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Abstract

In my dissertation I explore several applications of collective household models with limited commitment to study the behavior of singles and couples in the modern US marriage markets in presence of endogenous risk of divorce. In the first chapter, I show that the model is capable of rationalizing the patterns of childbearing inside and outside of marriage. Namely, I show that the presence of children distorts marriage choices significantly and often leads to the creation of risky marriages. This suggests a large variation in unobservable marriage quality and negative overall effects of potential marriage-promoting policies. In the second chapter, co-authored with Fabio Blasutto, we argue that the collective household model can be used to study the evolution of the choice between marriage and cohabitation. Exploiting the changes in the US divorce laws, we show that easier divorce makes more people prefer cohabitation to formal marriage. Couples with intermediate levels of match quality, who ex-ante have higher risks of divorce, would choose to avoid marriage altogether if the divorce procedure becomes easier. In the third chapter, I show that the mathematical properties of the model are often not desirable, as divorce decisions are binary and therefore can jump in response to small changes in the couple's resources. These jumps make savings decisions discontinuous and complicate obtaining precise numerical solutions. I propose a way to mitigate these discontinuities by introducing an alternative setup, where the divorce decisions are probabilistic.

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Preface

The dissertation has three separate chapters. Each chapter corresponds to a separate project. In this section I provide abstracts to the chapters.

Chapter One. Many couples marry either just before or soon after they have their first child. I show that married couples who have the first child before or in the year of marriage (kids-first) divorce around twice as often than those having their first kids in the year following their marriage or later (marriage-first). Various well-known determinants of divorce do not explain this difference. I show that this finding is consistent with a simple setup where people choose whether to marry based on their potential relationship quality. Unplanned pregnancies can affect their decisions as women face a risk of raising the child alone. I build and structurally estimate a lifecycle model replicating the difference in divorce rates and use it for policy analysis. First, promoting marriage results in higher divorce rates and lower welfare, and marriage rates themselves respond little to monetary incentives. Second, forcing fathers to pay child support has a mild impact on couples' marriage and divorce decisions, although it incentivizes more women to be single mothers. Third, policies that improve people's ability to control their fertility result in better marriages, less divorce, and higher welfare.

Chapter Two. What is the role of unilateral divorce in the rise of unmarried cohabitation? Exploiting the staggered introduction of unilateral divorce across the US states, we show that after the reform singles become more likely to cohabit than to marry, and that newly formed cohabitations last longer. To understand the mechanisms driving these outcomes, we build a life-cycle model with partnership choice, endogenous divorce/breakup, female labor force participation, and saving decisions. A structural estimation that matches the empirical findings suggests that unilateral divorce decreases the marriage gains that derive from cooperation and risk-sharing. This makes cohabitation preferred among couples that would have likely faced a divorce, which is more expensive than breaking up. As cohabiting couples formed after the reform are better matched, the average length of cohabitations increases by 27%. Consistent with data, the rise in cohabitation is larger in states that impose an equal division of property upon divorce. This is because men, who stand to lose more wealth in a divorce than in a breakup, convince women to cohabit in exchange for more household resources. A counterfactual experiment reveals that the time spent cohabiting would have been halved if the divorce laws had never changed.

Chapter Three. I present a version of the collective household model with dynamic bargaining where the exact solution can be obtained. I show that the divorce decisions may be discontinuous with respect to savings under common assumptions about functional forms, and as a result of it, the consumption-savings problem can have kinks and multiple local solutions. The reason for this is different returns to savings of couples and single agents. This leads to discontinuities in optimal savings policy function even in a very simple model, and these discontinuities accumulate and can make obtaining the accurate solution complicated. To deal with this, I present a way to smooth divorce decisions of couples by introducing taste shocks, that are widely used in the framework of dynamic discrete choice. When divorce decisions are probabilistic, kinks can be smoothed. I show that taste shocks can improve the accuracy of numeric approximations and present a tractable way to add taste shocks to general multi-period collective household models, like the one from the first two chapters of my thesis.

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Chapter 1

The Economics of Shotgun Marriage

1.1 Introduction

Marriage is associated with a range of desirable outcomes. Controlling for age and education, married couples are wealthier on a per-capita basis than never married or divorced people. Marriage provides spousal insurance against uncertainty and can enable efficient cooperation within the household. The benefits are especially apparent when it comes to children: married two-parent families are considered the best in terms of early and adult-life outcomes of children relative to never married or divorced parents (Chetty and Hendren 2018; Ginther and Pollak 2004). It is common, especially among conservative voices, to refer to marriage as "America's strongest anti-poverty weapon" and to advocate for policies that promote marriage.[1] Tax brackets, welfare programs design, childcare subsidies, and mortgage benefits for families are examples of pro-marriage policies worldwide.

This paper studies heterogeneity in marriages to answer a simple question: should policies encourage people to marry more? Clearly, not all couples are created equal: statistical benefits from marriage describe the *average* marriage in the economy, but to answer the policy question we need to understand what the *marginal* marriages induced by potential policies look like. In other words, we need to understand the characteristics of couples that are close to indifference in their decisions on whether to marry each other.

[1]See congressman Ted Budd here, among others.

I propose a novel way to identify the marginal couples based on the relative timing of marriage and childbirth. Some marriages follow the birth of the first child; others take place before the couple has children. Formally, I define "kids-first" marriages as marriages for which the first child was born before or at the year of the marriage and "marriage-first" as those marriages for which the childbirth happened at least in the following year. The former group includes what is traditionally referred to as a "shotgun marriage" — a marriage that occurs when a bride is pregnant.[2] Like shotgun marriages, the kids-first marriages suggest that an unintended pregnancy contributed to the decision to get married. I show that the kids-first couples are closer to the margin of marriage, therefore their marriage and divorce are sensitive to the economic situation and policies.

The key stylized fact that I establish is that the kids-first people divorce more. Namely, I show that for women of age 21–40 in the US, 23% of kids-first unions end in divorce within ten years, as opposed to 10% for marriage-first.[3] Most of these differences cannot be explained by various ways of controlling for age, demographics, education, and income. This pattern is robust to different choices of time horizons and measures of divorce. Perhaps more surprising, the difference is the largest for educated people, yet the share of the kids-first marriages is lower for them.

The lack of exogenous variation in marriage timing does not allow us to rely on the data to understand why people experience such different outcomes and the channels generating this difference. If we believe that the kids-first marriages have worse unobservable quality, which causes them to be less stable, studying policy and welfare questions crucially require understanding the magnitudes of these quality differences. I develop a

[2] Gibson-Davis, Ananat, and Gassman-Pines 2016 use North Carolina administrative data to show that around 10% of women are pregnant at the moment of marriage and this share is stable over the recent decades.

[3] To my knowledge, I am the first in the economic literature to document this fact. In demographic and sociological literature, Wang and Wilcox (2018) establish part of this result using a similar relative timing methodology. Gibson-Davis, Ananat, and Gassman-Pines (2016) discuss it for the shotgun marriages in a narrow sense.

quantitative model that can map the differences in divorce rates into marriage quality differences and separate the impact of marriage quality from the effects of age, income, and wealth.

My structural approach helps answer two questions. First, what mechanisms explain the difference in divorce rates between the kids-first and other marriages? Second, can economic policies create *successful* marriages? The two questions are closely related: I argue that the higher divorce rates can be rationalized with the kids-first couples having lower marriage quality because kids push some people towards marriage. Understanding this mechanism and quantifying the marriage quality differences with the model is crucial to understanding the distribution of marriages that are created by potential policies. As a starting point, I look at the consequences of pushing more kids-first couples to marry. Then I turn to several practical applications: the role of monetary incentives, child support, and fertility control improvements.

The model is based on a dynamic limited commitment framework (Kocherlakota 1996a; Ligon, Thomas, and Worrall 2000; Marcet and Marimon 2019), in which I endogenize marriage, divorce, and fertility choice. People are heterogeneous with respect to age, labor productivity, and savings. They randomly meet potential matches with different relationship quality. When a couple meets, the decision power is determined by symmetric Nash Bargaining. The relationship quality — match-specific utility gain on top of the economic gains — is a crucial factor affecting people's decisions to marry. It evolves over time, hit by stochastic "love shocks". Spouses cannot commit not to divorce, so all their choices of consumption, savings, labor force participation and fertility are subject to the participation constraints determined dynamically based on their option to divorce and possibly find new partners. Married childless couples endogenously decide on their fertility timing; children bring utility and require both money and time.

A main driving force for the marriage timing in the model is random fertility shocks happening to the partners before making their marriage decision.[4] When a potential couple meets, with some chance they have an unplanned child. If this happens, the couple's bargaining is affected: if the partners agree, they become a (kids-first) couple with a child; otherwise, the woman risks becoming a single mother or facing a costly pregnancy abortion, and the man loses access to the child. Relative to the regular situation, in which upon disagreement partners just wait for their new matches, breaking up after a pregnancy generates different selection pattern.

