered}
$$

$$2rp\delta\begin{pmatrix} -2q+6\delta-2q^2\delta^2+2q^2\delta^3-q^3\delta^2+2q^2\delta^4-2q^3\delta^3-q^3\delta^4-2p\delta-3q\delta \\ -2\delta^3+p\delta^2+p\delta^3+4q\delta^2-2q^2\delta+2q\delta^3-q\delta^4-pq\delta-2pq\delta^2-pq\delta^3-4 \end{pmatrix}$$
$$+2\left(q-1\right)\left(-\delta+q\delta-\delta^2+q\delta^2+2\right)\left(-\delta+p\delta-\delta^2+p\delta^2+2\right)\left(-\delta+p\delta+1\right)\geq$$
$$\left(r+1\right)\begin{pmatrix} -4q+20\delta-5p^2\delta^2+p^2\delta^3+3p^2\delta^4+q^2\delta^2+p^2\delta^5 \\ +11q^2\delta^3-2q^3\delta^2-q^2\delta^4-2q^3\delta^3-5q^2\delta^5+2q^3\delta^4+2q^3\delta^5 \\ -14p\delta-12\delta^2-4\delta^3+4\delta^4+19p\delta^2+3p\delta^3-7p\delta^4 \\ +13q\delta^2-6q^2\delta-p\delta^5-7q\delta^3-5q\delta^4+3q\delta^5-5pq^2\delta^2 \\ -p^2q\delta^2-5pq^2\delta^3-3p^2q\delta^3+5pq^2\delta^4-2pq^3\delta^3-3p^2q\delta^4 \\ +5pq^2\delta^5-4pq^3\delta^4-p^2q\delta^5-2pq^3\delta^5-4pq\delta-8pq\delta^2 \\ +8pq\delta^3+6pq\delta^4-2pq\delta^5-8 \end{pmatrix} \text{ue-f:nb}$$

If the woman is the first proposer, the corresponding shares are

$$\mu_e^e = \frac{1}{\delta+1}$$
$$\mu_u^u = \frac{1}{2\left(-\delta+q\delta-\delta^2+q\delta^2+2\right)\left(-\delta+p\delta-\delta^2+p\delta^2+2\right)\left(-2\delta+p\delta+q\delta+2\right)}\cdot$$
$$\begin{pmatrix} 2rpq\delta^2\left(\delta+1\right)\left(-3\delta+2p\delta+q\delta+\delta^3-p\delta^3-q\delta^2-q\delta^3+pq\delta^2+pq\delta^3+2\right) \\ +2\left(-\delta+q\delta-\delta^2+q\delta^2+2\right)\left(-\delta+q\delta+2\right)\cdot \\ \left(-\delta+p\delta-\delta^2+p\delta^2+2\right)\left(-\delta+p\delta+1\right) \\ -\left(r+1\right)\delta\left(\delta+1\right)\begin{pmatrix} 4p-p^2\delta^2-2p^2\delta^3+p^2\delta^4-q^2\delta^2+q^2\delta^4-8p\delta \\ -2q\delta+3p\delta^2+2p^2\delta+2p\delta^3-p\delta^4+3q\delta^2-q\delta^4 \\ +3pq^2\delta^2+5p^2q\delta^2-2pq^2\delta^3-3pq^2\delta^4-3p^2q\delta^4 \\ +8pq\delta+2p^2q^2\delta^3+2p^2q^2\delta^4-12pq\delta^2+4pq\delta^4 \end{pmatrix} \end{pmatrix}$$
$$\mu_u^e = \frac{2\left(r+1\right)-3\left(r+1\right)\delta+\left(r+1\right)\delta^2+\left(r+1\right)q\delta+2rq\delta^2-\left(r+1\right)q\delta^2}{\left(r+1\right)\left(-\delta+q\delta-\delta^2+q\delta^2+2\right)}$$
$$\mu_e^u = \frac{2\left(r+1\right)-2\left(r+1\right)\delta-\left(2r\right)p\delta+2\left(r+1\right)p\delta}{\left(r+1\right)\left(-\delta+p\delta-\delta^2+p\delta^2+2\right)}$$

Uneducated women get a premium

This equilibrium exists if

$$
\begin{aligned}
\frac{2}{(r+1)} &\geq \frac{\left(2p - p\delta + q\delta - p\delta^2 - q\delta^2 + 2pq\delta + 2pq\delta^2\right)}{2\left(-\delta + q\delta + 1\right)\left(p - \delta + p\delta + 1\right)} \text{ uu-m:b} \\
\frac{2}{(r+1)} &< \frac{q\left(\delta + 1\right)}{\left(q - \delta + q\delta + 1\right)} \text{ uu-f:b} \\
\frac{2}{(r+1)} &\leq \frac{-\left(\delta + 2\right)\left(\delta - 1\right)\left(p + p\delta - 2\right) + q\delta\left(\delta + 1\right)\left(2p - \delta + 2p\delta - 3\right)}{2\left(\delta + 1\right)^2\left(-\delta + q\delta + 1\right)\left(p - 1\right)} \text{ eu-m:nb} \\
\frac{2r}{(r+1)} &\leq \frac{\left(q - \delta + q\delta + 1\right)}{q\left(\delta + 1\right)} \text{ eu-f:nb} \\
\frac{2r}{(r+1)} &\leq \frac{\left(p - \delta + p\delta + 1\right)}{p\left(\delta + 1\right)} \text{ ue-m:nb} \\
\frac{2}{(r+1)} &\leq \frac{\left(-q + \delta - q\delta + 2\right)}{\left(\delta + 1\right)\left(1 - q\right)} \text{ ue-f:nb}
\end{aligned}
$$

If the woman is the first proposer, the corresponding shares are

$$
\begin{aligned}
\mu_e^e &= \frac{1}{\delta + 1} \\
\mu_u^u &= \frac{\left(2q\delta - 6\delta + 2\delta^2 - q\delta^2 + qr\delta^2 + 4\right)}{2q\delta - 2\delta - 2\delta^2 + 2q\delta^2 + 4} \\
\mu_u^e &= \frac{1}{\delta + 1} \\
\mu_e^u &= \frac{1}{\delta + 1}
\end{aligned}
$$

Uneducated men get a premium

This equilibrium exists if

$$
\begin{aligned}
\frac{2}{(r+1)} &< \frac{p(\delta+1)}{(p-\delta+p\delta+1)} \text{ uu-m:b} \\
\frac{2}{(r+1)} &\geq \frac{-\left(2q+p\delta-q\delta-p\delta^2-q\delta^2+2pq\delta+2pq\delta^2\right)}{2(q-\delta+q\delta+1)(-\delta+p\delta+1)} \text{ uu-f:nb} \\
\frac{2}{(r+1)} &\leq \frac{(p-\delta+p\delta-2)}{(\delta+1)(p-1)} \text{ eu-m:nb} \\
\frac{2r}{(r+1)} &\leq \frac{(q-\delta+q\delta+1)}{q(\delta+1)} \text{ eu-f:nb} \\
\frac{2r}{(r+1)} &\leq \frac{(p-\delta+p\delta+1)}{p(\delta+1)} \text{ ue-m:nb} \\
\frac{2}{(r+1)} &\leq \frac{2\left(\delta+\delta^2-2\right)-p\delta\left(3+4\delta+\delta^2\right)+q(\delta+1)\left(2-\delta+2p\delta-\delta^2+2p\delta^2\right)}{2(\delta+1)^2(-\delta+p\delta+1)(q-1)} \text{ ue-f:nb}
\end{aligned}
$$

If the woman is the first proposer, the corresponding shares are

$$
\begin{aligned}
\mu_e^e &= \frac{1}{\delta+1} \\
\mu_u^u &= -\frac{4\delta-3p\delta+pr\delta-4}{2p\delta-2\delta-2\delta^2+2p\delta^2+4} \\
\mu_u^e &= \frac{1}{\delta+1} \\
\mu_e^u &= \frac{1}{\delta+1}
\end{aligned}
$$

Uneducated women suffer

This equilibrium exists if

$$\frac{2}{(r+1)} < \frac{p(\delta+1)}{(p-\delta+p\delta+1)} \text{ uu-m:b}$$

$$2rpq\delta(\delta+1) + 4(q-\delta+q\delta+1)(-\delta+p\delta+1) \geq$$
$$(r+1)\left(2q+p\delta-p\delta^2-2q\delta^2+3pq\delta+3pq\delta^2\right) \text{ uu-f:nb}$$

$$\frac{2}{(r+1)} \leq \frac{(-p+\delta-p\delta+2)}{-(\delta+1)(p-1)} \text{ eu-m:fnb}$$

$$\frac{2r}{(r+1)} \leq \frac{(q-\delta+q\delta+1)}{q(\delta+1)} \text{ eu-f:nb}$$

$$\frac{2r}{(r+1)} > \frac{(p-\delta+p\delta+1)}{p(\delta+1)} \text{ ue-m:b}$$

$$2rp\delta(q+q\delta-2) + 4(\delta+1)(q-1)(-\delta+p\delta+1) \geq$$
$$(r+1)\left(2q+4\delta-5p\delta-p\delta^2-2q\delta^2+3pq\delta+3pq\delta^2-4\right) \text{ ue-f:nb}$$

If the woman is the first proposer, the corresponding shares are

$$\mu_e^e = \frac{1}{\delta+1}$$
$$\mu_u^u = -\frac{4\delta-3p\delta+pr\delta-4}{2p\delta-2\delta-2\delta^2+2p\delta^2+4}$$
$$\mu_u^e = \frac{1}{\delta+1}$$
$$\mu_e^u = -\frac{\delta-1}{r+1}\frac{2r-2\delta+2p\delta-2r\delta+2}{p\delta-3\delta+\delta^3-p\delta^3+2}$$

Uneducated men suffer

This equilibrium exists if

$$
\begin{gathered}
(r+1)\left(2p+q\delta-2p\delta^2-q\delta^2+3pq\delta+3pq\delta^2\right) \leq \\
2rpq\delta\,(\delta+1)+4\,(-\delta+q\delta+1)\,(p-\delta+p\delta+1) \ \text{ uu-m:nb} \\
(r+1)\left(2p+4\delta-5q\delta-2p\delta^2-q\delta^2+3pq\delta+3pq\delta^2-4\right) \leq \\
2rq\delta\,(p+p\delta-2)+4\,(\delta+1)\,(-\delta+q\delta+1)\,(p-1) \ \text{ uu-f:b} \\
\frac{2}{(r+1)} < \frac{q\,(\delta+1)}{(q-\delta+q\delta+1)} \ \text{ eu-m:nb} \\
\frac{2}{(r+1)} \leq \frac{(-q+\delta-q\delta+2)}{(1-q)\,(\delta+1)} \ \text{ eu-f:b} \\
\frac{2r}{(r+1)} > \frac{(q-\delta+q\delta+1)}{q\,(\delta+1)} \ \text{ ue-m:nb} \\
\frac{2r}{(r+1)} \leq \frac{(p-\delta+p\delta+1)}{p\,(\delta+1)} \ \text{ ue-f:nb}
\end{gathered}
$$

If the woman is the first proposer, the corresponding shares are

$$
\begin{aligned}
\mu_e^e &= \frac{1}{\delta+1} \\
\mu_u^u &= \frac{-6\delta+2q\delta+2\delta^2-q\delta^2+qr\delta^2+4}{2\,(-\delta+q\delta-\delta^2+q\delta^2+2)} \\
\mu_u^e &= \frac{2r-3\delta+q\delta-3r\delta+\delta^2-q\delta^2+r\delta^2+qr\delta+qr\delta^2+2}{(r+1)\,(-\delta+q\delta-\delta^2+q\delta^2+2)} \\
\mu_e^u &= \frac{1}{\delta+1}
\end{aligned}
$$

Men can expect more

This equilibrium exists if

$$r\begin{pmatrix} p\left(\delta+2\right)\left(\delta-1\right)\left(\delta-p\delta+\delta^2-p\delta^2-2\right)+2q\delta\left(\delta+1\right)\left(\delta-1\right)^2 \\ +pq\delta\left(\delta+1\right)\left(-\delta+p\delta-3\delta^2+p\delta^2+4\right)\end{pmatrix}>$$

$$\begin{pmatrix} p\left(\delta-1\right)\left(8\delta+2p\delta-5\delta^2-7\delta^3+5p\delta^2+3p\delta^3+4\right)-2q\delta\left(\delta+3\right)\left(\delta-1\right)^2 \\ +4\left(\delta+2\right)\left(\delta-1\right)^3+pq\delta\left(\delta+1\right)\left(\delta-p\delta+3\delta^2-p\delta^2-4\right)\end{pmatrix} \text{ uu-m:b}$$

$$r>\frac{\left(2q-8\delta+3p\delta+4\delta^2-3p\delta^2-2q\delta^2+pq\delta+pq\delta^2+4\right)}{\left(2q+p\delta-p\delta^2-2q\delta^2+pq\delta+pq\delta^2\right)} \text{ uu-f:b}$$

$$r\begin{pmatrix} -4\left(\delta+2\right)\left(\delta-1\right)^2+p\left(\delta-1\right)\left(4\delta-2p\delta+7\delta^2+\delta^3-3p\delta^2-p\delta^3-4\right) \\ +2q\delta\left(\delta-1\right)\left(3\delta+\delta^2+3\right)+pq\delta\left(\delta+1\right)\left(-3\delta+p\delta-3\delta^2+p\delta^2+4\right)\end{pmatrix}\leq$$

$$\begin{pmatrix} -4\delta\left(\delta+2\right)\left(\delta-1\right)^2-p\left(\delta-1\right)\left(4\delta+2p\delta-9\delta^2-7\delta^3+5p\delta^2+3p\delta^3+4\right) \\ +2q\delta\left(\delta-1\right)\left(3\delta+\delta^2+1\right)+pq\delta\left(\delta+1\right)\left(-3\delta+p\delta-3\delta^2+p\delta^2+4\right)\end{pmatrix} \text{ eu-m:nb}$$

$$r\left(q+\delta+q\delta-1\right)\leq q-\delta+q\delta+1 \text{ eu-f:nb}$$

$$r\left(p+\delta+p\delta-1\right)>p-\delta+p\delta+1 \text{ uu-m:b}$$

$$r\begin{pmatrix} -8\left(\delta-1\right)^2+p\delta\left(5\delta-p\delta+\delta^2-p\delta^2-6\right) \\ +2q\left(\delta+2\right)\left(\delta-1\right)^2+pq\delta\left(-\delta+p\delta-3\delta^2+p\delta^2+4\right)\end{pmatrix}\leq$$

$$\begin{pmatrix} -4\delta\left(\delta-1\right)^2-p\delta\left(9\delta-p\delta-7\delta^2+3p\delta^2-2\right) \\ +2q\left(\delta+2\right)\left(\delta-1\right)^2+pq\delta\left(-\delta+p\delta-3\delta^2+p\delta^2+4\right)\end{pmatrix} \text{ uu-f:nb}$$

If the woman is the first proposer, the corresponding shares are

$$\begin{aligned}
\mu_e^e &= \frac{1}{\delta+1} \\
\mu_u^u &= \frac{1}{4\left(-\delta+p\delta-\delta^2+p\delta^2+2\right)\left(-2\delta+p\delta+q\delta+2\right)}\cdot \\
&\begin{pmatrix} \left(\delta-2\right)\left(4\delta-3p\delta-4\right)\left(-\delta+p\delta-\delta^2+p\delta^2+2\right) \\ +q\delta\left(-10\delta+p^2\delta^2+p^2\delta^3+8p\delta+2\delta^3-p\delta^2-3p\delta^3+8\right) \\ -r\delta\begin{pmatrix} 4p+p^2\delta^2-p^2\delta^3-4p\delta-2q\delta-p\delta^2+2p^2\delta+p\delta^3 \\ +2q\delta^3+p^2q\delta^2+p^2q\delta^3+4pq\delta-pq\delta^2-3pq\delta^3\end{pmatrix}\end{pmatrix} \\
\mu_u^e &= \frac{1}{\delta+1} \\
\mu_e^u &= \frac{2\left(r-\delta+p\delta-r\delta+1\right)}{\left(r+1\right)\left(-\delta+p\delta-\delta^2+p\delta^2+2\right)}
\end{aligned}$$

Women can expect more

The equilibrium exists if

$$r\left(2p+q\delta-2p\delta^2-q\delta^2+pq\delta+pq\delta^2\right)>$$
$$\left(2p-8\delta+3q\delta+4\delta^2-2p\delta^2-3q\delta^2+pq\delta+pq\delta^2+4\right)\ \text{uu-m:b}$$
$$r\left(\begin{array}{c}2p\delta\left(\delta+1\right)\left(\delta-1\right)^2+q\left(\delta+2\right)\left(\delta-1\right)\left(\delta-q\delta+\delta^2-q\delta^2-2\right)\\+pq\delta\left(\delta+1\right)\left(-\delta+q\delta-3\delta^2+q\delta^2+4\right)\end{array}\right)$$
$$>-4\left(\delta+2\right)\left(\delta-1\right)^3+2p\delta\left(\delta+3\right)\left(\delta-1\right)^2$$
$$-q\left(\delta-1\right)\left(8\delta+2q\delta-5\delta^2-7\delta^3+5q\delta^2+3q\delta^3+4\right)$$
$$+pq\delta\left(\delta+1\right)\left(-\delta+q\delta-3\delta^2+q\delta^2+4\right)\ \text{uu-f:b}$$
$$r\left(\begin{array}{c}-8\left(\delta-1\right)^2+2p\left(\delta+2\right)\left(\delta-1\right)^2+q\delta\left(5\delta-q\delta+\delta^2-q\delta^2-6\right)\\+pq\delta\left(-\delta+q\delta-3\delta^2+q\delta^2+4\right)\end{array}\right)\leq$$
$$-4\delta\left(\delta-1\right)^2+2p\left(\delta+2\right)\left(\delta-1\right)^2-q\delta\left(9\delta-q\delta-7\delta^2+3q\delta^2-2\right)$$
$$+pq\delta\left(-\delta+q\delta-3\delta^2+q\delta^2+4\right)\ \text{eu-m:nb}$$
$$r\left(q+\delta+q\delta-1\right)>\left(q-\delta+q\delta+1\right)\ \text{eu-f:nb}$$
$$r\left(p+\delta+p\delta-1\right)\leq p-\delta+p\delta+1\ \text{ue-m:nb}$$
$$r\left(\begin{array}{c}-4\left(\delta+2\right)\left(\delta-1\right)^2+2p\delta\left(\delta-1\right)\left(3\delta+\delta^2+3\right)\\+q\left(\delta-1\right)\left(4\delta-2q\delta+7\delta^2+\delta^3-3q\delta^2-q\delta^3-4\right)\\+pq\delta\left(\delta+1\right)\left(-3\delta+q\delta-3\delta^2+q\delta^2+4\right)\end{array}\right)\leq$$
$$-4\delta\left(\delta+2\right)\left(\delta-1\right)^2+2p\delta\left(\delta-1\right)\left(3\delta+\delta^2+1\right)$$
$$-q\left(\delta-1\right)\left(4\delta+2q\delta-9\delta^2-7\delta^3+5q\delta^2+3q\delta^3+4\right)$$
$$+pq\delta\left(\delta+1\right)\left(-3\delta+q\delta-3\delta^2+q\delta^2+4\right)\ \text{ue-f:nb}$$

If the woman is the first proposer, the corresponding shares are

$$
\begin{aligned}
\mu_e^e &= \frac{1}{\delta+1} \\
\mu_u^u &= \frac{1}{4\left(-\delta+q\delta-\delta^2+q\delta^2+2\right)\left(-2\delta+p\delta+q\delta+2\right)} \cdot \\
&\quad \left(\begin{array}{c} -4\left(\delta-2\right)\left(\delta+2\right)\left(\delta-1\right)^2-2p\delta\left(\delta-1\right)\left(\delta-2\right)\left(r-\delta+r\delta-3\right) \\ +q\delta\left(\begin{array}{c} -14\delta+4q\delta+2r\delta-9\delta^2+7\delta^3+q\delta^2 \\ -3q\delta^3-r\delta^2-r\delta^3+qr\delta^2+qr\delta^3+16 \end{array}\right) \\ -pq\delta^2\left(4r+\delta-q\delta-r\delta+3\delta^2-q\delta^2-3r\delta^2+qr\delta+qr\delta^2-8\right) \end{array}\right) \\
\mu_u^e &= \frac{\left(1-\delta\right)\left(2r-3\delta+q\delta-3r\delta+\delta^2-q\delta^2+r\delta^2+qr\delta+qr\delta^2+2\right)}{\left(r+1\right)\left(q\delta-3\delta+\delta^3-q\delta^3+2\right)} \\
\mu_e^u &= \frac{1}{\delta+1}
\end{aligned}
$$

Market equilibrium

This equilibrium exists if

$$
\begin{aligned}
\left(r+1\right) &\leq \frac{p\left(\delta+1\right)\left(\delta+1\right)2rq\delta+2\left(-\delta+q\delta-\delta^2+q\delta^2+2\right)\left(p-\delta+p\delta+1\right)}{2p\left(\delta+1\right)^2\left(-\delta+q\delta+1\right)} \\
\left(r+1\right) &\leq \frac{q\left(\delta+1\right)\left(\delta+1\right)2rp\delta+2\left(-\delta+p\delta-\delta^2+p\delta^2+2\right)\left(q-\delta+q\delta+1\right)}{2q\left(\delta+1\right)^2\left(-\delta+p\delta+1\right)} \\
\left(r+1\right) &\geq \frac{\left(p+p\delta-2\right)2rq\delta+2\left(-\delta+q\delta-\delta^2+q\delta^2+2\right)\left(p-1\right)}{2\left(p+p\delta-2\right)\left(-\delta+q\delta+1\right)} \\
\frac{2r}{\left(r+1\right)} &> \frac{\left(q-\delta+q\delta+1\right)}{q\left(\delta+1\right)} \\
\frac{2r}{\left(r+1\right)} &> \frac{\left(p-\delta+p\delta+1\right)}{p\left(\delta+1\right)} \\
\left(r+1\right) &\geq \frac{2rp\left(q+q\delta-2\right)+2\left(q-1\right)\left(-\delta+p\delta-\delta^2+p\delta^2+2\right)}{2\left(p\delta-\delta^2+1\right)\left(q+q\delta-2\right)}
\end{aligned}
$$

If the woman is the first proposer, the corresponding shares are

$$
\begin{aligned}
\mu_e^e &= \frac{1}{\delta+1} \\
\mu_u^u &= \frac{1}{\delta+1} \\
\mu_u^e &= \frac{r\left(-3\delta+q\delta+\delta^2+q\delta^2+2\right)+(\delta-1)(\delta-q\delta-2)}{(r+1)(q\delta-\delta-\delta^2+q\delta^2+2)} \\
\mu_e^u &= \frac{2(r-\delta+p\delta-r\delta+1)}{(r+1)(-\delta+p\delta-\delta^2+p\delta^2+2)}
\end{aligned}
$$

A.4 Equilibria for Given Parameter Areas

Figure A.1 depicts the equilibria for the fraction of educated men, q, fixed at 0.3, and lets the female education propensity vary. The equilibria are the same as the ones described in section 1.4, simply substitute "women" with "men" in the characterization of the equilibria. The symmetric equilibria - the "forever after" equilibrium were the outside options are irrelevant, the "holding out for someone better" equilibrium were couples made up of two uneducated individuals immediately dissolve, and the "out of your league" equilibrium are the same in both cases.

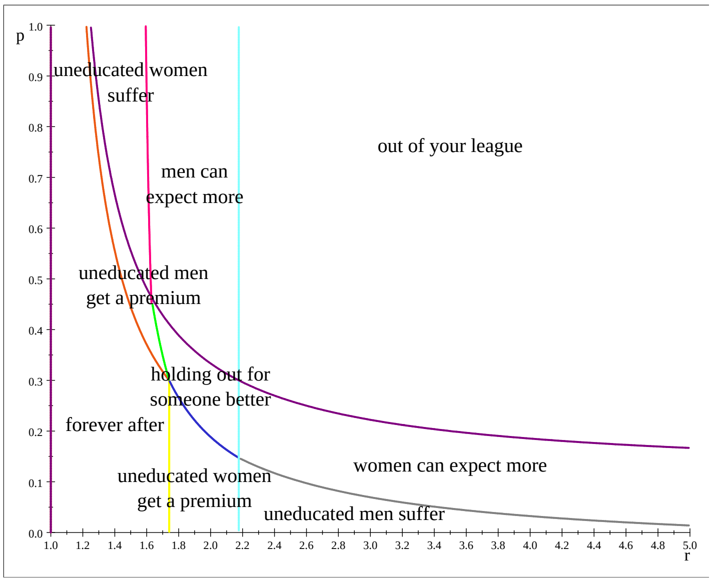

Figure A.1: $\delta = 0.8, q = 0.3$

A.5 The role of wage inequality

If educated individuals earn 2.4 times the wage of uneducated individuals, divorce occurs in equilibrium if at least 26 percent of all men or women are educated, provided at least 12 percent of the other gender group also obtain a degree, see figure A.2.

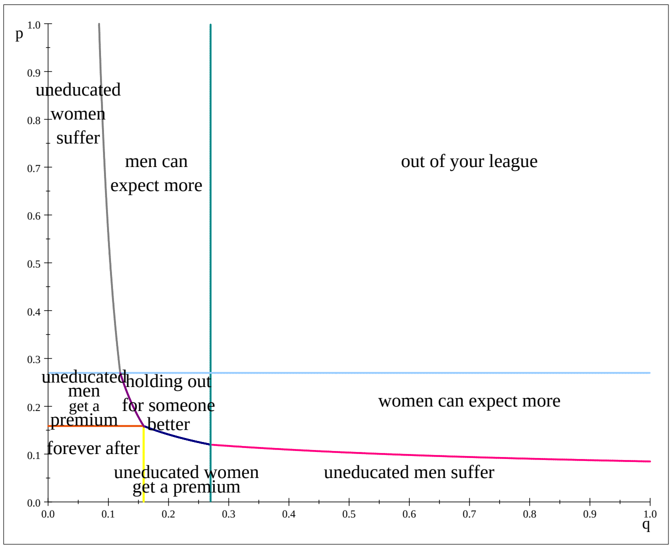

Figure A.2: $\delta = 0.8, r = 2.4$

A.6 Education Decision

The expected payoff from entering the marriage market as a woman of type $i \in \{e, u\}$ is given by equation (A.1), while the payoff for a man of type $i \in \{e, u\}$ is given in equation (A.2). Education is associated with a positive lump sum cost k, with $k \leq \frac{2r}{1-\delta}$, so that education is not impermissibly expensive.

At an interior solution, men and women must be indifferent between obtaining a degree or not. That is

$$\begin{aligned} -k \quad + \quad & \frac{\delta}{2} \cdot \left(q \cdot \left(V_e^{f_e} + \widetilde{V_e^{f_e}} \right) + (1-q) \cdot \left(V_u^{f_e} + \widetilde{V_u^{f_e}} \right) \right) = \\ & \frac{\delta}{2} \cdot \left(q \cdot \left(V_e^{f_u} + \widetilde{V_e^{f_u}} \right) + (1-q) \cdot \left(V_u^{f_u} + \widetilde{V_u^{f_u}} \right) \right) \end{aligned} \tag{A.18}$$

and

$$
\begin{aligned}
-k \quad + \quad & \frac{\delta}{2} \cdot \left(p \cdot \left(V_e^{m_e} + \widetilde{V_e^{m_e}} \right) + (1-p) \cdot \left(V_u^{m_e} + \widetilde{V_u^{m_e}} \right) \right) = \\
& \frac{\delta}{2} \cdot \left(p \cdot \left(V_e^{m_u} + \widetilde{V_e^{m_u}} \right) + (1-p) \cdot \left(V_u^{m_u} + \widetilde{V_u^{m_u}} \right) \right) \qquad \text{(A.19)}
\end{aligned}
$$

have to hold with equality. If the LHS exceeds the RHS for either of these equations, everyone decides to become educated; while if the RHS is bigger nobody obtains a degree. Since the continuation values of being in each couple are determined in the equilibria, equations (A.18) and (A.19) can be solved for p and q.