I estimate the model parameters using a simulated method of moments, matching the established data evidence to the quantities in the simulated data. The parameters I estimate are the preference for children, household technology features, and the transition probabilities. I match several sets of moments. The most important estimation goal is the percentage of divorced women by different durations of marriage in the kids-first and the marriage-first group. I also include the share of never-married and divorced with and without kids at each age, the percentage of couples having children at each marriage duration, and several other targets. To account for the education gradient flexibly, I perform two separate estimations on two subgroups — college graduates and high school graduates. The model fits very well in both subgroups. Estimating the model twice also allows me to assess the robustness of qualitative results and obtain (informal) bounds for quantitative conclusions.

The estimated threshold for acceptable relationship quality falls following the shock, leading to the creation of marriages that would not happen without an unplanned pregnancy. These marriages have the highest risk of divorce. Most importantly, following an unexpected pregnancy the woman's outside option drops: many women do not want

[4] According to Finer and Zolna 2016, nearly 45% of pregnancies in the US in 2008–2011 are unintended, and the highest incidence of unintended pregnancies is among unmarried cohabiting couples. The calculations combine administrative data on births with abortion surveys and NSFG. Unintended here refers to mistimed ("wanted later") or unwanted.

to raise the child on their own unless they are highly productive or have considerable savings.

Because of the drop in the agreement threshold, more than a half of college and around one-third of high-school kids-first couples in the model marry *because* they had a pregnancy. Two factors: imperfect fertility control and social stigma against unmarried parenting — explain more than two-thirds of the kids-first couples' excess divorces. For the high school graduates the relative importance of these factors is roughly equal, and for the college social stigma matters around twice less.

What are the effects of marriage promotion? In the model, the social stigma against unmarried parenting is an internal way society pushes the kids-first people towards marriage. More pushing immediately translates to higher divorce rates of newly created couples, eventually increasing the number of women who are single mothers. It also decreases the model's notion of a child's consumption. Finally, more pushing is strictly welfare decreasing. Men always lose from it, women can have small benefits depending on the methodology, but these benefits are minor relative to men's losses. In addition, the marriage decisions in the model respond very little to monetary incentives. If policy-makers want to subsidize couples to make people marry more, making one percent more people married at the age of 30 requires a four to six percent increase in couples' median annual resources. This result suggests that stimulating marriage by policies is not only inefficient but is also hard to achieve.

Furthermore, the model provides a way to look at post-marital policies like child support. Quantitatively, child support is welfare improving: men lose less than women gain. However, it comes with side effects: it increases the share of single mothers in the economy by making couples divorce more and singles to abort pregnancies less often. Consequently, the average consumption of a median child born in the economy decreases, so the model implies that child support does not necessarily benefit children.

The most obvious way to create better marriages in the model is to give people better control over their fertility and to eliminate the pressure to marry following a pregnancy. Both measures are welfare-improving for men, women, and children and reduce the count of single mothers in the economy and the divorce rates. Together they produce welfare benefits as large as multiple years of labor earnings, especially for the less educated. Quantitatively, for both genders and both education groups, the risk of unplanned pregnancy has the monetary equivalent of 1.5 to 3 times median annual labor earnings at 30, where the upper bound is for the high school males.

My paper contributes to the literature in four ways. First, I am the first to document a strong and robust underperformance of kids-first marriages in modern US data. Second, I am the first to estimate a lifecycle model featuring the interaction of limited commitment with a fertility choice, which is central in the model. Third, I am the first to study the interaction of creation and dissolution of shotgun marriages from a public policy perspective, which previously have been considered in isolation while being importantly related as two sources of formation of single-parent families. Fourth, I am the first to consider the welfare consequences of marriage-promoting policies within the family economics literature.

I am not the first to study shotgun marriages in the literature. A seminal piece of research is Akerlof, Yellen, and Katz (1996). They interpret shotgun marriage as commitment technology to access premarital sex and argue that contraception and abortion technologies lead to this practice's disappearance. Although the nature of the shotgun marriage likely changed over time, the data confirm that midpregnancy marriage is still relatively common, see footnote 2. Further, welfare expansion (Neal 2004) and the stock of potential partners (Chiappori and Oreffice 2008) were argued to influence women's decision to enter marriages following pregnancies. However, all these models are mostly of illustrative purposes. In contrast to this, my model is quantitative, it is capable of delivering policy counterfactuals and welfare implications.

Empirically, Alesina and Giuliano (2006) have shown that easier divorce increased the number of shotgun marriages created, and Tannenbaum (2020) and Rossin-Slater (2017) have shown that stricter child support enforcement reduces pregnancy-related marriages. These findings are consistent with the story that shotgun marriage is a device to obtain the required commitment and resources for childbearing. However, they focus on the angle of the creation of shotgun marriages rather than on understanding their dynamics. Two related papers — **?**) and Brown, Flinn, and Mullins (2011) — explore the impact of child support and alimony payments on the dynamics of divorce using models, yet they abstract from marriage creation. My work combines both of these lines of literature: I study both creation and dissolution, which results in non-trivial interaction through the selection of marriage quality. Another related paper is Kennes and Knowles (2015): they consider how exogenous changes in divorce rates affected decisions to become a single mother or to enter a shotgun marriage; my focus is different as I explicitly model the divorce rates.

From the model perspective, my work is within a growing branch of literature of lifecycle models of marriage and divorce, pioneered by Mazzocco (2007), and Voena (2015). Notable recent examples include Low et al. (2018), Shephard (2019) and Blasutto (2020). The context of fertility choice within lifecycle models without divorce was studied by Sommer (2016), and Ejrnæs and Jørgensen (2020), among others. Finally, the model broadly contributes to the literature understanding the value of marriage, which has been discussed since the work of Becker (1981). Modern studies emphasize roles of risk-sharing (Lise and Yamada 2019), the general comparative advantage of being a couple (Chiappori 1997), and shared production of public good (Greenwood et al. 2016). My work here primarily focuses on the last one: children are the crucial part of the value created within a couple and therefore are first-order issues in how couples form.

The rest of the paper is organized in the following way. First, I document the behavior of kids-first marriages empirically in Section 2. I discuss and present a theoretical model in Section 3. Section 4 presents the details of the solution and estimation. Section 5 presents the the model fit and the estimation results. Section 6 provides a series of results aiming to understand the causes and implications of the differences in divorce rates. Section 7 presents and discusses marriage promotion counterfactuals. Section 8 concludes.

1.2 Empirical Patterns

Before presenting a model, I summarize the main results of the incidence and presence of shotgun marriage. This section does not aim to establish causality, and yet I attempt to argue that there is no obvious explanation in the data for the reasons why relative timing matters. First, using ACS as the primary data source, I show the main result of marriage performance for kids-first and marriage-first couples. Second, I confirm that it holds on large subsamples of the data. Whether I pick older or younger or more or less educated, I still get a persistent difference, although its magnitude varies. Relatedly, I show that controlling for many variables influencing the share of divorced does not invalidate the result. Third, using a supplementary sample from SIPP data, I argue that the fact the in the primary dataset marriage and fertility history cannot be recovered perfectly is not likely to drive the conclusions. Finally, I demonstrate that with my definitions majority of kids-first couples have their own children as opposed to being a result of single mothers finding a new partner, though the fact of having the own children does not seem to play a huge role.

I mainly use the American Community Survey (ACS) samples of 2009–2017 for the main empirical exercise and the model estimation. Its advantage is large sample sizes with very precise household data: it can deliver very detailed partitions of the data, like focusing only on people surveyed a certain number of years after their marriage. Its primary disadvantage is the incompleteness of the marriage and fertility histories, which I address later.

To classify the couples by fertility timing, I consider the following simple measure:

$$\Delta T = \text{Year of the first birth} - \text{Year of the first marriage} \tag{1.1}$$

assuming both events happened by the time the person is observed. Based on the ΔT I call kids-first (KF) women those who have $\Delta T \leq 0$ and marriage-first (MF) those who have $\Delta T > 0$.

To form the sample for the analysis, I pick 2009–2017 ACS, pick women aged 21–40 at the moment of the survey, exclude those with marital statuses "spouse absent", "widowed" and "separated". The resulting selection is what I refer to as a general population of women. Within this population, I focus on females who are either married or divorced now, have children present in a household, and are married no more than once. Finally, within those, I focus on an 11-year window between the years of marriage and fertility $-5 \leq \Delta T \leq 5$. The first birth year is computed based on the age of the eldest child, so this assumes that the eldest child still resides with the woman.[5] ACS person-specific weights are used in all calculations.