Divorce in Equilibrium

In four of the nine equilibria, uneducated couples divorce in equilibrium. When calculating the expected value of remaining uneducated, an individual therefore has to consider that he or she might be matched to an uneducated individual and subsequently be divorced. So remaining uneducated comes at the risk of having to "wait" several periods on the marriage market until one is matched to an educated individual.

Consider an uneducated woman. If she is matched to an educated man in the first period ($t = 0$), her payoff is $\frac{1}{2} \cdot \left(V_e^{f_u} + \widetilde{V_e^{f_u}} \right)$; her present value of being matched to an educated man in period $t = 1$ is $\frac{\delta}{2} \cdot \left(V_e^{f_u} + \widetilde{V_e^{f_u}} \right)$. Those events occur with probability q and $(1-q) \cdot q$ respectively. Hence, the present value of the expected lifetime utility for an uneducated woman if uneducated couples divorce in equilibrium is

$$
\sum_{t=0}^{\infty} q \cdot (1-q)^t \, \delta^t \cdot \frac{1}{2} \cdot \left(V_e^{f_u} + \widetilde{V_e^{f_u}} \right), \qquad \text{(A.20)}
$$

which converges to

$$
\frac{q}{1-\delta\,(1-q)} \frac{1}{2} \left(V_e^{f_u} + \widetilde{V_e^{f_u}} \right). \qquad \text{(A.21)}
$$

Forever after

It is easy to verify that inserting the Rubinstein values for V_j^i's and $\widetilde{V_j^i}$'s, with $i \in \{f_e, f_u, m_e, m_u\}$ and $j \in \{e, u\}$ into equations (A.18) and (A.19) results in p and q dropping out of these equations. If condition (1.8) holds with equality, individuals are indifferent between obtaining a university education or not, so all values of p and q that support *forever after* as an equilibrium on the marriage market stage are a SSPE of the augmented game. Conversely, if $k > \frac{\delta}{2(1-\delta)}(r-1)$, education is too costly and no-one becomes educated, this as well is a SSPE. If, on the other hand, $k < \frac{\delta}{2(1-\delta)}(r-1)$, everyone becomes educated, and *forever after* breaks down at the marriage market stage, so this is not an SSPE.

Holding out for someone better

Plugging in the equilibrium values of V_j^i's and $\widetilde{V_j^i}$'s, with $i \in \{f_e, f_u, m_e, m_u\}$ and $j \in \{e, u\}$ of this equilibrium into equations (A.18) and (A.19) yields that women are indifferent between becoming educated or not if

$$k = \frac{\delta\left(r - 2q - \delta + 2q\delta - r\delta - \delta q^2 + r\delta q^2 + 1\right)}{2\left(q\delta - \delta + 1\right)\left(1-\delta\right)}, \tag{A.22}$$

men are indifferent if

$$k = \frac{\delta\left(r - 2p - \delta + 2p\delta - r\delta - p^2\delta + p^2 r\delta + 1\right)}{2\left(p\delta - \delta + 1\right)\left(1-\delta\right)}. \tag{A.23}$$

At an interior solution, for a given k, the RHSs of these two conditions have to be equal. Setting them equal and simplifying yields

$$\begin{aligned}\delta\left(p-q\right)\big(3\delta - p\delta - q\delta - r\delta + pr\delta + qr\delta - \delta^2 + p\delta^2 + q\delta^2 + r\delta^2 \\ -pq\delta^2 - pr\delta^2 - qr\delta^2 + pqr\delta^2 - 2\big) = 0.\end{aligned} \tag{A.24}$$

The first interior solution therefore is the one quoted in the proposition were $p = q$. The second term can be solved for p such that

$$p = \frac{\left(1-\delta\right)\left(\delta - q\delta - r\delta + qr\delta - 2\right)}{\delta\left(r-1\right)\left(\delta - q\delta - 1\right)}. \tag{A.25}$$

It can be readily verified that this is only smaller than 1 for very high (economically uninteresting) levels of r or else for $\delta \to 1$, for which case *holding out for someone better* breaks down at the marriage market stage. Therefore, $p = q$ is the only SSPE.

Out of your league

In this equilibrium, it is optimal for women to become educated if

$$\begin{aligned} k \quad < \quad & \frac{\delta}{(1-\delta)\left(p\delta-\delta-\delta^2+p\delta^2+2\right)\left(q^2\delta^3+q^2\delta^2-2q\delta^3-q\delta^2+3q\delta+\delta^3-3\delta+2\right)} \cdot \\ & (2r-4q-5\delta+2q^2\delta^2+q^2\delta^3+p\delta+8q\delta-5r\delta+3\delta^2+\delta^3-\delta^4-p\delta^2-p\delta^3+p\delta^4 \\ & -3q^2\delta-2q\delta^3+q\delta^4+3r\delta^2+r\delta^3-r\delta^4-2pq^2\delta^2-2pq^2\delta^3-q^2r\delta^3-3pq\delta+pr\delta \\ & +pq\delta^2+3pq\delta^3-pq\delta^4-pr\delta^2-pr\delta^3+pr\delta^4-3qr\delta^2+q^2r\delta+qr\delta^4+pq^2r\delta^2 \\ & +2pq^2r\delta^3+2qr\delta-3q\delta^2+pq^2r\delta^4+pqr\delta+2pqr\delta^2-pqr\delta^3-2pqr\delta^4+2), \quad \text{(A.26)} \end{aligned}$$

for men the same condition holds with q exchanged by p. At an interior solution, condition (A.26) and the twin condition for men have to hold with equality for a given level of k. Setting the two equal and simplifying yields

$$\begin{aligned} & (\delta-1)\left(\delta-q\delta+\delta^2-q\delta^2-2\right)(p-q)\left(-5\delta+3p\delta+3q\delta+r\delta-\delta^2+\delta^3+\delta^4\right. \\ & -p\delta^2-p\delta^3-p\delta^4-q\delta^2-q\delta^3-q\delta^4-r\delta^2-r\delta^3+r\delta^4-pr\delta-qr\delta+2pq\delta^2+pq\delta^3 \\ & \left.+pq\delta^4+pr\delta^2+pr\delta^3-pr\delta^4+qr\delta^2+qr\delta^3-qr\delta^4-pqr\delta^2+pqr\delta^4+4\right)=0 \quad \text{(A.27)} \end{aligned}$$

The first and second term can only be 0 for $\delta = 1$. Setting the fourth term 0 and solving for p yields

$$p = \frac{(\delta-1)\left(\delta\left(-r+2\delta+\delta^2+r\delta^2\right)(q-1)+\delta(3q-1)+4\right)}{\delta\left(\delta(2q-1)+\delta^2(\delta+r\delta+1)(q-1)+r(\delta-1)+r\delta(-q+\delta)+3\right)}, \tag{A.28}$$

which is positive only for very high values of r (e.g. for $\delta = 0.8$, r would have to be bigger than 10 to make this positive). This leaves us with the interior solution $p = q$ stated in the proposition.

Uneducated Men Get a Premium

If this is the outcome of the game at the marriage market stage, it is optimal for women to become educated if

$$k < \frac{\delta\left(2\left(p\delta-q\delta+p\delta^2+q\delta^2+1-r\right)+\delta+r\delta-3\delta^2+r\delta^2+p\delta(\delta+1)(-q-2r+qr)\right)}{2(\delta-1)\left(-\delta+p\delta-\delta^2+p\delta^2+2\right)} \tag{A.29}$$

while the corresponding condition for men is

$$k < \frac{\delta\left(p^2\delta^2 - 3\delta - 2r + 2p\delta + r\delta + \delta^2 - 2p\delta^2 + p^2\delta + r\delta^2 - p^2r\delta^2 - p^2r\delta + 2\right)}{2\left(\delta - 1\right)\left(-\delta + p\delta - \delta^2 + p\delta^2 + 2\right)}. \quad \text{(A.30)}$$

The RHSs of these condition equal and simplifying yields

$$-\delta\left(p + q - 2\right)\left(p - 2\delta + p\delta - pr - pr\delta + 2\right) = 0 \quad \text{(A.31)}$$

The second term is only 0 if $p = q = 1$, for which *uneducated men get a premium* is not an equilibrium at the marriage market stage. The third term is 0 for $p = \frac{2(1-\delta)}{(r-1)(\delta+1)}$. Given this p, men are indifferent between obtaining an education and not if $k = \frac{\delta(r-1)}{2(1-\delta)}$ as stated in the proposition.

Uneducated Women Suffer

For a given k, men and women are indifferent between obtaining a degree and not if

$$q + r + 3\delta - 2p\delta - q\delta - r\delta - qr + 2pr\delta + qr\delta - 3 = 0. \quad \text{(A.32)}$$

The p and q quoted in the proposition solve this equation. They are interior solutions if

$$\frac{\delta\left(r^2 - 1\right)}{\left(1 - \delta\right)\left(3r + \delta + r\delta - 1\right)} < k < \frac{\delta\left(r - 1\right)}{2\left(1 - \delta\right)}, \quad \text{(A.33)}$$

(this condition is necessary so that $p, q \in (0, 1)$), and

$$\frac{3 - \delta}{(\delta + 1)} < r < \frac{1}{\delta}, \quad \text{(A.34)}$$

(this must hold so that the existence conditions listed in section A.3 do not contradict with (1.13) and (1.12) being interior values for p and q). It can easily be seen from condition (A.34) that the range of permissible values for r becomes very narrow as δ increases in economically relevant territory. For example, if we want to set $\delta = 0.8$, r must be in $(1.22, 1.25)$. This puts k at quite low values in $(0.44, 0.5)$.

If k is big enough to discourage all men ((1.15) does not hold), but not all women from obtaining an education, condition (1.14) simplifies to

$$p = \frac{\left(1 - \delta\right)\left(2k\left(\delta + 2\right)\left(\delta - 1\right) - \delta\left(3\delta + 2\right) + r\delta\left(\delta + 2\right)\right)}{-2\delta\left(\delta + 1\right)\left(-k - \delta + k\delta + r\delta\right)}, \quad \text{(A.35)}$$

Men Can Expect More

Women want to get educated as long as

$$k < \frac{\delta}{2(1-\delta)(-\delta+q\delta+1)(-\delta+p\delta-\delta^2+p\delta^2+2)} \left(\begin{array}{c} -q(\delta-1)\left(\delta-2q\delta+2\delta^2-q\delta^2-4-r\delta+2qr\delta+qr\delta^2\right) \\ +(\delta+2)(\delta-1)^2(r+1)-p\delta\left(\delta^2-1\right)(r+1) \\ +pq\delta(\delta+1)(r+2\delta-q\delta+qr\delta-3). \end{array} \right) \tag{A.36}$$

The corresponding condition for men is

$$k < \frac{\delta\left(-p(\delta-1)(3\delta+3r\delta-4)+p^2\delta(r+\delta+r\delta-3)+2(\delta-1)^2(r+1)\right)}{2(1-\delta)(-\delta+p\delta-\delta^2+p\delta^2+2)(-\delta+p\delta+1)}. \tag{A.37}$$

It is easily verified that, if condition (1.10) holds, no man decides to obtain a degree, and women are indifferent from doing and not doing so, independently of p and q, so any p that is a SSPE in the marriage market game is an SSPE in the augmented game.

A.7 Supplement: Allowing for a Positive Single Utility

Solving the Game

As above, in the game in which the woman makes the first offer, let

- V^{f_e} denote an educated woman's continuation value of being married (in the current period) - the subscript is omitted because in this version of the model there are only uneducated men,
- V^{f_u} denote an uneducated woman's continuation value of being married (again, necessarily to an uneducated man),
- V_e^m denote an uneducated man's value of being married to an educated woman,
- V_u^m denote an uneducated man's value of being married to an uneducated woman.

In the twin game in which the man is the first proposer, the analogous values are $\widetilde{V^{f_e}}, \widetilde{V^{f_u}}, \widetilde{V_e^m}, \widetilde{V_u^m}$. Again, I only consider symmetric sub-game perfect equilibria in stationary strategies. In such an equilibrium, the following conditions have to hold:

For a mixed couple with an educated wife

$$\begin{aligned} V^{f_e} &= \frac{1}{1-\delta} \cdot \zeta_m - max\left\{D^m, \delta\widetilde{V_e^m}\right\} \\ V_e^m &= max\left\{D^m, \delta\widetilde{V_e^m}\right\} \\ \widetilde{V^{f_e}} &= max\left\{D^{f_e}, \delta V^{f_e}\right\} \\ \widetilde{V_e^m} &= \frac{1}{1-\delta} \cdot \zeta_m - max\left\{D^{f_e}, \delta V^{f_e}\right\} \end{aligned} \tag{A.38}$$

For a couple of two uneducated individuals

$$\begin{aligned} V^{f_u} &= \frac{1}{1-\delta} \cdot \zeta_u - max\left\{D^m, \delta\widetilde{V_u^m}\right\} \\ V_u^m &= max\left\{D^m, \delta\widetilde{V_u^m}\right\} \\ \widetilde{V^{f_u}} &= max\left\{D^{f_u}, \delta V^{f_u}\right\} \\ \widetilde{V_u^m} &= \frac{1}{1-\delta} \cdot \zeta_u - max\left\{D^{f_u}, \delta V^{f_u}\right\} \end{aligned} \tag{A.39}$$

This leads to the following inequalities:

$$\begin{aligned}
\underbrace{p \cdot \delta V_e^m + (1-p)\delta V_u^m}_{=D^m} &\gtreqless \delta \widetilde{V_e^m} && \text{and} \\
\underbrace{\zeta_s + \delta V^{f_e}}_{=D^{f_e}} &\gtreqless \delta V^{f_e} && \text{for a mixed couple,} \\
\underbrace{p \cdot \delta V_e^m + (1-p)\delta V_u^m}_{=D^m} &\gtreqless \delta \widetilde{V_u^m} && \text{and} \\
\underbrace{\delta V^{f_u}}_{=D^{f_u}} &\gtreqless \delta V^{f_u} && \text{a homogenous couple.}
\end{aligned} \tag{A.40}$$

From A.40, it is obvious that educated women will always chose to divorce after rejecting an offer, while, because of my tie breaking assumption, uneducated women always stay opt to make a counteroffer. This leaves four possible equilibria. The case in which men have a credible divorce threat in both types of couples by the same reasoning detailed for the more complicated game in section A.2. This leaves the three equilibria discussed in the text.

Equilibria

High single utility

This equilibrium exists if

$$\frac{\zeta_m - \zeta_s}{\zeta_u} < \frac{\delta(1-p)}{1-p\delta} \tag{A.41}$$

If the woman is the first proposer, the shares are

$$\begin{aligned}
\mu_e &= 1 - \frac{\delta^2(1-p)}{(1-p\delta)(1+\delta)} \cdot \frac{\zeta_u}{\zeta_m} \\
\mu_u &= \frac{1}{1+\delta}
\end{aligned} \tag{A.42}$$

Result 2. High single utility *is the unique SSPE in stationary strategies for all combinations of parameter values that satisfy condition A.41, with equilibrium shares A.42.*

Proof. Consider the following strategies:

- Educated Women: Always offer $\mu_e = 1 - \frac{\delta^2(1-p)}{(1-p\delta)(1+\delta)} \cdot \frac{\zeta_u}{\zeta_e}$, accept any offer $\widetilde{\mu_e}' \geq \widetilde{\mu_e}$, reject any other offer. Always divorce after rejecting an offer.
- Uneducated women: Always offer $\mu_u = \frac{1}{1+\delta}$, accept any offer $\widetilde{\mu_u}' \geq \widetilde{\mu_u}$ and reject any offer other offer. Always choose to make a counteroffer after rejecting an offer.

- Uneducated men: When married to an educated woman: always offer $\widetilde{\mu_e}= \delta - \frac{\delta^3(1-p)}{(1-p\delta)(1+\delta)}\frac{\zeta_u}{\zeta_e} + (1-\delta)\frac{\zeta_s}{\zeta_e}$, accept any offer $\mu_e' \leq \mu_e$ and reject any other offer. Always divorce after rejecting an offer. When married to an uneducated woman: Always offer $\widetilde{\mu_u} = \frac{\delta}{1+\delta}$, accept any offer $\mu_u' \leq \mu_u$ and reject any other offer. Always choose to make a counteroffer after rejecting an offer.

As before, these strategies are stationary and symmetric, and uniqueness follows from the fact that I verified that the other possible equilibria do not exist on this parameter space. I therefore only have to prove subgame perfection. I will to show that this strategy profile is a SPE in every subgame for both types of couples, working backwards through the game. Remember that in this simplified version of the game, the wife makes the first offer in every new union.

The wife is educated I start with the subgame in which the husband proposer. At the end of any period in which the a woman rejected an offer, it is optimal for her to divorce if $\zeta_s + \frac{\delta}{1-\delta}\mu_e \cdot \zeta_m > \frac{\delta}{1-\delta}\mu_e \cdot \zeta_m$, which is true since I assumed ζ_s to be positive. Moving up one node, it is optimal for an educated woman to accept an offer $\widetilde{\mu_e}'$ if $\frac{1}{1-\delta}\widetilde{\mu_e}' \cdot \zeta_m \geq \zeta_s + \frac{\delta}{1-\delta}\left(1 - \frac{\delta^2(1-p)}{(1-p\delta)(1+\delta)} \cdot \frac{\zeta_u}{\zeta_m}\right) \cdot \zeta_m \Leftrightarrow \widetilde{\mu_e}' \geq \delta\left(1 - \frac{\delta^2(1-p)}{(1-p\delta)(1+\delta)} \cdot \frac{\zeta_u}{\zeta_m}\right) + (1-\delta)\frac{\zeta_s}{\zeta_m}$ Replacing the $\geq$ with a $<$ in the same condition shows that it is optimal for her to reject any offer $\widetilde{\mu_e}' < \widetilde{\mu_e}$.Moving up one node, it cannot be optimal for the husband to offer $\widetilde{\mu_e}' > \widetilde{\mu_e}$, since his wife would accept $\widetilde{\mu_e}$ which gives him a higher pay-off. Offering $\widetilde{\mu_e}' < \widetilde{\mu_e}$, on the other hand side gives him an expected utility of $\frac{\delta}{1-\delta}\left(p \cdot (1-\mu_e)\zeta_m + (1-p)(1-\mu_u)\zeta_u\right)$ because according to her strategy his wife will reject such an offer and divorce him. Thus, making an offer she will accept is optimal if $\frac{\delta}{(1+\delta)} \cdot \frac{\delta(1-p)}{1-p\delta} < \frac{\zeta_m - \zeta_s}{\zeta_u}$ holds, which must be true since A.41 holds. Now for the subgame in which the wife is the first proposer. At the end of any period in which the husband rejected an offer, divorcing gives him a higher utility than waiting to make a counteroffer if $\frac{\delta}{1-\delta}\left(p \cdot (1-\mu_e)\zeta_m + (1-p)(1-\mu_u)\zeta_u\right) > \frac{\delta}{1-\delta}\left(1-\widetilde{\mu_e}\right) \cdot \zeta_m$, simplfying redily yields A.41.. Moving up one node, it is optimal for him to accept $\mu_e' \leq \mu_e$ if $\frac{1}{1-\delta}\left(1-\mu_e'\right) \cdot \zeta_m \geq \frac{\delta}{1-\delta}\left(p \cdot (1-\mu_e)\zeta_m + (1-p)(1-\mu_u)\zeta_u\right) \Leftrightarrow \left(1 - \frac{\delta^2(1-p)}{(1-p\delta)(1+\delta)} \cdot \frac{\zeta_u}{\zeta_m}\right) \leq \mu_e'$

Replacing the $\leq$ by an shows that it is optimal for him to reject $\mu_e' > \mu_e$. It remains to be shown that it is optimal for an educated woman to offer μ_e given the equilibrium strategy of her husband. As above, it cannot be optimal for the wife to offer $\mu_e' < \mu_e$.Offering μ_e instead of an offer that is going to be rejected and lead to a divorce is optimal if $\frac{1}{1-\delta}\left(1 - \frac{\delta^2(1-p)}{(1-p\delta)(1+\delta)} \cdot \frac{\zeta_u}{\zeta_m}\right) \cdot \zeta_m > \zeta_s + \frac{\delta}{1-\delta}\left(1 - \frac{\delta^2(1-p)}{(1-p\delta)(1+\delta)} \cdot \frac{\zeta_u}{\zeta_m}\right) \Leftrightarrow \frac{\delta}{(1+\delta)} \cdot \frac{\delta(1-p)}{1-p\delta} < \frac{\zeta_m - \zeta_s}{\zeta_u}$, which again holds if which must be true since A.41 holds. This establishes that this is a SSPE for the mixed couple.

Both are uneducated. Again, I start with the subgame in which the husband makes the first offer. At the end of each period in which the woman rejected an offer, the woman's outside option is degenerate because there are no educated men - she will be matched to an uneducated man and get the same pay-off she will get if she waits one period in her present match, also her single utility is 0. Since I made the assumption that individuals make a counteroffer if they are indifferent between making a counteroffer and divorcing, this is a best response. Moving up one node, it is optimal for the wife to accept any offer $\widetilde{\mu_u'} \geq \widetilde{\mu_u}$ if $\frac{1}{1-\delta} \cdot \widetilde{\mu_u'}\zeta_u \geq \frac{\delta}{1-\delta} \cdot \mu_u\zeta_u \Leftrightarrow \widetilde{\mu_u'} \geq \delta\mu_u$ which is true for $\widetilde{\mu_u'} \geq \widetilde{\mu_u}$. Exchanging the $\geq$ by an $<$ shows that it is conversely optimal for her to reject any $\widetilde{\mu_u'} < \widetilde{\mu_u}$. Moving up one node, again it can never be optimal for the husband to offer $\widetilde{\mu_u'} > \widetilde{\mu_u}$. Offering $\widetilde{\mu_u}$ is optimal if $\frac{1}{1-\delta} \cdot (1-\widetilde{\mu_u})\zeta_u > \frac{\delta}{1-\delta} \cdot (1-\mu_u)\,\zeta_u \Leftrightarrow \delta^2 \leq 1$.Moving up one node, staying put to make a counteroffer is optimal for him if $p\delta V_u^m + (1-p)V_e^m \leq \delta\widetilde{V_u^m}$. Again, explicit calculation yields that this is true since $\delta < 1$.Moving up one node, accepting any offer $\mu_u' \leq \mu_u$ is optimal if $\frac{1}{1-\delta} \cdot (1-\mu_u')\zeta_u \geq \frac{\delta}{1-\delta} \cdot (1-\widetilde{\mu_u})\zeta_u \Leftrightarrow \frac{1}{1+\delta} \geq \mu_u'$. Again, reversing the weak greater sign by a strict smaller sign establishes that it is not optimal for the husband to accept a $\mu_u' > \mu_u$. Finally, I have to show that it is optimal for the wife to offer μ_u at the beginning of period. Again, $\mu_u' < \mu_u$ cannot be optimal. Offering if μ_u instead of $\mu_u' < \mu_u$, which would be rejected, is optimal if $\frac{\delta}{1-\delta} \cdot \mu_u\zeta_u \geq \frac{1}{1-\delta} \cdot \widetilde{\mu_u}\zeta_u \Leftrightarrow 1 \geq \delta^2$. This establishes subgame perfection of strategy profile *high single utility* for all combinations of parameter values that satisfy (A.41). □

Low single utility

This equilibrium exists if

$$\frac{p\delta - \delta + 1}{p\delta} < \frac{\zeta_m - \zeta_s}{\zeta_u}. \tag{A.43}$$

If the woman is the first proposer, the shares are

$$\begin{aligned} \mu_e &= \frac{1}{1+\delta} + \frac{\delta}{(1+\delta)} \cdot \frac{\zeta_s}{\zeta_m} \\ \mu_u &= 1 - \frac{p\delta^2}{(1+\delta)\,(p\delta - \delta + 1)} \cdot \frac{(\zeta_m - \zeta_s)}{\zeta_u} \end{aligned} \tag{A.44}$$

Result 3. *There is a continuum of SSPE in stationary strategies for all combinations of parameter values that satisfy condition A.43, that are pay-off-equivalent, with equilibrium shares A.44. These strategy profiles differ only in the strategies pursued off the equilibrium path.*

For a range of parameter values, men married to uneducated women have a binding outside option in the subgame in which they can make the first offer, and would therefore like to divorce in this period. Since only the responder can initiate a divorce, they choose some offer that their wife will reject - therefore there is a continuum of strategies they could choose, that lead to the same outcome. Since agreements are reached without delay, this is off the equilibrium path. Since all offers that are rejected lead to the same outcome (divorce), there is a continuum of strategy profiles that lead to divorce in each subgame that starts with the offer of a man married to an uneducated woman. All of these strategy profiles are pay-off-equivalent, and I therefore discuss them together. Remember that the woman makes the first offer in every match.

Proof. Consider the following strategies:

- Educated women: always propose $\mu_e = \frac{1}{1+\delta} + \frac{\delta}{(1+\delta)} \cdot \frac{\zeta_s}{\zeta_m}$, accept any offer $\widetilde{\mu_e}' \geq \widetilde{\mu_e}$, reject any other offer. Always divorce after rejecting an offer.
- Uneducated women: always propose $\mu_u = 1 - \frac{p\delta^2}{(1+\delta)(p\delta-\delta+1)} \cdot \frac{(\zeta_m-\zeta_s)}{\zeta_u}$, accept any offer $\widetilde{\mu_u}' \geq \widetilde{\mu_u}$, reject any offer. Never divorce.
- Uneducated men: When married to educated women: always propose $\widetilde{\mu_e} = \frac{\delta}{1+\delta} + \frac{1}{1+\delta} \cdot \frac{\zeta_s}{\zeta_m}$, accept any offer $\mu_e' \leq \mu_e$ and reject any offer $\mu_e' > \mu_e$. Never divorce. When married to uneducated women:
  1. For parameter values satisfying $\frac{(1+\delta)(p\delta-\delta+1)}{p\delta^2} \geq \frac{\zeta_m-\zeta_s}{\zeta_u} > \frac{p\delta-\delta+1}{p\delta}$: always propose $\widetilde{\mu_u} = \delta - \frac{p\delta^3}{(1+\delta)(p\delta-\delta+1)} \frac{(\zeta_m-\zeta_s)}{\zeta_u}$, accept any offer $\mu_u' \leq \mu_u$ and reject any other offer. Always divorce after rejecting an offer.
  2. For parameter values satisfying $\frac{\zeta_m-\zeta_s}{\zeta_u} > \frac{(1+\delta)(p\delta-\delta+1)}{p\delta^2}$: always propose $\widetilde{\mu_u}' \in [0, \widetilde{\mu_u})$, accept any offer $\mu_u' \leq \mu_u$ and reject any other offer. Always divorce after rejecting an offer.

As before, these strategies are stationary and symmetric, and uniqueness follows from the fact that I verified that the other possible equilibria do not exist on this parameter space. I therefore only have to prove subgame perfection.