The described restrictions aim to address the imperfections of the ACS data, which is a large-scale cross-sectional household survey. Focusing on women allows capturing divorces more accurately, as children staying with mothers is a default custody allocation in the US. Restricting the age allows focusing on women who are likely to reside with their children. Picking married once is a limitation of the data, as only the year of the most recent marriage is recorded. In Subsection 1.2.1 I argue that these restrictions are not crucial for the empirical result. Finally, picking a window around $\Delta T = 0$ allows

[5]Some cases have the age difference between the mother and the child is above 14, for them the year was treated as missing.

mitigating family arrangements that are likely to have stepchildren and families where the older child has moved out. Appendix **??** shows that result still holds without this restriction, although observations with ΔT outside the window decrease the magnitude of the differences I discuss.

The top part of Table 1.3 illustrates the differences in the divorce between kids-first and marriage-first groups in general, as well as the relative proportion of the kids-first group. To measure the divorce, I focus on shares of divorced women among those ever married. I first use a simple cross-sectional measure, comparing the raw percentages of divorced people in each of the two groups. This measure does not account for duration properly: given ΔT, some couples may be married longer than others at the moment of the survey. Therefore I also present the difference conditional on particular durations. The table shows the results conditional on being 5 or 10 years after the marriage; the large sample size allows doing this. Surprisingly, this conditioning does not change the difference substantially. Further, the bottom part of the table illustrates the heterogeneity by partitioning people on education groups and comparing women with earlier and later births.

Few patterns are worth noting. First, people in the kids-first group systematically have higher divorce rates. Second, this difference is more pronounced for college graduates, despite the smaller yet sizable share of the kids-first group for them: with comparable absolute difference marriage-first group is relatively much more stable. Third, although very related to the previous one, the difference is more visible for women who give birth later rather than earlier. Fourth, heterogeneity in shares of kids-first and shares of divorced by subgroups suggests that composition is an essential factor.

As the divorced rates are heterogeneous within the population, the ratio of shares of divorced is more informative than the difference. In particular, the table suggests that the divorce rate for kids-first high school graduates is 1.4 times higher than for the

Table 1.1: Share of divorced among kids-first and marriage-first, ACS

	share of divorced if ...		
	marriage-first	kids-first	(share of kids-first)
All sample			
Cross-sectional share of divorced	9.9	18.1	(26.1)
Divorced 5 years after marriage	5.1	14.3	(24.6)
Divorced 10 year after marriage	10.4	22.8	(24.4)
Cross-sectional share of divorced for subsamples			
High school only	12.8	17.3	(37.0)
Some college	14.3	21.0	(31.3)
College or more	5.3	14.8	(11.9)
First birth before 25	15.5	19.9	(41.8)
First birth at 25 or later	6.2	10.9	(10.7)

Notes. This is American Community Survey data, 2009–2017. The numbers are percentages. Two left columns show the percentage of divorced conditional on being in a marriage-first or kids-first group, respectively. The right column shows the relative proportion of kids-first in those who belong to either group. Kids-first refers to women who have their first child before or at the year of marriage, marriage first to those who have their first child at least in the following year. Everything is conditional on being married once and having children at home; see the text for precise definitions.

marriage-first, and this ratio is 2.8 for college graduates.

Table 1.2 uses a flexible linear regression to control for the composition. The specification is

$$\text{Divorced}_i = \Delta \cdot \text{KF}_i + \gamma \cdot X_i + \varepsilon_i$$

where X_i represents possible controls. Raw difference in the divorce rate corresponds to $\hat{\Delta}$ when X_i contains only constant.

I employ three sets of controls: individual characteristics include dummy variables age and education interacted, as well as race, fixed effects of state, belonging to a metropolitan area and survey year. Duration controls include dummies for all interactions of age with age of the first marriage and age of the first birth. Finally, income controls are a third degree polynomial of log income on a subsample of women who are employed, have non-missing income data, work at least 10 hours per week, and report labor earnings more than $3000 a year. To supplement this result, I present a matching estimator based on a propensity score, which is an implied probability of being in the kids-first group predicted by the same controls (excluding duration controls, as predicting the treatment perfectly by definition).

These regression results are subject to an important limitation: as kids-first and marriage-first couples differ in their marriage and birth timing, the common support is violated — it is not possible to pick people from two groups with identical timing. This motivates exclusion of duration when predicting propensity score, and this also generally hurts the statistical interpretation of all the differences in divorce. Nevertheless, its large magnitude and robustness do suggest that this is not solely an artifact of the data structure.

Table 1.2: Difference in share of divorced, regression and matching

Regression equation: $\text{Divorced}_i = \Delta \cdot \text{kids-first}_i + \text{Controls}_i + \varepsilon_i$

	Estimates		
	Difference (Δ)	(standard error)	Ratio $= \frac{\text{div if KF}}{\text{div if MF}}$
All sample, regression			
No controls (raw difference)	8.2	(0.1)	1.83
Demographic controls	5.7	(0.1)	1.58
Duration controls	5.8	(0.2)	1.59
Demographic + duration	4.8	(0.2)	1.48
Demographic + duration + income	4.1	(0.3)	1.41
All sample, propensity score matching			
Demographic controls	5.0	(0.3)	1.50
Demographic controls + income	4.9	(0.2)	1.49

Notes. This is American Community Survey data, 2009–2017. The numbers are regression estimates in percents. Δ corresponds to the difference in share of divorced between kids first and marriage first. Ratio is the ratio of the percentages of divorced between kids-first and marriage first, in a context of regression it is defined as $1 + \frac{\hat{\Delta}}{\text{div if MF}}$. Regression with income controls is for subsample of those whose income data is non-missing and of good quality, see the text for precise definitions. Propensity score matching is done using default Stata `psmatch2` options, interactions of the controls were not included due to computational reasons.

This evidence suggests that although composition plays a role, regardless of observable characteristics kids-first women are divorced more often than marriage first. Marriage duration and demographics only explains less than half of these differences.

The following subsections and Appendix **??** provide few extra checks and additional insights. Shortly, using more detailed and more complete data does not change the patterns I discuss here.

1.2.1 Full Marital History (SIPP)

This section provides further evidence using Survey of Income and Program Participation data, Wave 2014. The main distinguishing feature is the concrete recording of the year of the first marriage and the age of the first birth for every woman. This allows for relaxing two sampling restrictions: conditioning on women ever married instead of married once (counting remarried) and correctly counting women with non-residential children (including women older than 40). In the dimensions excluding those two things, the methodology is identical, including the use of ± 5 year window for ΔT.

1.2.2 Finer Partitions of the Data

This part supplements the main result by digging deeper into the composition of the kids-first group. Shortly, regardless of who is considered, the qualitative findings that kids-first people have higher divorce rates hold, although quantitatively, it may differ quite a lot.

1.2.2.1 Partition by Relative Timing (ACS)

In the main exercise people with $\Delta T \leq 0$ were pooled together. This part aims to see how people with $\Delta T = 0$ (fertility at the marriage year) and $\Delta T < 0$ (fertility before marriage) are different. Table 1.4 shows the first set of results, redoing the comparison with and

Table 1.3: Share of divorced among kids-first and marriage-first, SIPP

	share of divorced if ...		
	marriage-first	kids-first	(share of kids-first)
All sample, cross-sectional shares			
Ever divorced	34.4	48.0	(21.0)
Divorced if married once	12.4	19.3	
Remarried	22.0	28.7	
Cross-sectional share of ever divorced for subsamples			
High school only	37.5	46.3	(26.4)
Some college	41.6	52.0	(22.0)
College or more	24.6	45.8	(12.7)
First birth before 25	45.1	53.1	(28.2)
First birth at 25 or later	20.7	23.4	(9.4)

Notes. This is Survey of Income and Program Participation data, the cross-section of Wave 1, 2014. The numbers are percentages. Two left columns show the percentage of divorced conditional on being in a marriage-first or kids-first group, respectively. The right column shows the relative proportion of kids-first in those who belong to either group. Kids-first refers to women who have their first child before or at the year of marriage, marriage first to those who have their first child at least in the following year.

without controls. It shows that regardless of controlling strategy, women who have kids at the very year of marriage have somewhat higher divorce rates than those who married in the following years, although all of them divorce more than marriage-first women.

Finally, I show the graphs with the percentages of divorced 5 years after marriage for each ΔT on Figure 1.1. The graph shows that $\Delta T = 0$ generally has the highest share of divorced. The largest difference is between people with $\Delta T = 0$ and $\Delta T \in \{2, 3, 4\}$, and it drives most of the result, where for other points the difference is less striking or even reversed, although their weight (indicated by height of the bars) is lower, and therefore they do not overturn the main result.