The wife is educated. I start with the subgame in which the husband is the first proposer. As above, the wife will choose to divorce after rejecting an offer because her single utility ζ_s is positive. It is optimal for her to accept an offer $\widetilde{\mu_e}' \geq \widetilde{\mu_e}$ if $\frac{1}{1-\delta} \cdot \widetilde{\mu_e}' \cdot \zeta_m \geq \zeta_s + \frac{\delta}{1-\delta} \cdot \left(\frac{1}{1+\delta} + \frac{\delta}{(1+\delta)} \cdot \frac{\zeta_s}{\zeta_m}\right) \cdot \zeta_m$. Rearranging yields that this true if $\widetilde{\mu_e}' \geq \widetilde{\mu_e}$. Replacing the $\geq$ with an $<$ establishes that rejecting $\widetilde{\mu_e}' < \widetilde{\mu_e}$ is optimal. Moving up one node, again, the husband will never offer $\widetilde{\mu_e}' > \widetilde{\mu_e}$, since $\widetilde{\mu_e}$ will be accepted. it is optimal for him to offer $\widetilde{\mu_e}$ instead of $\widetilde{\mu_e}' < \widetilde{\mu_e}$ which would trigger a divorce if $\frac{1}{1-\delta} \cdot (1 - \widetilde{\mu_e})\zeta_m \geq p\frac{\delta}{1-\delta} \cdot (1 - \mu_e)\zeta_m + (1 - p) \cdot \frac{\delta}{1-\delta} \cdot (1 - \mu_u)\zeta_u$. Inserting the expressions for $\widetilde{\mu_e}$, μ_e and μ_u proves this to be true without further restrictions on the parameters. Moving up another node, it is a best response for the husband to wait a counteroffer in his current match instead of divorcing after rejecting an offer, if $\frac{\delta}{1-\delta}(1 - \widetilde{\mu_e})\zeta_m \geq p\frac{\delta}{1-\delta}(1 - \mu_e)\zeta_m + (1 - p)\,\frac{\delta}{1-\delta}(1 - \mu_u)\zeta_u$ which is readily verified by plugging in all relevant expressions and r arranging. It is optimal for the husband to reject an offer $\mu_e' > \mu_e$ if $\frac{\delta}{1-\delta}(1 - \widetilde{\mu_e})\zeta_m > \frac{1}{1-\delta}(1 - \mu_e')\zeta_m$. Plugging in the expression for $\widetilde{\mu_e}$ and rearranging shows that this holds if $(1 - \mu_e') < (1 - \mu_e)$. As above, exchanging the $>$ in the above condition by a $\leq$ proves that is optimal for the husband to accept any offer $\mu_e' \leq \mu_e$. It remains to be shown that it is optimal for the wife to offer μ_e at the beginning of period 1. Again, it cannot be optimal to offer $\mu_e' < \mu_e$. Offering $\mu_e' > \mu_e$ will trigger a rejection, and she will accept her husband's counteroffer in the next period. Thus, offering μ_e is a best response if $\frac{1}{1-\delta} \cdot \left(\frac{1}{1+\delta} + \frac{\delta}{(1+\delta)} \cdot \frac{\zeta_s}{\zeta_m}\right) \cdot \zeta_m \geq \frac{\delta}{1-\delta} \cdot \left(\frac{\delta}{1+\delta} + \frac{1}{1+\delta} \cdot \frac{\zeta_s}{\zeta_m}\right) \cdot \zeta_m$ which is true. This concludes the argument for the mixed couple.

Both are uneducated. Again, I begin with the subgame in which the husband proposes a distribution of intra-household resources. After rejecting an offer, the wife is indifferent between divorcing her husband and making a counteroffer, because her single utility is zero - therefore, I assume that she stays put and makes a counteroffer in the next period. On the previous node, it is optimal for her to accept an offer $\widetilde{\mu_u}' \geq \widetilde{\mu_u}$ if $\frac{1}{1-\delta}\widetilde{\mu_u}'\zeta_u \geq \frac{\delta}{1-\delta}\left(1 - \frac{p\delta^2}{(1+\delta)(p\delta-\delta+1)} \cdot \frac{(\zeta_m-\zeta_s)}{\zeta_u}\right)\zeta_u$, which is true for $\widetilde{\mu_u}' \geq \widetilde{\mu_u}$. To show that it is optimal for her toreject any $\widetilde{\mu_u}' < \widetilde{\mu_u}$, it suffices to replace the $\geq$i by a $<$.

Moving up one node, to the husband's offer, we have to distinguish two cases:

1. If the parameters satisfy $\frac{(1+\delta)(p\delta-\delta+1)}{p\delta^2} \geq \frac{\zeta_m-\zeta_s}{\zeta_u}$, offering $\widetilde{\mu_u}$ is superior to offering $\widetilde{\mu_u}' < \widetilde{\mu_u}$. To see why, plug the expressions for $\widetilde{\mu_u}$, μ_e and μ_e into $\frac{1}{1-\delta}(1 - \widetilde{\mu_u})\zeta_u \geq \frac{\delta}{1-\delta}\left(p \cdot (1 - \mu_e)\,\zeta_m + (1 - p)\,(1 - \mu_u)\,\zeta_u\right)$ and rearrange, obtaining the condition $\frac{(1+\delta)(p\delta-\delta+1)}{p\delta^2} \geq \frac{\zeta_m-\zeta_s}{\zeta_u}$.

2. If on the other hand $\frac{\zeta_m-\zeta_s}{\zeta_u} > \frac{(1+\delta)(p\delta-\delta+1)}{p\delta^2}$, it is optimal for the husband to offer $\widetilde{\mu_u}' < \widetilde{\mu_u}$ to prompt his wife divorce him, which is established by repeating the above exercise, and replacing the $\geq$ by a $<$.

Offering $\widetilde{\mu_u}' > \widetilde{\mu_u}$ can however not be optimal, since the woman is ready to accept $\widetilde{\mu_u}$. Moving up one node, making a counteroffer after rejecting an offer is dominated for the husband by divorcing if $\frac{\delta}{1-\delta}(1 - \widetilde{\mu_u})\zeta_u < \frac{\delta}{1-\delta}\left(p \cdot (1 - \mu_e)\,\zeta_m + (1 - p)\,(1 - \mu_u)\,\zeta_u\right)$. Plugging in the expression for μ_e and μ_u and rearranging yields condition A.43. Moving up one node, accepting $\mu_u' \leq \mu_u$ is optimal for the husband if $\frac{1}{1-\delta}(1-\mu_u')\zeta_u \geq \frac{\delta}{1-\delta}\left(p\cdot(1-\mu_e)\zeta_e+(1-p)(1-\mu_u)\zeta_u\right)$, which simplifies to $(1-\mu_u')\zeta_u \geq (1-\mu_u)\zeta_u$. Exchanging the $\geq$ for an $<$ shows that it is optimal for him to reject any $\mu_u' > \mu_u$.Finally, again it can never be optimal for the wife to offer $\mu_u' < \mu_u$. Offering μ_u dominates offering $\mu_u' > \mu_u$ which will trigger a divorce if $\frac{1}{1-\delta}\cdot\zeta_u \geq \delta\cdot\frac{1}{1-\delta}\cdot\zeta_u$, (the RHS being her expected value of divorce) which is clearly true. This concludes the argument that *high single utility* is a subgame perfect equilibrium. □

Rubinstein-type equilibrium

This equilibrium exists if

$$\frac{(1-p)\,\delta}{(1-p\delta)} \leq \frac{\zeta_e-\zeta_s}{\zeta_u} \leq \frac{(p\delta-\delta+1)}{p\delta} \tag{A.45}$$

If the woman is the proposer, the shares are

$$\begin{aligned}\mu_e &= \frac{1}{(1+\delta)}+\frac{\delta}{(1+\delta)}\cdot\frac{\zeta_s}{\zeta_m} \\ \mu_u &= \frac{1}{1+\delta}\end{aligned} \tag{A.46}$$

Result 4. *The* Rubinstein-type equilibrium *is the unique SSPE in stationary strategies for all combinations of parameter values that satisfy condition A.45, with equilibrium shares A.46.*

Proof. Consider the following strategies:

- Educated women: Always propose $\mu_e = \frac{1}{(1+\delta)}+\frac{\delta}{(1+\delta)}\cdot\frac{\zeta_s}{\zeta_m}$, accept any offer $\widetilde{\mu_e}' \geq \widetilde{\mu_e}$, reject any other offer. Always divorce after rejecting an offer.
- Uneducated women: Always propose $\mu_u = \frac{1}{(1+\delta)}$, accept any offer $\widetilde{\mu_u}' \geq \widetilde{\mu_u}$, reject any other offer. Never divorce.
- Uneducated men: When married to an educated woman: always propose $\widetilde{\mu_e} = \frac{\delta}{(1+\delta)}+\frac{1}{(1+\delta)}\cdot\frac{\zeta_s}{\zeta_m}$, accept any offer $\mu_e' \leq \mu_e$, reject any other offer. Never divorce after rejecting an offer. When married to an uneducated woman: always propose $\widetilde{\mu_u} = \frac{\delta}{(1+\delta)}$, accept any offer $\mu_e' \leq \mu_e$, reject any other offer. Never divorce after rejecting an offer.

As before, these strategies are stationary and symmetric, and uniqueness follows from the fact that I verified that the other possible equilibria do not exist on this parameter space. I therefore only have to prove subgame perfection.

The wife is educated. I begin with the subgame in which the husband is the proposer. After rejecting an offer, it is optimal for the wife to divorce since $\zeta_s + \frac{\delta}{1-\delta}\mu_e \cdot \zeta_m > \frac{\delta}{1-\delta}\mu_e \cdot \zeta_m$, because ζ_s is positive, and $\frac{1}{1-\delta}\mu_e \cdot \zeta_m$ is what she would get both if she waited to make a counteroffer in her current match, or got divorced and was rematched the next period. Moving up one node, her decision to accept any offer $\widetilde{\mu_e}' \geq \widetilde{\mu_e}$ is optimal if $\frac{1}{(1-\delta)}\widetilde{\mu_e}'\zeta_m \geq \zeta_s + \frac{\delta}{(1-\delta)}\left(\frac{1}{(1+\delta)} + \frac{\delta}{(1+\delta)} \cdot \frac{\zeta_s}{\zeta_m}\right)\zeta_m$. Rearranging shows that this is true for $\widetilde{\mu_e}' \geq \widetilde{\mu_e}$. Conversely, replacing the $\geq$ by a $<$ in the previous expression establishes that it is optimal to reject any $\widetilde{\mu_e}' < \widetilde{\mu_e}$. Moving up one node, again, offering $\widetilde{\mu_e'} > \widetilde{\mu_e}$, can never be optimal for the husband. Offering her $\widetilde{\mu_e'} < \widetilde{\mu_e}$ will prompt her to divorce. Therefore, offering $\widetilde{\mu_e}$ is optimal if $\frac{\delta}{1-\delta}\left(p \cdot (1-\mu_e)\,\zeta_m + (1-p)\,(1-\mu_u)\,\zeta_u\right) \leq \frac{1}{1-\delta}(1-\widetilde{\mu_e})\zeta_m$. Plugging in the expressions for μ_e, μ_u and $\widetilde{\mu_e}$ and rearranging yields that this action is optimal as long as $\frac{\delta^2(1-p)}{1-p\delta^2} \leq \frac{\zeta_m-\zeta_s}{\zeta_u}$. Since $\frac{\delta^2(1-p)}{1-p\delta^2} < \frac{(1-p)\delta}{(1-p\delta}$, this holds for the relevant parametervalues by (A.45). Moving up one node, it is optimal for the husband to stay put and wait for his turn to make a counteroffer after rejecting an offer if $\frac{\delta}{1-\delta}(1-\widetilde{\mu_e})\zeta_m \geq \frac{\delta}{1-\delta}\left(p \cdot (1-\mu_e)\,\zeta_m + (1-p)\,(1-\mu_u)\,\zeta_u\right)$. Plugging in the expressions for μ_e, μ_u and $\widetilde{\mu_e}$ yields the condition $\frac{(1-p)\delta}{1-p\delta} \leq \frac{\zeta_m-\zeta_s}{\zeta_u}$, which is the case by condition (A.45). Accepting any offer $\mu_e' \leq \mu_e$ is optimal for the husband if $\frac{1}{1-\delta}(1-\mu_e')\zeta_m \geq \frac{\delta}{1-\delta}(1-\frac{\delta}{(1+\delta)} + \frac{1}{(1+\delta)} \cdot \frac{\zeta_s}{\zeta_m})\zeta_m$. Rearranging yields that this is true if $\mu_e \geq \mu_e'$. Replacing the $\geq$ in the above condition by $<$ shows that rejecting any $\mu_e' \geq \mu_e$ is a best response. Finally, I have to show that the wife's best action at beginning of period 1 given the strategy profile is to offer μ_e. Again, offering any $\mu_e' < \mu_e$ cannot be optimal. If she offers $\mu_e' > \mu_e$, her husband will reject this offer, and the couple will settle on the husband's offer $\widetilde{\mu_e}$ in the next period. Thus, offering $\mu_e' > \mu_e$ is optimal if $\frac{\delta}{1-\delta}\widetilde{\mu_e} \cdot \zeta_m > \frac{1}{1-\delta}\mu_e \cdot \zeta_m$. This simplifies to the condition $\delta\widetilde{\mu_e} > \mu_e$, which is not true. This establishes subgame perfection for the mixed couple.

Both are uneducated. Again, I start with the subgame in which the man is the proposer. After rejecting an offer, the woman has the same expected utility from staying put and making a counteroffer as from divorcing and being rematched int he next period, so staying put is a best response. Moving up one node, it is optimal for the wife to accept any offer $\widetilde{\mu_u}' \geq \widetilde{\mu_u}$ if $\frac{1}{1-\delta} \cdot \widetilde{\mu_u}' \cdot \zeta_u \geq \frac{\delta}{1-\delta} \cdot \frac{1}{(1+\delta)} \cdot \zeta_u$ which is true for $\widetilde{\mu_u}' \geq \widetilde{\mu_u}$. Again, replacing $\geq$ by $<$ shows that it is optimal for her to reject any $\widetilde{\mu_u}' < \widetilde{\mu_u}$. Again, offering $\widetilde{\mu_u}' > \widetilde{\mu_u}$, can never be optimal for the husband. Offering $\widetilde{\mu_u}$ is a best response if $\frac{1}{1-\delta}(1-\frac{\delta}{(1+\delta)})\zeta_u \geq \frac{\delta}{1+\delta}(1-\frac{1}{(1+\delta)})\zeta_u$, which is true. Moving up one node, the it is optimal for the husband to wait and make a counteroffer rather than get divorced and be rematched in the next period if $\frac{\delta}{1+\delta}(1-\widetilde{\mu_u})\zeta_u \geq \frac{\delta}{1+\delta}(p \cdot (1-\mu_u)\zeta_u + (1-p)(1-\mu_e)\zeta_m)$.

Inserting the relevant expressions for μ_u and $\widetilde{\mu_u}$ and rearranging yields that it is optimal for the husband to make a counteroffer if $\frac{\zeta_m - \zeta_s}{\zeta_u} \leq \frac{1-\delta-p\delta}{p}$, which is true by (A.45). On the previous node, accepting any $\mu'_u \leq \mu_u$ is a best response if $\frac{1}{1-\delta}(1-\mu'_e)\zeta_u \geq \frac{\delta}{1-\delta}(1-\frac{\delta}{1+\delta})\zeta_u$ which is true for $\mu'_u < \frac{1}{1+\delta}$. Again, replacing $\geq$ by $<$ shows that it is optimal to reject any $\mu'_e > \mu_e$. Lastly, it is optimal for the wife to offer μ_e because offering $\mu'_e > \mu_e$ will prompt a rejection and counteroffer by the man, and since $\frac{1}{1-\delta}\frac{1}{1-\delta}\zeta_u \geq \frac{\delta}{1-\delta}\frac{\delta}{1-\delta}\zeta_u$, offering $\mu_e = \frac{1}{1-\delta}$ gives her a higher pay-off, and offering $\mu'_e < \mu_e$ cannot be optimal, because μ_e will be accepted. This establishes that *Rubinstein-type equilibrium* is a subgame perfect equilibrium on the relevant parameter area. $\square$

A.8 Supplement: A more General Specification of Marital Output

Solving the Game

Since in this version of the model individuals do not have a gender, they are only identified by their educational class. As in the full version of the model, a fair coin decides the identity of the proposer immediately after a new match is formed. For individuals who have been selected as first proposers, we have:

- V_e^e is an educated proposer's continuation value of being married to an educated individual,
- V_u^e is an educated proposer's continuation value of being married to an uneducated individual,
- V_e^u is an uneducated proposer's continuation value of being married to an educated individual,
- V_u^u is an uneducated proposer's continuation value of being married to an uneducated individual.

The responders' continuation values of being in the same marriages are $\widetilde{V_e^e}$, $\widetilde{V_u^e}$, $\widetilde{V_e^u}$ and $\widetilde{V_u^u}$. Note that, if an offer is accepted, the continuation value of the responder is $\widetilde{V_i^j} = \frac{1}{1-\delta} \cdot \zeta_k - V_j^i$, with $i, j \in \{e, u\}$ and $k \in \{e, m, u\}$. The probability to be matched to an educated individual on the marriage market is p. The continuation value of divorcing in the current period for an uneducated individual is

$$\begin{aligned} D^e &= \frac{\delta}{2} \cdot \left(p \cdot \left(\max\left\{V_e^e, D^e\right\} + \max\left\{ \left(\frac{1}{1-\delta} \cdot \zeta_e - V_e^e \right), D^e \right\} \right) \right. \\ &\qquad \left. + (1-p) \cdot \left(\max\left\{V_u^e, D^e\right\} + \max\left\{ \left(\frac{1}{1-\delta} \cdot \zeta_e - V_e^u \right), D^e \right\} \right) \right), \end{aligned} \tag{A.47}$$

while for an uneducated individual the continuation value of divorce is

$$\begin{aligned} D^u &= \frac{\delta}{2} \cdot \left(p \cdot \left(\max\left\{V_e^u, D^u\right\} + \max\left\{ \left(\frac{1}{1-\delta} \cdot \zeta_m - V_u^e \right), D^u \right\} \right) \right. \\ &\qquad \left. + (1-p) \cdot \left(\max\left\{V_u^u, D^u\right\} + \max\left\{ \left(\frac{1}{1-\delta} \cdot \zeta_u - V_u^u \right), D^u \right\} \right) \right). \end{aligned} \tag{A.48}$$

As before, I only consider symmetric subgame perfect equilibria in stationary strategies. In such an equilibrium, the following conditions have to hold:

For a couple of two educated individuals

$$V_e^e = \frac{1}{1-\delta} \cdot \zeta_e - \max\left\{\delta V_e^e, D^e\right\} \tag{A.49}$$

For a couple of two uneducated individuals

$$V_u^u = \frac{1}{1-\delta} \cdot \zeta_u - \max\left\{\delta V_u^u, D^u\right\} \tag{A.50}$$

For a mixed couple, if the educated individual is the proposer

$$V_u^e = \frac{1}{1-\delta} \cdot \zeta_m - \max\left\{\delta V_e^u, D^u\right\}. \tag{A.51}$$

For a mixed couple, if the uneducated individual is the proposer

$$V_e^u = \frac{1}{1-\delta} \cdot \zeta_m - \max\left\{\delta V_u^e, D^e\right\} \tag{A.52}$$

There is only one condition for the two homogeneous couples because these couples are completely symmetric, and the conditions for the twin game in which the proposer and responder roles are reversed are the same as (A.49) and (A.50).

This leads to the following inequalities:

$$\begin{aligned}
&\delta V_e^e \gtreqless u_D^e && \text{for a couple of two educated individuals,} \\
&\delta V_u^u \gtreqless u_D^u && \text{for a couple of two uneducated individuals,} \\
&\delta V_e^u \gtreqless u_D^u && \text{for a mixed couple if the educated individual} \\
& && \text{makes the first offer and} \\
&\delta V_u^e \gtreqless u_D^e && \text{for a mixed couple if the uneducated individual} \\
& && \text{makes the first offer.}
\end{aligned} \tag{A.53}$$

There are 16 possible combinations of the inequalities listed in (A.53), each of them is a possible equilibrium. I checked if they exist on non-empty parameter spaces; these calculations are available on request. As in the full version of the model, all cases in which educated individuals in homogeneous marriages credibly threaten with divorce lead to contradictions. Because the individuals are hybrids, both partners fish in the same pond for potential future spouses, and are currently in the union that generates the highest output. Hence, it cannot be beneficial for them to divorce and take the risk to be matched to someone who contributes less to the marriage than their present partner.

Furthermore, both cases, in which an uneducated individual as a responder can credibly threaten with divorce in a mixed marriage while an educated individual cannot, lead to contradictions. In a mixed marriage, uneducated individuals are matched to the type of individual they can generate the most output with. If this individual is unable to extract most of this output, because their divorce threat is not credible, there is no reason why an uneducated individual would be better off divorced. Finally, the case in which uneducated individuals in both types of marriages does not exist by the same argument as in the full version of the model.

Equilibria

Forever after

The divorce threat is not credible in any couple, the outside option is irrelevant for the bargaining outcome. This is the Rubinstein equilibrium.

This quilibrium exists if

$$\frac{\zeta_e}{\zeta_m} \leq \frac{(p-\delta+p\delta+1)}{p\,(\delta+1)} \tag{A.54}$$

$$\frac{\zeta_u}{\zeta_m} \geq \frac{p\,(\delta+1)}{(p-\delta+p\delta+1)}. \tag{A.55}$$

The shares for the first proposer are

$$\mu_e^e = \mu_e^u = \mu_u^e = \mu_u^u = \frac{1}{1+\delta}. \tag{A.56}$$

Holding out for someone better

Uneducated individuals in homogenous marriages have a credible divorce threat. This equilibrium exists if

$$\begin{aligned} \frac{\zeta_e}{\zeta_m} &\leq \frac{(p-\delta+p\delta+1)}{p\,(\delta+1)} \\ \frac{\zeta_u}{\zeta_m} &< \frac{p\,(\delta+1)}{(p-\delta+p\delta+1)}. \end{aligned} \tag{A.57}$$

The shares of the first proposers are

$$\begin{aligned}
\mu_e^e &= \frac{1}{1+\delta} \\
\mu_u^u &= \frac{2\zeta_u - \zeta_u\delta + \zeta_u p\delta - \zeta_m p\delta}{2\zeta_u} \\
\mu_u^e &= \frac{1}{1+\delta} \\
\mu_e^u &= \frac{1}{1+\delta}.
\end{aligned} \tag{A.58}$$

Out of your league

Uneducated individuals in homogeneous marriages and educated individuals in mixed marriages have a credible divorce threat.

This equilibrium exists if

$$\begin{aligned}
\zeta_m &> \frac{\delta p^2\zeta_e(\delta+1)^2 + \zeta_u\left(p\delta - \delta - \delta^2 + p\delta^2 + 2\right)(p - \delta + p\delta + 1)}{2p(\delta+1)^2(p\delta - \delta + 1)} \\
\frac{\zeta_e}{\zeta_m} &> \frac{(p - \delta + p\delta + 1)}{p(\delta+1)}.
\end{aligned} \tag{A.59}$$

The proposers' shares are

$$\begin{aligned}
\mu_e^e &= \frac{1}{1+\delta} \\
\mu_u^u &= \frac{2\delta p(\delta+1)(p\delta - \delta + 1)\zeta_m - \delta^2 p^2(\delta+1)\zeta_e}{2(\delta - p\delta + \delta^2 - p\delta^2 - 2)\zeta_u} + \frac{(p\delta - \delta + 2)}{2} \\
\mu_u^e &= \frac{\left(p\delta - 3\delta + \delta^2 + 2\right)\zeta_m + \zeta_e p\delta^2}{\zeta_m(p\delta - \delta - \delta^2 + p\delta^2 + 2)} \\
\mu_e^u &= \frac{\zeta_e p\delta - 2\zeta_m(p\delta - \delta + 1)}{\zeta_m(\delta - p\delta + \delta^2 - p\delta^2 - 2)}.
\end{aligned} \tag{A.60}$$

Market Equilibrium

Educated individuals in mixed marriages credibly threaten with divorce.

This equilibrium exists if

$$\begin{aligned}
\frac{\zeta_e}{\zeta_m} &> \frac{(p-\delta+p\delta+1)}{p(\delta+1)} \\
\zeta_m &\leq \frac{\delta p^2(\delta+1)^2\zeta_e+\zeta_u\left(p\delta-\delta-\delta^2+p\delta^2+2\right)(p-\delta+p\delta+1)}{2p(\delta+1)^2(p\delta-\delta+1)} \\
\zeta_m &\geq \frac{\delta p\zeta_e(p+p\delta-2)+\zeta_u(p-1)\left(p\delta-\delta-\delta^2+p\delta^2+2\right)}{2(p\delta-\delta+1)(p+p\delta-2)}.
\end{aligned} \tag{A.61}$$

The proposers' shares are

$$\begin{aligned}
\mu_e^e &= \frac{1}{1+\delta} \\
\mu_u^u &= \frac{1}{1+\delta} \\
\mu_u^e &= \frac{\zeta_m(1-\delta)(-p\delta+\delta-2)-\zeta_e p\delta^2}{\zeta_m(\delta-p\delta+\delta^2-p\delta^2-2)} \\
\mu_e^u &= \frac{2\zeta_m(-p\delta+\delta-1)+\zeta_e p\delta}{\zeta_m(\delta-p\delta+\delta^2-p\delta^2-2)}.
\end{aligned} \tag{A.62}$$

Birds of a feather

The divorce threat is credible for both educated and uneducated individuals if they are in mixed marriages.

This e quilibrium exists if

$$\begin{aligned}
\zeta_m &< \frac{p\delta\zeta_e(p+p\delta-2)+\zeta_u(p-1)\left(p\delta-\delta-\delta^2+p\delta^2+2\right)}{2(p\delta-\delta+1)(p+p\delta-2)} \\
\zeta_m &< \frac{p\zeta_e\left(p\delta+p\delta^2-2\right)+\delta\zeta_u(p-1)(p-\delta+p\delta+1)}{2(p\delta-1)(p-\delta+p\delta+1)}.
\end{aligned} \tag{A.63}$$

The proposers' shares are

$$\begin{aligned}
\mu_e^e &= \frac{1}{1+\delta} \\
\mu_u^u &= \frac{1}{1+\delta} \\
\mu_u^e &= \frac{\zeta_e p^2\delta^2+\delta\zeta_u(p-1)(p\delta-\delta+2)-2\zeta_m(p\delta-\delta+2)(p\delta-1)}{2(2-\delta)\zeta_m} \\
\mu_e^u &= \frac{\delta p\zeta_e(p\delta-2)+\delta^2\zeta_u(p-1)^2-2\zeta_m(p\delta-\delta+1)(p\delta-2)}{2\zeta_m(2-\delta)}.
\end{aligned} \tag{A.64}$$

Appendix B

Marriage Markets and Divorce - Data

B.1 The Effect of the Marriage Market on the Divorce Hazard

Main Results

Table B.1: Probit for divorcing this month

	Pooled	State fixed effects	State fixed effects + state linear trend
Marriage Market Controls			
Male Education Premium	**-0.878**	-0.632	-0.574
	(0.405)	(0.405)	(0.406)
Sex-ratio	0.311	0.279	0.246
	(0.375)	(0.358)	(0.367)
Proportion of women 18-45	0.208	**0.433**	**0.414**
who hold a college degree	(0.186)	(0.225)	(0.230)
Proportion of men 18-45	**-0.383**	-0.270	-0.243
who hold a college degree	(0.218)	(0.225)	(0.229)
Mean wage (full time working men)	**-0.300**	0.028	-0.018
	(0.097)	(0.136)	(0.148)
Interaction of the Couple's Education with the Inequality Measure			
At most one of the spouses	**0.830**	**0.771**	**0.724**
is a HS dropout	(0.419)	(0.408)	(0.413)
One is a HS graduate, the other	**1.217**	**1.178**	**1.151**
has at least SC	(0.505)	(0.492)	(0.494)
Both have at least some College	0.754	**0.764**	0.727
	(0.457)	(0.447)	(0.446)
Socio-Economic Controls			
At most one of the spouses	**-0.979**	**-0.912**	**-0.853**
is a HS dropout	(0.499)	(0.486)	(0.492)
One is a HS graduate, the other	**-1.433**	**-1.387**	**-1.353**
has at least SC	(0.605)	(0.589)	(0.591)
Both have at least some College	**-0.962**	**-0.975**	**-0.931**
	(0.549)	(0.579)	(0.536)
Cohabiting Couple	**0.582**	**0.578**	**0.583**
	(0.037)	(0.037)	(0.037)
Number of own kids under 18	**-0.043**	**-0.043**	**-0.044**
in the household	(0.008)	(0.008)	(0.008)
Number of other kids under 18	**0.209**	**0.219**	**0.220**

Continued from the previous page

	Pooled	State fixed effects	State fixed effects + state linear trend
in the household	(0.029)	(0.029)	(0.029)
Wife more than 5 years older	0.056	0.057	0.056
than husband	(0.042)	(0.041)	(0.042)
Husband more than 5 years older	0.029	0.033	0.033
than wife	(0.028)	(0.028)	(0.028)
Number of times previously	**0.149**	**0.146**	**0.145**
married, wife	(0.015)	(0.015)	(0.015)
Number of times previously	-0.010	-0.015	-0.016
married, husband	(0.019)	(0.019)	(0.019)
Husband white	**0.090**	**0.072**	**0.071**
	(0.019)	(0.020)	(0.020)
Couple is the same race	**-0.108**	**-0.105**	**-0.107**
	(0.031)	(0.031)	(0.031)
House owned by occupants	**-0.387**	**-0.397**	**-0.399**
	(0.018)	(0.018)	(0.018)
Wife's Age	**-0.006**	**-0.006**	**-0.006**
	(0.003)	(0.003)	(0.003)
Husband's Age	-0.004	-0.004	-0.004
	(0.003)	(0.003)	(0.003)
Year fixed effects	Yes	Yes	Yes
State fixed effects	No	Yes	Yes
State specific linear time trends	No	No	Yes
Constant included	Yes	Yes	Yes
Number of Observations	1,367,623	1,367,070	1,367,070

Weighted probit regressions, dependent variable "got divorced this month", women aged 46 and younger, 1990-2007. Variables significant at the 10% level printed in bold, standard errors in parenthesis. Standard errors clustered according to US Census Bureau recommendations, (U.S. Census Bureau, 2009).