Table 1.4: Difference in share of divorced, by different ΔT

Regression equation: $\text{Divorced}_i = \Delta_0 \cdot \mathbb{I}[\Delta T = 0] + \Delta_< \cdot \mathbb{I}[\Delta T < 0] + \text{Controls}_i + \varepsilon_i$

	Estimates	
	Kids-first, at (Δ_0)	Kids-first, before ($\Delta_<$)
No controls (raw difference)	8.6	8.0
Demographic controls	6.8	5.2
Duration controls	6.2	5.1
Demographic + duration	5.2	3.9
Demographic + duration + income	5.0	2.3

Notes. ACS, 2009–2017. The numbers are regression estimates in percents. The estimates indicate the difference in share of divorced relative to the marriage-first women

1.2.2.2 Multi-Partner Women (SIPP)

Although the use of ± 5 years window is dedicated to reducing the concern of people having stepchildren, it does not eliminate it entirely. Within the kids-first group, one may desire to consider women marrying the father of her first child and women marrying someone else than the child father separately. An essential issue of most of the surveys is that relation of the male to the child is clear if the male is present in the household, but once the couple divorces and the male is not present, only a few sources provide information on the retrospective relationship. This issue is impossible to overcome directly in ACS; however, it is possible to handle using SIPP.

For a subsample of women having more than one child, SIPP asks the question about having children from multiple partners. Therefore I introduce a partition on three groups. Marriage-first women are those having $\Delta T > 0$ as before. Kids-first-own are those with $\Delta T \leq 0$ who (1) do not report to have multi-partner fertility, and (2) have had children born both before and after their first marriage. Kids-first-other are those who do not meet these criteria. In the data, more than three-quarters of this group do report multipartner fertility. Because of the nature of the multipartner fertility questions, I also exclude women who are married more than once: most of them are likely to be misclassified to

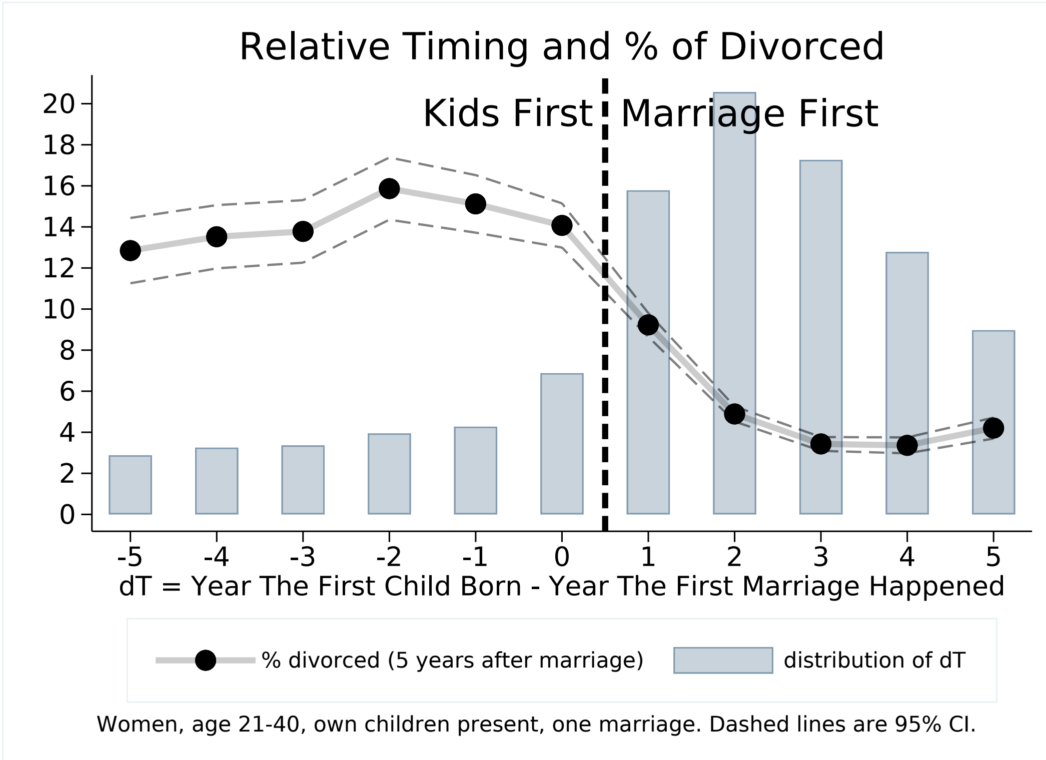


Figure 1.1: Share of divorced in 5 years by relative timing of marriage and fertility.

the "other" group. To repeat the strategy from the ACS part, I also restrict attention to women 40 or younger: as many people remarry later, the attrition will introduce bias considering solely women married once.

Table 1.5 shows the distribution of the females 21–40 and older conditional on having more than one child and being married once by the three groups, as well as share of divorced in each of them. Three important conclusions are (1) the majority of the kids-first group seem to have their own children, (2) the percentage of divorced is higher for both subgroups of kids-first, (3) people with multipartner fertility have higher divorce rates, but their share is relatively smaller.

Table 1.5: Finer partition of kids-first, SIPP

	share in sample	share of divorced
Women 21–40, 1 marriage, 2+ children		
Marriage-first	72.1	10.5
Kids-first-own	16.4	14.6
Kids-first-other	11.4	27.2

Notes. This is Survey of Income and Program Participation data, cross-section of Wave 1, 2014. The numbers are percentages. Kids-first-own is a subset of kids-first for which it is verifiable that woman married a father of the first child, kids-first-other includes all other cases.

1.3 Model

There is a number of well-established features for the models of individual agents' lifecycle that reproduce desirable properties of the microdata, the dynamics of couples is explored relatively less. Moreover, endogenous transitions between singleness and marriage and back require these options to be comparable, and the model of collective household with endogenous decision weight is intended to achieve this.

The transitions are based on total values of being in a particular state, so some features of the model (like one-dimensional income process and no state for child's human capital) are simplistic relative to the modern literature and are modeled in a somewhat reduced form. Three features of the model are crucial. First, the marriage market has to be rich to capture how spouses are selected against particular partners. Second, intrahousehold utility should capture the value of marriage and the possible presence of couples with and without children, so the value of fertility is well-understood. Third, the remarriage market has to be realistic: it should both be related to the primary marriage market and reflect the difficulties in finding partners after a divorce.

The economy consists of women and men, who both start their life single and childless at time $t = 1$. It corresponds to the age of 21 for women and the age of 23 for men. Single and childless people without kids work full-time. In each period, with some probability p_t^{meet} singles meet a random partner, coming from a fixed distribution of singles of the opposite gender.

People are heterogeneous with respect to their age t, labor productivity, z, and savings (assets) a. Couples have two additional dimensions: a common marriage quality ψ, that is enjoyed by both partners, and decision weight θ, which reflects the relative decision power of the woman in the couple (Pareto weight). Finally, singles and couples can have up to one child, which stays with them forever, brings value and childbearing costs. If a couple breaks up, child custody is always assigned to the mother.

Therefore, in total, there are five types of agents: a single woman (f), a single man (m), a single woman with a child (single mother henceforth) (fk), a couple without children (c), a couple with a child (ck). Single fathers can be defined analogously, but are outside of the baseline consideration.

The marriage market is central to the creation of shotgun marriages. It is modeled through random shocks to the matches: when two potential partners meet, with some probability, an unplanned pregnancy happens and interferes with their decisions to marry each other. If the pregnancy does not happen, upon disagreement two partners keep being single and meeting other people. If the pregnancy does happen, then upon disagreement woman either stays a single mother or carries costly abortion. Abortion access is imperfect: with probability $1 - p^a$ woman gets no access to abortion (note that this also captures a share of women who got their babies born before the marriage decision), and with probability p^a she can choose to have an abortion with utility costs ϕ_a. It is assumed that women do not know the realization of the abortion costs at the moment of marriage decision. This assumption both justifies friction in decision making (marriage decisions are not immediate, and abortion decisions have to be made quickly) and slightly economizes on computations. If potential partners get a pregnancy shock, the child support may also be paid; this is discussed later in A.2.2. Figure 1.2 summarizes the discussed transitions.

There are several aspects that I have to abstract from in my modeling choices. First, I do not model unmarried cohabitation. It is not a common family arrangement in the US: as documented by Payne (2013), only about 3% of children live in unions with unmarried cohabitating parents, as opposed to 21% living with single mothers. The transition from cohabitation to marriage is an understudied area. We explore it outside of the fertility context in **?**), and combining fertility and cohabitation choices complicates the model's setup and identification. Second, given the substantial amount of heterogeneity, the model abstracts from the marriage market in a classic sense: agents meet potential partners from an exogenous distribution of available singles. Third, for the same reasons, I also abstract from modeling the number of children: all childbearing couples are treated identically.