Alternative Measures of Wage Inequality

Table B.2: Probit for divorcing this month

	Pooled	State fixed effects	State fixed effects + state linear trend
		Male education premium	
Pure effect	**-0.878**	-0.632	-0.574
	(0.405)	(0.405)	(0.406)
Interaction of the Couple's Education with the Inequality Measure			
At most one of the spouses	**0.830**	**0.771**	**0.724**
is a HS dropout	(0.419)	(0.408)	(0.413)
One is a HS graduate, the other	**1.217**	**1.178**	**1.151**
has at least SC	(0.505)	(0.492)	(0.494)
Both have at least some College	0.754	**0.764**	0.727
	(0.457)	(0.447)	(0.446)
		Male education premium - pure effect only	
Pure effect	-0.072	0.153	0.178
	0.130	0.148	
		Standard deviation of log male wages	
Pure Effect	**-1.326**	**-0.799**	-0.780
	(0.442)	(0.469)	(0.479)
Interaction of the Couple's Education with the Inequality Measure			
At most one of the spouses	0.490	0.402	0.393
is a HS dropout	(0.450)	(0.454)	(0.463)
One is a HS graduate, the other	**1.359**	**1.308**	**1.319**
has at least SC	(0.487)	(0.489)	(0.494)
Both have at least some College	**1.293**	**1.282**	**1.306**
	(0.466)	(0.471)	(0.479)
Socio-Economic controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
State fixed effects	No	Yes	Yes
State specific linear time trends	No	No	Yes
Constant included	Yes	Yes	Yes

Weighted probit regressions, dependent variable "got divorced this month", women aged 46 and younger, 1990-2007. Variables significant at the 10% level printed in bold, standard errors in parenthesis. Standard errors clustered according to US Census Bureau recommendations. Standard deviation of log hourly and ratio of mean log wages of college graduates/ non-graduates calculated for full time working men, ages 18-50,

B.2 Survey Design

Sample Selection

The SIPP has a very complex survey design that aims to make the SIPP representative of the entire non institutionalized US population (i.e. of all individuals residing in the United States who are not permanently in prison, the armed forces or mental health facilities) while also delivering reliable estimates for special subgroups (low and high income households, ethnic minorities etc). It is not a random sample of the US population, but has a multi-stage survey design. The SIPP's primary sampling units (PSU) are either counties or independent cities, that are either grouped together with neighbouring counties (these are called non-self-representing counties) or constitute PSUs by themselves (are self-representing). The bigger, self-representing PSUs are in fact not PSUs but strata, because they are selected into the sample with probability one (U.S. Census Bureau, 2009). The smaller, non-self representing PSU's are grouped together with other PSUs in the same region - the Census Bureau distinguishes four regions, South, North-east, Midwest and West - to form *strata*. PSU's that are similar according to socio-economic information from the decennial Census are grouped in the same strata (U.S Census Bureau, 1998). Within most strata, two PSU's are sampled (U.S. Census Bureau, 2009), with a probability proportional to the number of housing units within the PSU (U.S Census Bureau, 1998). Within those PSU's, clusters are sampled, and finally addresses are randomly sampled within clusters, and the households residing in these addresses are interviewed.

This discussion has important implications for the computation of variances based on SIPP data. If the data is treated as a random sample of the US population, variance estimates will generally underestimate the true variances (U.S. Census Bureau, 2009). The Census Bureau provides a variance stratum code to identify the stratum each observation was selected from, and a half-sample code to identify the PSU within the stratum, for variance estimation purposes. Not only do strata cross state lines (they never cross region lines however), but also some PSUs span across state boundaries (Siegel and Mack, 1998). Therefore, clustering the standard errors at the state level (because the main variables of interest in my analysis are measured at the state level) as recommended in the modern micro-econometrics literature (see, e.g. Angrist, 2002) necessarily comes at the cost of ignoring the the SIPP sample design. Ignoring the SIPP sample design means ignoring the between PSU variance, which is why the standard errors are lower in this specification than they are if I disregard US census recommendations and treat the state as the PSU.[1] I cannot cluster the standard errors at the state level *and* take the SIPP survey design into account at the same time, specifically because the SIPP strata and some PSU's cross state boundaries. I cannot have my cake and eat it too. There are two solutions to this problem: first, I could simply ignore the sampling procedure, treat the sample as a random sample, and cluster the standard errors at the state level. Working with the same dataset on a similar research question, Marinescu (2011) completely disregards the survey structure - variance variables and survey weights (see below) and treats the sample as a random sample. With this strategy, I could still use the weights to account for survey attrition, I would only ignore between PSU variance, and underestimate my variances. The second possibility is to follow US Census Bureau recommendations, and forgo the clustering of the standard errors at the state level. This should not be a problem for the majority of the PSU's that do not cross state boundaries, but comes at the risk of disregarding a correlation in the variances within states for PSU's that do cross state lines. Intuitively, I tend towards the second option because it seems to be the more conservative one (the standard errors are larger).

Data Collection and Weighting

SIPP interviews take place at a quarterly basis, and all individuals currently residing in sampled households are interviewed. If *original sample members* move out of a sample, the SIPP aims to follow them (unless they become institutionalized or move abroad). However, as the survey progresses, *survey attrition* (the loss of sample members because they move or refuse interviews) becomes a problem, especially since survey attrition varies among socio-economic groups.

The SIPP aims to correct for this using sampling weights. The sampling weight associated to a person or household is an estimate of the number of individuals in the US population that the person or household represents. Ignoring the weights can lead to biases: for example, the 2004 SIPP included an oversampling of low income households; as a consequence, the fraction of female headed households with no spouse present in the sample is higher than in the US population. At the person level, the magnitude of the differences between population and sample is lower, but still appreciable, e.g. over representation of non-whites (U.S. Census Bureau, 2001). As the sample progresses, adjustments are made to the weights to correct for survey attrition, since different subgroups might differ in their propensity to move out of the sample. In particular, individuals who separate, divorce or become widowed are subject to higher survey attrition than individ-

[1] I was made aware of this by US Census Bureau Staff.

uals in steady relationships; although the SIPP sample weights try to correct for this, the incidence of family breakdown is subject to a downward bias in the SIPP.

The sample weight for a person in any reference- month is a product of four components: the inverse of the probability of the person's address being selected into the sample, a "duplication control factor" (if the dwelling turns out to be larger than expected, and only a part of the dwelling is selected into the sample), a household non-interview adjustment factor (controls for different rates of non-response in more than 500 non-response adjustment classes defined on characteristics such as social strata, census region, race, property ownership, metropolitan status, household size) and Wave 1 second stage calibration adjustment that adjusts the sample with independent estimates of population totals. The characteristics used for this include age, race, sex, Hispanic origin, family relationship, household type and state (U.S. Census Bureau, 2001, p 8-8 of the revised edition). As the survey progresses, the weight from the previous month is always carried over, and adjusted to compensate for changes in the sample resulting from movers and non-response. The non-interview adjustment classes are defined on the basis of household characteristics, mostly demographic characteristics, house ownership, household type, and other characteristics such as poverty status, type of income, financial assets, census division etc.The Census Bureau provides a whole battery of weights. Since my analysis is on a person/ month level I use the person weight.

B.3 Identifying Married Couples

For each married individual who is currently living in the same household with his or her spouse (i.e. whose marital status is reported as "married, spouse present") the SIPP provides an ID number of the spouse. Thus, I can associate couples by generating a joint couple id (by concatenating the wife's and husband's id numbers). However, there are mistakes in the spouse ID numbers: from the 3,159,906 observations of women who report to be married and living with their spouse in a given month and who provide a spouse ID, I cannot match a husband to 411,884 or about 13% of all cases. That these non-matches are not equally distributed across panels, with 27% of all non-matches coming from the 1996 panel, corroborates the suspicion that these are mistakes in the recording of the spouse IDs. Another possibility to match couples is to match married individuals of opposite sexes who are counted as belonging to the same subfamily.[1] The problem

[1]In the SIPP, a family, as opposed to a household, is a group of people residing together who are related to each other by blood, marriage or adoption. A subfamily is a nuclear family residing with other related individuals in one household. For example, a primary family would be a married couple living with their son and daughter in law, and the son and daughter in law would be a subfamily. So a subfamily

arising from this approach is that it is not always clear who constitutes a couple: if for example a married couple resides with their daughter in law while their son is serving in the armed forces, it would be difficult to correctly match the wife, and not the daughter in law, to the husband. I have, however, information on the year of the last marriage for most married individuals.[1] So I match individuals who I could not match using the more direct approach of the spouse id numbers using the unique subfamily id and year of last marriage. I think it is very unlikely that two individuals who report to be married with their spouse present in the same subfamily would report the same year of marriage.[2] This could only be the case if a married couple was living with their married child, and both generations would have wedded in the same year. Using this approach, I can match another 328,421 women/month observations, and bring the women/ month observations in my sample who are not matched to husbands down to 83,463.

B.4 Identifying Cohabiting Couples

Up to the 1996 panel, the SIPP did not record unmarried partners separately, but subsumed them under the category "house-mate/ room-mate". Therefore I only include cohabiting couples from the 1996 panel onwards. The variable ERRP (household relationship) defines the relationship of each person living in the household to the household reference person (who would typically be the one interviewed, or the "householder" in the more conservative sense). Therefore I cannot include unmarried couples, when neither of the partners is ever the household reference person - this would be couples who durably live with their parents or are roomers/ boarders of the reference person. There is no question in the SIPP that directly addresses the resolution of unmarried relationships;[3] I therefore assume that an unmarried couple is separated if they no longer live in the same household, as advised by US Census Bureau staff. The only possible source of noise with this approach is if one of the partners joins the armed forces, and therefore leaves the SIPP sample universe.

can never contain more than one married couple.

[1]This question is asked in the marital history topical module file in the second wave of the panel, so it is primarily missing from individuals who get married during the panel, but after the second wave.

[2]I drop any observations were there are two individuals of the same sex in the same subfamily reporting the same year of marriage. These are only a couple of dozen observations that are most likely due to measurement error.

[3]I was cautioned by US Census Bureau staff against the use of ULFTMAIN because it is an unedited variable.

B.5 Wages and Earnings

When comparing wage data over time, some comparability issues have to be considered, most importantly the Census Bureau's practice of *topcoding* weekly earnings, their treatment of tips, commissions and overtime for hourly paid workers, their treatment of outliers and changes of the recording of hours worked over time (see Schmitt, 2003, for a thorough discussion of these issues).[1] I follow the CEPR's recommendations for dealing with these issues, specifically, I use the CEPR wage series that uses a log normal imputation to adjust for topcoding, excludes extreme values for hourly wages, disregards tips, commissions and overtime for hourly paid workers and uses imputed data for workers who report their hours "wary".[2]. The wage rates I use are in constant 2010 US Dollars.

B.6 Combining Datasets from different Panels

The 1990 - 1993 panels were overlapping, that is multiple panels ran at the same time.[3]. To deal with this overlap, the US Census Bureau (see U.S. Census Bureau, 1993, p.6) recommends to drop the first wave of every panel because the questionnaires of the first wave and subsequent waves differ somewhat, and therefore the first wave data are not comparable to data of simultaneously running later waves. Furthermore, to ensure that the weights sum to the total US population in each month, the Census Bureau recommends to apply a weighting factor that is calculated using the number of interviews conducted in the respective panels. I follow these recommendations, and use the adjustment factors provided by the Census Bureau (see U.S. Census Bureau, 2001, p. 8-22).

The Census Bureau does not provide adjustment factors for post- 1996 panels, because they only overlap at the fringes.[4] For the sake of consistency, I drop first month from the 1996 and the first three months from the 2004 panel.

[1]topcoding is the practice of truncating weekly earnings at a maximum value to protect the privacy of high earners. Because the Census Bureau only sporadically adjusts the topcoding threshold, the earnings distribution becomes skewed over time. Also, the census allows individuals to state that their weekly hours of work "vary", which can lead to systematic biases.

[2]The CEPR deals with topcoding by assuming a lognormal distribution of wages above the topcode, that is allowed to differ by gender. Hours worked that "vary" are imputed using regression analysis, see again Schmitt (2003)

[3]The 1990 panel covers the period October 1989-August 1993, the 1991 panel October 1990-August 1993, the 1992 panel October 1991-December 1994 and the 1993 panel goes from October 1992-December 1995

[4]The 1996 panel covers December 1995 to February 2000, the 2001 panel October 2000- December 2003, and the 2004 panel October 2003 - December 2007.

Appendix C

Specialisation in the Bargaining Family

Proof of Proposition 11 (Efficiency).

It may be optimal that one spouse fully specializes on market work, so we have to maximize the joint inter-temporal utility $U(g^f, g^m)$ subject to the non-negativity constraints $g^f \geq 0$ and $g^m \geq 0$. The Kuhn-Tucker first order conditions are

$$\frac{\partial U}{\partial g^f} = -\underline{w} + 2v'(G)h^f + w'(g^f) \leq 0, \quad \frac{\partial U}{\partial g^f} \cdot g^f = 0, \quad g^f \geq 0, \tag{C.1}$$

$$\frac{\partial U}{\partial g^m} = -\underline{w} + 2v'(G)h^m + w'(g^m) \leq 0, \quad \frac{\partial U}{\partial g^m} \cdot g^m = 0, \quad g^m \geq 0. \tag{C.2}$$

Our Inada assumptions regarding the spouses' preferences imply that the solution to the joint maximization problem (3.6) involves a strictly positive provision level of the family public good $\bar{G} > 0$, so we cannot obtain $g^f = g^m = 0$. They also imply that both $g^f < 1$ and $g^m < 1$. Thus, it suffices to show that only one spouse contributes to the family public good and that, in the case of asymmetric productivities, the only contributor is the spouse with the higher productivity.