The rest of this section summarizes the decision problems and the agents' value functions, starting from couples to singles. Then it discusses the described marriage market formally, finally it covers divorce and other essential features.

1.3.1 Couple and Child

Let $V_t^{f,ck}$ and $V_t^{m,ck}$ represent the values of male and female of being in a couple with a child conditional on staying together in period t, and $V_t^{f,dk}$, $V_t^{m,dk}$ represent the value of divorce of such a couple. This section describes their recursive definition, starting from value 0 in the last period.

The couple enters the period with savings a, bringing gross return $R \cdot a$, productivities z^m and z^f, love shock ψ and decision weights $\theta' = (\theta^f, \theta^m)$. Productivities, together with age, determine female and male wages $W_t^f(z^f)$, $W_t^m(z^m)$. The couple gets utility from spouses' consumption and the child's consumption; part of the latter can be produced at

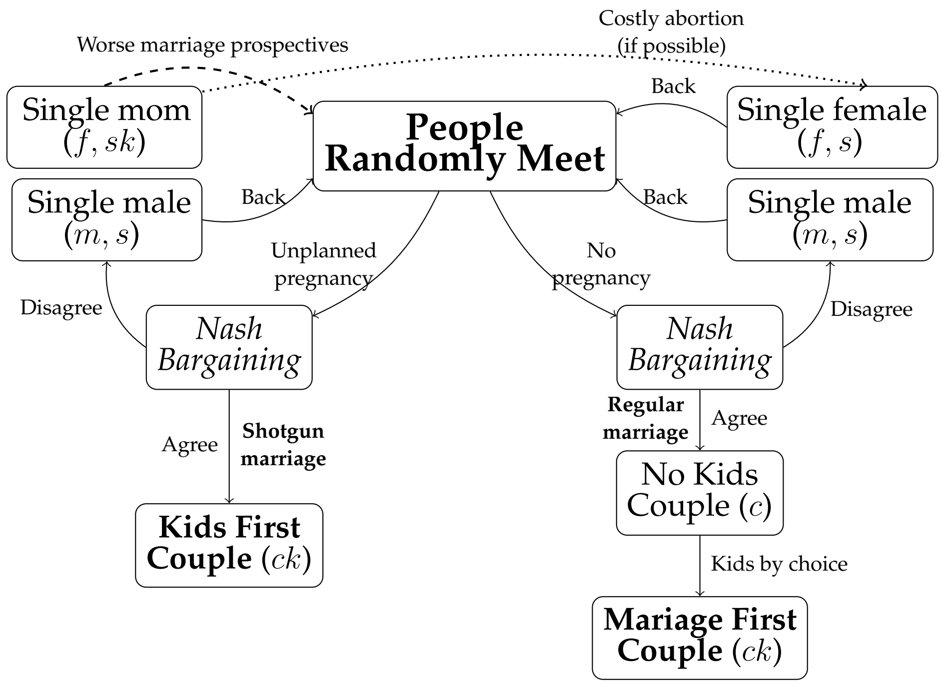


Figure 1.2: Transitions around the marriage market.

home by reducing the female labor supply. The love shock represents an additive utility surplus of being together.

Conditional on staying together in the period t, the choice of the couple are spouses' consumption c^f, c^m, expenditures on the child x, female labor supply l^f and savings a'. I summarize the "exogenous" state by $\omega = (z^m, z^f, \psi)$. After making the decisions, the couple transitions to the next period $t+1$ and gets a draw of ω'. Given a' and ω' it chooses whether to divorce, which is represented by a binary indicator $d_{t+1}(a', \omega')$. If it does not, it enters the next period with the decision weights $\theta' = \theta'(a', \omega', \theta)$, evolution of which is determined by renegotiation; otherwise the couple divorces.[6]

The couple's decisions are defined by the following optimization problem and the contin-

[6]Note that the conditioning on staying together allows us to omit the participation constraints from the problem representation, as they are implicitly enforced at the interim stage: prior to entering the period, the couple decides whether to stay together or divorce (chooses d_{t+1}). Therefore, potential violation of the next period's participation constraints is expressed through the divorce terms and dynamics of θ.

uation values:

$$(\tilde{a}', \tilde{c}^f, \tilde{c}^m, \tilde{x}, \tilde{l}^f) = \underset{a', c^f, c^m, x, l^f}{\arg\max} \left\{ \theta^f \cdot u(c^f) + \theta^m \cdot u(c^m) + \psi + \phi(q) + \beta \cdot \mathbb{E}_{\omega'|(l^f,\omega)} \mathcal{V}_{t+1}^{ck} \right\} \quad (1.2)$$

$$\begin{aligned}
\text{s.t.} \quad & a' + c + x = R \cdot a + W_t^m(z^f) + l_f \cdot W_t^f(z^m) && \text{(evolution of joint assets)}, \\
& c = C(c^f, c^m) && \text{(increasing returns in consumption)}, \\
& q = f(x, l^f) \geq \underline{q} && \text{(required costs of childcare)},
\end{aligned}$$

$$\begin{aligned}
\text{where} \quad \mathcal{V}_{t+1}^{ck} = & (1 - d_{t+1}) \cdot \left[\theta^f \cdot V_{t+1}^{f,ck}(a', \omega', \theta') + \theta^m \cdot V_{t+1}^{m,ck}(a', \omega', \theta') \right] && \text{(no divorce)}, \\
& + d_{t+1} \cdot \left[\theta^f \cdot V_{t+1}^{f,dk}(a', \omega', \theta') + \theta^m \cdot V_{t+1}^{m,dk}(a', \omega', \theta') \right] && \text{(divorce)}.
\end{aligned}$$

Note that the decisions are homogeneous of degree 0 with respect to θ, which allows assuming $\theta^f + \theta^m = 1$. The corresponding individual continuation values are:

$$\begin{aligned}
V_t^{f,ck}(a, \omega, \theta) = & \, u(\tilde{c}^f) + \psi + \phi(\tilde{q}) + \qquad (1.3) \\
& \beta \cdot \mathbb{E}_{\omega'|(l^f,\omega)} \left\{ (1 - d_{t+1}) \cdot V_{t+1}^{f,ck}(a', \omega', \theta') + d_{t+1} \cdot V_{t+1}^{f,dk}(a', \omega', \theta') \right\}, \\
V_t^{m,ck}(a, \omega, \theta) = & \, u(\tilde{c}^m) + \psi + \phi(\tilde{q}) + \qquad (1.4) \\
& \beta \cdot \mathbb{E}_{\omega'|(l^f,\omega)} \left\{ (1 - d_{t+1}) \cdot V_{t+1}^{m,ck}(a', \omega', \theta') + d_{t+1} \cdot V_{t+1}^{m,dk}(a', \omega', \theta') \right\}.
\end{aligned}$$

The divorce decision and the law of motion for θ are defined in Section 1.3.7. The divorce values $V^{\cdot,dk}$, and the child support assignment are given in Section A.2.2.

The transition for female productivity includes possible skill depreciation, which depends on the female labor supply's value l^f. Therefore the expectation operator is $\mathbb{E}_{\omega'|(l^f,\omega)}$. The transition laws are discussed in 1.3.5.

1.3.2 Childless Couple

Childless married couples have both partners working full-time. They enjoy the match quality stock ψ, and choose their consumption and savings. A childless couple may try to conceive a child. This decision precedes all consumption-savings decisions and happens after realizing the shocks and renegotiation, conditional on staying together at this period. The conception decision at the beginning of the following period is denoted by k_{t+1}. The decision problem is otherwise similar to those of a couple with a child:

$$(\tilde{a}', \tilde{c}^f, \tilde{c}^m) = \underset{a', c^f, c^m}{\arg\max} \left\{ \theta^f \cdot u(c^f) + \theta^m \cdot u(c^m) + \psi + \beta \cdot \mathbb{E}_{\omega'|\omega} \mathcal{V}^c_{t+1} \right\} \tag{1.5}$$

$$\begin{aligned} \text{s.t.}\quad & a' + c = R \cdot a + W^m_t(z^f) + W^f_t(z^m) && \text{(evolution of joint assets)}, \\ & c = C(c^f, c^m) && \text{(increasing returns in consumption)}, \end{aligned}$$

where $\mathcal{V}^c_{t+1} =$

$$\begin{aligned} & (1 - d_{t+1}) \cdot (1 - k_{t+1}) \cdot \left[\theta^f \cdot V^{f,c}_{t+1}(a', \omega', \theta') + \theta^m \cdot V^{m,c}_{t+1}(a', \omega', \theta') \right] && \text{(no divorce, no birth)}, \\ & (1 - d_{t+1}) \cdot k_{t+1} \cdot \left[\theta^f \cdot V^{f,c\tilde{k}}_{t+1}(a', \omega', \theta') + \theta^m \cdot V^{m,c\tilde{k}}_{t+1}(a', \omega', \theta') \right] && \text{(no divorce, try birth)}, \\ & \quad + d_{t+1} \cdot \left[\theta^f \cdot V^{f,d}_{t+1}(a', \omega', \theta') + \theta^m \cdot V^{m,d}_{t+1}(a', \omega', \theta') \right] && \text{(divorce)}. \end{aligned}$$