Joint utility U can be expressed as a function of g^f and $\bar{G}$, since $g^m = \frac{1}{h^m}\bar{G} - \frac{1}{h^m}h^f g^f$:

$$U(g^f, \bar{G}) = F(g^f, \bar{G}) + w(g^f) + w(\bar{G} - g^f), \tag{C.3}$$

where $F(g^f, \bar{G}) := \underline{w} \cdot (1 - g^f) + \underline{w} \cdot (1 - g^m(\bar{G})) + 2v(h^f g^f + h^m g^m(\bar{G}))$.

Consider first the case of equal productivities, $h^f = h^m$. The contributions g^f and g^m in the term $F(\cdot)$ are perfect substitutes and thus spouses' individual contributions are irrelevant as long as their sum equals $\bar{G}$. Therefore, for a given $\bar{G}$, $U(g^f, \bar{G})$ is maximized whenever the sum $w(g^f) + w(\bar{G} - g^f)$ is maximized. Since w is a convex function, this sum is maximized when the values g^{f*} and $g^{m*} = \bar{G} - g^{f*}$ are on the border of the interval at a corner solution where $g^{f*} = \bar{G}$ and $g^{m*} = 0$ or, alternatively, $g^{m*} = \bar{G}$ and $g^{f*} = 0$.

Consider now the case $h^f > h^m$. By the same argument, the sum $w(g^f) + w(\bar{G} - g^f)$ is maximized at the corners of the interval, that is at $g^{f*} = \bar{G}, g^{m*} = 0$ and $g^{m*} = \bar{G}, g^{f*} = 0$. But g^f and g^m are no perfect substitutes in the term $2v(h^f g^f + h^m g^m)$ any more. If $h^f > h^m$, the term $2v(h^f g^f + h^m g^m)$ is greater if $g^{f*} = \bar{G}$ than if $g^{m*} = \bar{G}$. Therefore, if $h^f > h^m$, the only efficient outcome is the corner solution $g^{f*} = \bar{G}$ and $g^{m*} = 0$. QED.

Proof of Lemma 1 (Non-cooperative marriage).

For each spouse, the first and second order conditions (FOC and SOC) are

$$\begin{aligned} \frac{\partial U^i}{\partial g^i} &= -\underline{w} + v'(h^f g^f_{NC} + h^m g^m_{NC})h^i + w'(g^i_{NC}) \leq 0, \qquad \text{(C.4)} \\ & \frac{\partial U^i}{\partial g^i} \cdot g^i_{NC} = 0, \quad g^i_{NC} \geq 0, \\ \frac{\partial {U^i}^2}{\partial^2 g^{i*}} &= v''(h^f g^f_{NC} + h^m g^m_{NC}){h^i}^2 + w''(g^i_{NC}) < 0 \quad \text{for a maximum.} \end{aligned}$$

Consider first the case $h^f = h^m$. We will show by contradiction that $g^f_{NC} = g^m_{NC}$. Suppose $g^f_{NC} \neq g^m_{NC}$, and without loss of generality let $g^f_{NC} > g^m_{NC}$. Then, because of the convexity of $w(g^i)$, the RHS of (3.15) (the wife's first order condition) is larger than the RHS of (3.16) (the husband's). Since the LHS of both conditions are equal, equality can only hold for one spouse. If it holds for the husband, the concavity of $v(h^f g^f_{NC} + \overline{h^m g^m_{NC}})$ would induce the wife to withdraw part of her contribution, since her marginal cost would otherwise exceed her marginal gain from the public good. If it holds for the wife, the husband would increase his contribution, because his marginal gain from the public good exceeds his marginal cost. Hence, $g^f_{NC} = g^m_{NC}$. Observe that our Inada assumptions (3.7) guarantee that $g^f_{NC} = g^m_{NC}$ are strictly positive.

Now consider the case $h^f > h^m$. First, observe that $g^f_{NC} \neq g^m_{NC}$. If they were equal, both conditions could not hold simultaneously, because the marginal utility from the public good has to be the same for both spouses. Then, assume that $g^m_{NC} \in (g^f_{NC}, 1]$. If this were true, $w - w'(g^m_{NC}) > w - w'(g^f_{NC})$ because of the convexity of $w(\cdot)$, and both conditions cannot hold because $\frac{1}{h^m} > \frac{1}{h^f}$. Finally, consider $g^m_{NC} \in (0, g^f_{NC})$. Rearrange (3.15) and (3.16) such that

$$\begin{aligned} h^f \cdot v'(h^f g^f_{NC} + \overline{h^m g^m_{NC}}) &= w - w'(g^f_{NC}), \qquad \text{(C.5)} \\ h^m \cdot v'(\overline{h^f g^f_{NC}} + h^m g^m_{NC}) &= w - w'(g^m_{NC}). \qquad \text{(C.6)} \end{aligned}$$

Clearly, the LHS of (C.6) is larger than the LHS of (C.5). If both conditions hold with equality we have: $\underline{w} - w'(g^f_{NC}) > \underline{w} - w'(g^m_{NC})$, rearranging yields $w'(g^m_{NC}) > w'(g^f_{NC})$. Because $w(g^i)$ is decreasing and convex, this implies that $g^m_{NC} > g^f_{NC}$, which leads to a contradiction. Thus, both spouses cannot be in an interior solution, and $g^m_{NC} = 0$.

What remains to be shown is that $g^f_{NC} < g^{f*}$. First, observe that $g^f_{NC} \neq g^{f*}$, for if it were, the RHS of (3.10) and (C.6) would coincide, resulting in their LHS to be equal as well which clearly cannot be the case. To see that $g^f_{NC} < g^{f*}$, multiply the RHS of (3.10) by two. Because the RHS is positive, the RHS must then be larger than the LHS:

$$2 \cdot h^f v'(h^f g^{f*}) < 2 \cdot (\underline{w} - w'(g^{f*})). \tag{C.7}$$

By (C.6), this condition holds with equality at $g^f = g^f_{NC}$, so if $g^{f*} < g^f_{NC}$, it would have to be increased to equal g^f_{NC}. Increasing g^f reduces both sides of the condition, but the first derivative of the RHS must be larger than the first derivative of the LHS since $U^i(g^f, g^m)$ is globally concave and (3.9) has to hold in g^{f*}. Therefore increasing g^f would would shrink the RHS of (C.7) slower than the LHS, aggravating the equality. Hence, g^{f*} cannot be smaller than or equal to g^f_{NC}, and must therefore be larger. QED.

Proof of Lemma 2 (Divorce).

That $g^f_D = g^m_D$ if $h^f = h^m$ follows from the first order conditions (3.20) and (3.21). For the case of asymmetric productivities, one cannot say whether a higher household productivity leads to more or less time spent on household work. The first order conditions only allow us to state that the "expenditure" $h^f g^f_D$ on G by the more productive spouse must be larger than the "expenditure" of the less productive spouse $h^m g^m_D$. That the wife's contribution to the public good is the same in both threat point specifications is obvious since the first order conditions (3.15) and (3.20) coincide for both threat point specifications. QED.

Proof of Proposition 12 (Efficiency under binding agreements).

The NBS is efficient by construction, so by Proposition 11 there is full specialization within the couple. Lemmas 1 and 2 and Table 3.1 imply that, if the wife has a comparative advantage in household production, she is better off (and the husband is correspondingly worse off) if the threat point is divorce than if it is non-cooperative marriage, and that with equal productivities, the choice of the threat point does not matter for intra-household distribution. It only remains to show that, for both threat point specifications, the first and the second period transfer payments do not violate the husband's budget constraints.

Consider first the individual budget constraints when the threat point is non-cooperative marriage. In the first period, the husband has an income of $\underline{w}$, which is greater than the first period transfer $\frac{1}{2}\underline{w} \cdot (g^{f*} - g^f_{NC})$, since $g^{f*} - g^f_{NC} < 1$. His second period income is $w(0)$, which again is greater than the second period transfer $\frac{1}{2}(w(g^f_{NC}) - w(g^{f*}))$, since both $g^f_{NC} > 0$ and $g^{f*} > 0$, therefore $w(0) > w(g^f_{NC})$ and $w(0) > w(g^{f*})$ and thus $w(0) > \frac{1}{2}(w(g^f_{NC}) - w(g^{f*}))$.

For the divorce threat point, direct calculation shows that if $T^f_D + T^m_D < U^{f*} + U^{m*}$, then $P_D < U^{m*}$. QED.

Proof of Lemma 3 ($f(u^m)$ is decreasing and strictly concave).

To see that $f(u^m)$ is decreasing, fix two arbitrary points u^m_1 and u^m_2 with $u^m_1 \in \Omega$ and $u^m_2 \in \Omega$ such that $u^m_1 > u^m_2$. Since ${u^m}^{-1}(u^m) = g^f(u^m)$ is strictly increasing, $g^f(u^m_1) > g^f(u^m_2)$. $u^f(g^f)$ must be strictly decreasing for $g^f \in (g^f_D, g^{f*})$ because $g^{f*} > g^f_D$ and g^f_D is the maximum of this function. Hence, $U^f(g^f(u^m_1)) < U^f(g^f(u^m_2))$, which is equivalent to stating that $f(U^m_1) < f(U^m_2)$.

We now show that $f(U^m)$ is strictly concave. Again, fix u^m_1 and u^m_2 with $u^m_1 \in \Omega$ and $u^m_2 \in \Omega$ such that $u^m_1 > u^m_2$. Fix any $\alpha \in [0, 1]$ and define $g^f_1 = g^f(u^m_1)$, $g^f_2 = g^f(u^m_2)$ and $g^f_3 = \alpha g^f(u^m_1) + (1-\alpha)g^f(u^m_2)$. Since $u^f(g^f)$ is strictly concave, we have

$$U^f(g^f_3) > \alpha U^f(g^f_1) + (1-\alpha)U^f(g^f_2). \tag{C.8}$$

Define $u^m_3 = \alpha u^m_1 + (1-\alpha)u^m_2$. Since $g^f(U^m)$ is strictly convex (because $U^m(g^f)$ is strictly concave),

$$g^f(u^m_3) < \alpha g^f(u^m_1) + (1-\alpha)g^f(u^m_2), \tag{C.9}$$

and hence $g^f(u^m_3) < g^f_3$. Moreover, since $U^f(g^f)$ is strictly decreasing for $g^f \in (g^f_D, g^{f*})$, (C.9) implies that $U^f(g^f(u^m_3)) > \alpha U^f(g^f(u^m_1)) + (1-\alpha)U^f(g^f(u^m_2))$, which, since $f(u^m) = U^f(g^f(u^m))$, establishes that $f(u^m)$ is strictly concave. QED.

Proof of Proposition 13 (Binding agreements not feasible).

If the sum of the payments determined in section 3.4 is lower than the husband's first period income, $P^1 + P^2 \leq \underline{w}$, the constraint $P^2 = 0$ is not binding in the model without binding agreements - the husband can afford to pay the wife both P^1 and P^2 in the first period. Consequently, it does not influence the maximization problem, which establishes case 1.

Now consider the case where the parameters of the model are such that the solution of the original problem, as discussed in section 3.4, incorporates payments from husband to wife that exceed the husband's first period income. Then, all utility pairs on the UPF where $U^f \in [\overline{U^f}, \widehat{U^f})$ are of the form described in (3.32) and (3.31), and only depend on g^f (because the wife controls all income that can be distributed between the spouses).

U^m can be written as a function of g^f, and since $U^m(g^f)$ is strictly increasing in g^f, its inverse exits:

$$U^{m^{-1}}(u^m) = g^f(u^m) = \frac{1}{h^f} \cdot v^{-1}(u^m - w(0)). \tag{C.10}$$

Hence, $U^f(g^f)$ can be written as a function of u^m:

$$\begin{aligned} f(u^m) \quad \equiv \quad & U^f(g^f(u^m)) = u^m - w(0) + \underline{w} \cdot \left(2 - \frac{1}{h^f} \cdot v^{-1}\left(u^m - w\left(0\right)\right)\right) \\ & +w\left(\frac{1}{h^f} \cdot v^{-1}\left(u^m - w\left(0\right)\right)\right). \end{aligned} \tag{C.11}$$

To find the NBS, we have to maximize the Nash product, $(U^f - T^f)(U^m - T^m)$ on the UPF, $U^f(u^m) = f(u^m)$. This is equivalent to maximizing $\left(f(u^m) - T^f\right)(U^m - T^m)$ over u^m. The first order condition is

$$-f'(u^m)\,(U^m - T^m) = \left(f(u^m) - T^f\right). \tag{C.12}$$

Plugging in the first derivative of (C.11) and rearranging yields condition

$$\underline{w} - w'(g^f_{NB}) = \left(1 + \frac{U^f(g^f_{NB}) - T^f}{U^m(g^f_{NB}) - T^m}\right) h^f v'(h^f g^f_{NB}). \tag{C.13}$$

To establish that g^f_{NB} decreases with a rise in T^f, fix the NBS of a bargaining problem that lies on $f(u^m)$ and consider an increase of T^f in the NBS. This diminishes $\dfrac{U^f(g^f_{NB}) - T^f}{U^m(g^f_{NB}) - T^m}$ on the RHS of condition (3.36). Since the RHS is positive, the LHS must now be larger than the RHS. To arrive at the new NBS, g^f_{NB} must increase or dicline. Increasing g^f_{NB} results in $v'(h^f g^f_{NB})$ diminishing faster than $-w'(g^f_{NB})$ by the global concavity condition (3.9). Also, $U^f(g^f_{NB})$ is decreasing in g^f_{NB}, while $U^m(g^f_{NB})$ is increasing in g^f_{NB}. This reduces $\dfrac{U^f(g^f_{NB}) - T^f}{U^m(g^f_{NB}) - T^m}$. Both effects aggravate the inequality. Hence, g^f_{NB} must be reduced to arrive at the new NBS. To prove that g^f_{NB} rises with an increase in T^m, reverse this argument. QED.

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