I assume childbearing itself to be costless, but its success is random and uncertain. p^{success}_t is assumed to be age-specific. Therefore, for a fertile couple, the value of trying to conceive a child is

$$V^{j,c\tilde{k}}_{t+1}(a', \omega', \theta') = p^{\text{success}}_t \cdot V^{j,ck}_{t+1}(a', \omega', \theta') + (1 - p^{\text{success}}_t) \cdot V^{j,c}_{t+1}(a', \omega', \theta'), \;\; j \in \{f, m\} \tag{1.6}$$

The decision to conceive is based on a weighted value function *after* the renegotiation (weighted with the next period's weights). Define the couple's weighted values as

$$V^{fm,c\tilde{k}}(a',\omega',\theta') = \theta^{f\prime} \cdot V^{f,c\tilde{k}}_{t+1}(a',\omega',\theta') + \theta^{m\prime} \cdot V^{m,c\tilde{k}}_{t+1}(a',\omega',\theta'),$$

$$V^{fm,c}(a',\omega',\theta') = \theta^{f\prime} \cdot V^{f,c}_{t+1}(a',\omega',\theta') + \theta^{m\prime} \cdot V^{m,c}_{t+1}(a',\omega',\theta'),$$

and the decision to (try to) give a birth is then

$$k_{t+1}(a',\omega',\theta') = \mathbb{I}\left[V^{fm,c\tilde{k}}(a',\omega',\theta') \geq V^{fm,c}(a',\omega',\theta')\right]. \tag{1.7}$$

There are two important remarks here. First, the value function $V^{fm,\cdot}$ is different from the weighted value function used in the couple's problem in the definition of $\mathcal{V}_{t+1}$ because of the timing of the decisions. This weighting is an artifact of the timing, and it makes decisions consistent with the broader limited commitment framework, dynamic aspects of which are discussed in Marcet and Marimon (2019). From a practice view, this formulation preserves homotheticity. However, it prevents writing the weighted terms as one value function, as they depend on a mixture of the current and expected future decision weights.[7]

1.3.3 Single Women and Men

Each period single people may meet one potential partner with probability p^{meet}. The partners differ with assets and productivities (a, z), and each match additionally receives a draw of initial marriage quality ψ, on top of this, with some chances men meet single mothers. The details of the partners market are described in 1.3.6, right

[7]For a straightforward example, imagine that almost all bargaining weight belongs to the wife in a couple in the current period. Let $(\theta^f, \theta^m) = (1, \varepsilon)$ for some small ε. Suppose also that starting from the next period with certainty and forever $(\theta^f, \theta^m) = (\varepsilon, 1)$. This situation has very low expected value for the wife, and it needs to be assessed accordingly, with decision weights reflecting the current state. Otherwise, the husband's future benefits are counted in the value function that now mostly reflects the utility of the wife.

now we just denote the distribution of characteristics of the potential future matches by $\Gamma^M = \Gamma_{t+1}(a^M, z^M, \psi^M)$, and corresponding marriage decision $m^M = m_{t+1}(a^M, z^M, \psi^M)$ and resulting bargaining weight $\theta^M = \theta_{t+1}(a^M, z^M, \psi^M)$. So let $d\Gamma^M$ denotes the density of the matches with specified characteristics, and ω^M denotes future couple's exogenous state.

As I discuss above, there is a chance of p^{preg} that an unplanned pregnancy happens when a potential couple meets. Given a match, the resulting marriage decision m and the resulting bargaining weight θ may depend on pregnancy status, so I denote them $m^{m,p}$, $\theta^{m,p}$ when pregnancy happens and $m^{m,np}$, $\theta^{m,np}$ when it does not.

If unplanned pregnancy does not happen and woman agrees to marry, she enters a childless couple, that can later have a child and become a marriage-first couple. In unplanned pregnancy does happen and woman agrees, she enters a couple with a child, that is classified as a kids-first couple.

In case of unplanned pregnancy both partners face social stigma ϕ_s, that is expressed as a disutility of refusing to marry following an unplanned pregnancy.

Additionally, if woman refuses to marry she faces uncertain access to costly abortion: with a chance of p^a she may choose to be a single mother or to abort the pregnancy with utility costs ϕ_a, a chance of $1 - p^a$ she stays a single mother. At the moment of marriage decision the realization of the abortion access is unknown.

Finally, the woman who refuse to enter the marriage following a pregnancy and kept the pregnancy may be awarded a child support. This happens with probability $p^{cs,n}$. Realization of the child support access happens after the pregnancy access and is uncertain at the moment of abortion decision, and the value of the child support is specific to the characteristics of the partner and the woman, as discussed in A.2.2.

Therefore woman who rejects a proposal gets the following expected value:

$$V_t^{f,sk?}(a,z^f) = p^a \cdot \max\left\{\mathbb{E}_{cs} V^{f,sk}(a,z^f), V_t^{f,s}(a,z^f) - \phi_a\right\} + (1-p^a)\cdot V_t^{f,sk}(a,z^f). \quad (1.8)$$

where

$$\mathbb{E}_{cs} V^{f,sk}(a,z^f) = p^{cs,n}\cdot V_t^{f,sk}(a,z^f + CS^m) + (1-p^{cs,n})\cdot V_t^{f,sk}(a,z^f). \quad (1.9)$$

The child support is match-specific, so this abuses the notation slightly.

Apart from the meeting of partners and pregnancies, the problem of the singles is a standard consumption-savings problem. Starting with single females:

$$\begin{aligned}
V_t^{f,s}(a,z^f) = \max_{a',c^f} \Bigg\{ \; & u(c^f) + && (1.10)\\
\beta\cdot\mathbb{E}_{z^{f\prime}|z^f}\Bigg(& (1-p_t^{\text{meet}})\cdot V^{f,s}(a',z^{f\prime}) + && \text{(no partner met)}\\
p_t^{\text{meet}}\cdot(1-p_t^{\text{preg}})\cdot \int & \Big[m^{M,np}\cdot V_{t+1}^{f,c}(a'+a^M,\omega^M,\theta^{M,np}) + && \text{(met, no pregnancy, agree)}\\
& (1-m^{M,np})\cdot V_{t+1}^{f,s}(a',z^{f\prime})\Big] d\Gamma^M + && \text{(disagree)}\\
p_t^{\text{meet}}\cdot p_t^{\text{preg}}\cdot \int & \Big[m^{M,p}\cdot V_{t+1}^{f,ck}(a'+a^M,\omega^M,\theta^{M,p}) + && \text{(met, shotgun marriage)}\\
& (1-m^{M,p})\cdot\left\{V_{t+1}^{f,sk?}(a',z^{f\prime}) - \phi_s\right\}\Big] d\Gamma^M \Bigg)\Bigg\} && \text{(disagree, social stigma)}\\
\text{s.t. } \; a' + c^f = R\cdot a + W_t^f(z^f) & && \text{(evolution of the assets).}
\end{aligned}$$

The decision problem for single males, defining $V_t^{m,s}(a,z^m)$ is described in the Appendix A.2.1.

1.3.4 Single Mothers

Single mothers have sole custody of their children and pay the costs of them fully out of their labor income (that could have been adjusted in a past to account for the child support received). This can partially be done by a reduction in labor supply l^f.

They also have a chance to meet a single male, who has a utility loss ϕ_d from potentially having stepchildren, as shown in A.2. I refer to these losses as a remarriage penalty in the further parts.

The optimization problem and the value function definition therefore is

$$V_t^{f,sk}(a, z^f) = \max_{a', c^f, x, l^f} \Bigg\{ u(c^f) + \phi(q) + \tag{1.11}$$

$$\beta \cdot \mathbb{E}_{z^{f\prime}|(l^f, z^f)} \Bigg((1 - p_t^{\text{meet}}) \cdot V^{f,s}(a', z^{f\prime}) + \qquad \text{(no partner met)}$$

$$p_t^{\text{meet}} \cdot \int \Big[m^{M,sm} \cdot V_{t+1}^{f,ck}(a' + a^M, \omega^M, \theta^{M,np}) + \qquad \text{(met, agree)}$$

$$(1 - m^{M,sm}) \cdot V_{t+1}^{f,sk}(a', z^{f\prime}) \Big] d\Gamma^M \Bigg) \Bigg\} \qquad \text{(disagree)}$$

$$\text{s.t. } a' + c^f + x = R \cdot a + l_f \cdot W_t^f(z^f) \qquad \text{(evolution of the assets),}$$

$$q = f(x, l^f) \geq \underline{q} \qquad \text{(required costs of childcare).}$$

1.3.5 Shocks and Income Trends

I assume that shocks for productivity terms z^f, z^m and love shock ψ follow random walk process. For male productivity and love shocks the laws of motions are:

$$z_{t+1}^m = z_t^m + \varepsilon_{t+1}^{z,m}, \quad \varepsilon_{t+1}^{z,m} \sim \mathcal{N}(0, \sigma_{z,m}^2), \tag{1.12}$$

$$\psi_{t+1} = \psi_t + \varepsilon^{\psi}_{t+1}, \;\; \varepsilon^{z,m}_{t+1} \sim \mathcal{N}(0, \sigma^2_{\psi}). \tag{1.13}$$

The random walk structure with no mean reversion allows to interpret the productivity shocks as components of permanent income, therefore both female skills depreciation and the income reallocation through child support can be interpreted as shifts in z. The law of motion for the female productivity is

$$z^f_{t+1} = z^f_t + \varepsilon^{z,f}_{t+1} - \delta(l^f), \;\; \varepsilon^{z,f}_{t+1} \sim \mathcal{N}(0, \sigma^2_{z,f}), \;\; \delta(1) = 0. \tag{1.14}$$

The model assumes that women without children always have labor supply of 1, and women with children (both single and in couples) can reduce their labor supply as an input to the home production of the child's consumption q.

Finally, the labor earnings are determined by z and age trends using the following expressions:

$$W^f_t(z^f) = \exp(\text{Trend}^f_t + z^f), \;\; W^m_t(z^m) = \exp(\text{Trend}^m_t + z^m). \tag{1.15}$$

1.3.6 Marriage Market

As all the decisions are homogeneous of degree 0 with respect to (θ^f, θ^m), to lighten the notation since this part I assume that $\theta^f = \theta$ and $\theta^m = 1 - \theta$, so in this part θ is a scalar. This also assumes that values of being in a couple, $V^{f,ck}_t$, $V^{m,ck}_t$ are monotonic with respect to θ.[8]

Following Voena (2015), I assume that men always meet women who are two years

[8]Numerical solutions may not exactly obey this monotonicity, but the modification of the conditions is straightforward. One important requirement to such a modification is that if, for example, female participation constraint binds, female bargaining power cannot decrease.

younger, and vice versa, which corresponds to the modal age difference in the US. The rest of the marriage market is as follows.

I assume that productivity of singles of each gender follows some exogenous (non-parametric) distribution over age, $F_t(z)$. Conditional on z, the distribution of log-assets is assumed to be truncated log-normal, namely, I assume that a latent variable is

$$\log a_t^* \sim \mathcal{N}(\mu_t^a(z), (\sigma_t^a(z))^2), \tag{1.16}$$

and the realized actual value of assets is $a = a_t^* \cdot \mathbb{I}(a_t^* \geq \bar{a})$. This defines a distribution of available singles $F_t(z, a)$.[9]

After meeting a potential partner, the couple draws a realization of their match quality ψ from a distribution $\mathcal{N}(\mu_{\psi,0}, \sigma_{\psi,0}^2)$. The realization of this match quality is independent on the qualities of the partner. The match quality together with the potential partner's characteristics define distributions Γ^M that are used in the definitions of the value function.

For women, for instance, this is the distribution $\Gamma_t^f(a^m, z^m, \psi)$, that implies that, if they agree to marry, the couple will have $a = a^m + a^f$ and $\omega = (z^f, z^m, \psi)$. The agreement decision and the resulting bargaining weights are determined using the symmetric Nash Bargaining, there are three types of matches: regular match of childless singles without an unplanned pregnancy (np), match with an unplanned pregnancy (p) and males meeting single mothers (sm).

To lighten the notation, in this section we assume that the potential couple's characteristics $(a^f, a^m, z^f, z^m, \psi)$ are fixed, and therefore the value functions depend solely on θ. The correct represetnation of the matching decision for the match type q will be, however, $m_t^q(a^f, a^m, z^f, z^m, \psi)$, and I shorten this to just m_t^q.

[9]Regardless of characteristics, each individual draws potential partners from this distribution, so the mating is not assortative exogenously. Endogenously, however, people tend to agree more if the partner has similar characteristics, so there is endogenously generated assortativeness.

Case 1: regular match (np). This is the case when two childless singles meet each other and no unplanned pregnancy happens. Upon agreement, the partners become a childless couple and receive the values $V_t^{f,c}(\theta)$ and $V_t^{m,c}(\theta)$. If disagree, they remain singles and receive $V_t^{f,s}$, $V_t^{m,s}$. Therefore the marriage decision is given by

$$m_t^{np} = \mathbb{I}(\Theta_t^{np} \neq \varnothing), \text{ where } \Theta_t^{np} = \left\{\theta \ : \ V_t^{f,c}(\theta) \geq V_t^{f,s}, \ V_t^{m,c}(\theta) \geq V_t^{m,s}\right\},$$

and the initial bargaining weight is defined as

$$\theta_t^{np} = \underset{\theta \in \Theta_t^{np}}{\arg\max} \left[V_t^{f,c}(\theta) - V_t^{f,s}\right] \times \left[V_t^{m,c}(\theta) - V_t^{m,s}\right]. \tag{1.17}$$

Case 2: unplanned pregnancy (p). This is the case when two childless singles meet each other and an unplanned pregnancy happens. There are hree important changes from the last case. First, both partners suffer social stigma ϕ_s, altering their disagreement options. Second, women has a risk of becoming a single mother, and her expected value is described by 1.8. Third, men pay child support and women receive child support, so men's value is also altered with $\mathbb{E}_{csm}$ operator as in A.1.[10] The marriage decision is hence given by

$$m_t^{p} = \mathbb{I}(\Theta_t^{p} \neq \varnothing), \text{ where } \Theta_t^{p} = \left\{\theta \ : \ V_t^{f,ck}(\theta) \geq V_t^{f,sk?} - \phi_s, \ V_t^{m,ck}(\theta) \geq \mathbb{E}_{csm} V_t^{m,s} - \phi_s\right\},$$

and the initial bargaining weight is defined as

$$\theta_t^{p} = \underset{\theta \in \Theta_t^{p}}{\arg\max} \left[V_t^{f,ck}(\theta) - (V_t^{f,sk?} - \phi_s)\right] \times \left[V_t^{m,ck}(\theta) - (\mathbb{E}_{csm} V_t^{m,s} - \phi_s)\right]. \tag{1.18}$$

[10] The timing of this bargaining is a little bit subtle. I assume that the woman cannot commit on whether to keep the pregnancy in case of the man's refusal to marry, and has to re-optimize the decision in this subgame.

Case 3: single mothers match (sm). This is the case when single male meets a woman who already has a child from previous relationships. It is somewhat analogous to the previous case: if the couple agrees to marry, they become couple with a child (kids-first, for the record). However, a conceptual issue is that people generally do not like having stepchildren, and to compensate for this, I introduce a utility penalty to a potential husband ϕ_r, which is paid as a one-time cost in case the male agrees to enter such a marriage. Additionally, as no new children are born, there is no child support assigned in this case. Therefore

$$m_t^{sm} = \mathbb{I}(\Theta_t^{sm} \neq \varnothing), \text{ where } \Theta_t^{sm} = \left\{\theta \ : \ V_t^{f,ck}(\theta) \geq V_t^{f,sk}, \ V_t^{m,ck}(\theta) - \phi_r \geq V_t^{m,s}\right\},$$

and

$$\theta_t^{sm} = \arg\max_{\theta \in \Theta_t^{sm}} \left[V_t^{f,ck}(\theta) - V_t^{f,sk}\right] \times \left[(V_t^{m,ck}(\theta) - \phi_r) - V_t^{m,s}\right]. \tag{1.19}$$

1.3.7 Renegotiation and Divorce Decisions

The divorce decision happens before decisions on consumption, savings and labor supply, value of exogenous state $\omega = (z^f, z^m, \psi)$ is realized and couples has savings a from the previous period. At this moment individuals know their values of staying together and value of divorce. For couples with children, these are $V_t^{f,ck}$, $V_t^{m,ck}$ and $V_t^{f,dk}$ and $V_t^{m,dk}$ respectively.

Given a and ω I define two sets, that represent values of θ that are satisfactory for each partner:

$$\Theta_t^f(a,\omega) = \left\{\tilde{\theta} \ : \ V_t^{f,ck}(a,\omega,\tilde{\theta}) \geq V_t^{f,dk}(a,\omega)\right\},$$

$$\Theta_t^m(a,\omega) = \left\{\tilde{\theta} \ : \ V_t^{m,ck}(a,\omega,\tilde{\theta}) \geq V_t^{m,dk}(a,\omega)\right\}.$$

and their union:

$$\Theta(a,\omega) = \Theta_t^f(a,\omega) \cap \Theta_t^m(a,\omega).$$

The divorce therefore is defined:

$$d_t(a,\omega) = \begin{cases} 1, & \Theta(a,\omega) = \varnothing, \\ 0, & \Theta(a,\omega) \neq \varnothing. \end{cases} \tag{1.20}$$

In case of $d_t = 0$, the evolution of θ is defined through this set. Namely, given θ, and the next period's set $\Theta_{t+1}(a',\omega')$, if $\theta \in \Theta_{t+1}(a',\omega')$ the θ is kept at the same level, otherwise, it adjusts according to which participation constraint binds to ensure the lowest deviation.

To be precise, for a non-empty set one can define $\theta_t^f(a,\omega) = \inf \Theta_t(a,\omega)$ to be the minimal bargaining power such that both participation constraints are satisfied. This corresponds to a point $\tilde{\theta}$ for which female participartion constraint exactly binds $V_t^{f,ck}(a,\omega,\tilde{\theta}) = V_t^{f,dk}(a,\omega)$ and $V_t^{m,ck}(a,\omega,\tilde{\theta}) \geq V_t^{m,dk}(a,\omega)$. In a symmetric manner I define $\theta_t^m(a,\omega) = \sup \Theta_t(a,\omega)$. Then, continuing to assume monotonicity,

$$\theta \in \Theta_t \Leftrightarrow \theta_t^f \leq \theta \leq \theta_t^m,$$

and therefore the transitions for θ are defined through these two functions:

$$\theta'(\theta,a',\omega') = \begin{cases} \theta, & \text{if } \ \theta^{f\prime}(a',\omega') \leq \theta \leq \theta^{m\prime}(a',\omega'), \ \Theta'(a',\omega') \neq \varnothing, \\ \theta^{f\prime}, & \text{if } \ \theta < \theta^{f\prime}(a',\omega'), \ \Theta'(a',\omega') \neq \varnothing, \\ \theta^{m\prime}, & \text{if } \ \theta_t > \theta^{m'}(a',\omega'), \ \Theta'(a',\omega') \neq \varnothing, \\ \varnothing, & \text{if } \ \Theta'(a',\omega') = \varnothing. \end{cases} \tag{1.21}$$

This definition ensures the minimal deviation from the full commitment allocation, in which the bargaining weights are fixed. This maps into the classic limited commitment framework as in Marcet and Marimon (2019) a Lagrange multiplier on a binding participation constraint corresponds to an increase in θ after rescaling, and the rescaling is possible because the decisions are homogeneous of degree zero in the bargaining weights.

1.3.8 Additional Details

Appendix A.2 presents several additional elements of the model. In particular, Section A.2.2 shows how to define value functions in divorce $V_t^{f,d}$ and $V_t^{m,d}$, relating them to the values of singleness, together with the details on child support modeling. Section A.2.3 discusses functional forms and intrahousehold allocation of consumption. Section A.2.4 presents few extra details about retirement and tax schedule.

1.4 Quantification Approach

The model has a great degree of flexibility, which is achieved by a large number of parameters. Some of them can be estimated outside the model and fixed externally, however, there is a number of crucial preference and transition parameters that cannot be inferred directly as they affect many outcomes simultaneously, for them an estimation procedure is needed.

Appendix A.3 discusses how I solve the model using backward iteration. Shortly, all exogenous variables are discretized and represented by Markov processes whenever possible, and GPUs are used to compute things efficiently.

1.4.1 Strategy

To provide more focused evidence and also to facilitate understanding the education differences in the shotgun marriage patterns, I perform estimation on two distinct subsamples: college graduates and high school graduates. As Table 1.3 suggests, the college graduates have substantially larger differences between kids-first and marriage-first couples in terms of divorce, and this difference is mostly expressed in the lower divorce rates for the marriage-first group. This makes comparing two separate instances of the estimated model particularly promising.

This approach is similar to Low et al. (2018), who study welfare utilization and consider only the lower-education subsample. Similar to them, yet slightly unrealistically I assume that college graduates always marry college graduates and high school graduates always marry high school graduates.

I mainly use ACS data as my key empirical results are obtained from there, however, for the purpose of external estimation of things that are not observed in ACS I utilitze SIPP data. Finally, few estimation targets are taken from literature.

1.4.2 Ex-Ante Fixed Parameters

The agents being at age 21 for females (23 for males), retire at 65 (67) with 0.4 of median income as a pension benefits (on top of their savings) and die deterministically at 75 (77), leaving no bequest.

I take $\beta = 0.96$ and $R = 1/\beta$ which is among the standard choices in the lifecycle literature.

For the labor supply side, the drift $\delta(\underline{l})$ is set to 0.09 for college graduates and 0.06 for high school graduates, so woman loses roughly 9% or 6% of her income per 1 year out of labor force. These numbers replicate structural estimates of Adda, Dustmann, and Stevens (2017), despite them being on German data. Blasutto (2020) gets similar numbers through structural estimation of a model similar to this on PSID. Additionally, those out of labor force are assumed to have $\underline{l} = 0.2$ instead of zero, so they still get one-fifth of their regular income. This assumption is mostly for computational reasons, but also reflects heterogeneous potential for home production.

For the preference side, I assume intertemporal elasticity of substitution in consumption to be a standard number $\sigma = 1.5$, and I assume that this elasticity is the same for the child's consumption (equation A.9), so $\phi_1 = \sigma = 1.5$. For the returns to scale within a couple I fix $\rho_c = 0.23$ following Voena (2015), which indicated mildly increasing returns to scale. In the child's quality production function $f(x, l^f)$ the substitutability between money and time is assumed to be high and is set to be $\lambda = 0.7$, as in Sommer (2016).

For the child support enforcement, I assume that the value of the child support assigned corresponds to 20% of male's income, that is considered to be an modal value in the US (see here). For the enforcement strengths, I assume that $p^{a,nm} = 0.284$ of never married women and $p^{a,nm} = 0.461$ of divorced women get child support, these numbers correspond to the statistical share of eligible mothers receiving the child support in 2011 (Grall 2013).

For the success in a child's conception I use the following success probabilities: 86% at 21–24, 78% at 25–29, 63% at 30–34 and 52% at 35–40 (Rosenthal 2002). These numbers reflect chances of women to get pregnant within a year if using no birth control. More modern Kennes and Knowles (2015) use somewhat higher chances, but they model infertility and have taste shocks that may prevernt childbearing, so I pick the lower values to balance this. I assume that infertility is deterministic at starts at 41.

At the beginning of the life 2% of college graduate women and 20% of high-school graduate women have kids. I assume that by the age of 21 nobody is married, which is counterfactual, but does not determine the results. Everyone starts with zero assets, initial distributions of productivities are based on the data, as described below.

The scale of all income-like numbers is thousands of 2017 USD. I restrict assets choices such that no one can have more that $\$1m$ in savings, this constraint is binding for a small share of individuals.

1.4.3 Externally Estimated Parameters

Three crucial objects to estimate from the data are the variance of income shocks, the distribution of assets and productivities singles and the income trends. The variances require observing individual over time and the distribution requires the assets data, none of which is possible using the ACS data. Therefore for them I use SIPP data, 2014 Waves 1–3, that cover three years. To be more in line with the main data, the income trends are still estimated using the ACS, as SIPP estimates are less smooth, and the described SIPP technique does not utilize dynamic structure in estimation of the trends.

1.4.3.1 SIPP: Income Shocks and Distribution of Singles

For SIPP, I impose the following restrictions on the data, replicating the approach that is done in Section 1.2 for ACS. I treat as working those who work at least 10 hours per week. I drop people with hourly income less than one-half of the federal minimum wage and with hourly income above 95% quantile of the distribution, I also drop those whose income went up or down more than four times in two consecutive years.

The estimation approach follows Meghir and Pistaferri (2004). Endogenous choice of female labor supply is an important concern in estimating the individual productivity shocks, therefore a Heckman correction is used.

At the first stage the labor force participation regression is estimated, using presence of the mortgage as an excluded instrument (following Blundell, Pistaferri, and Saporta-Eksten (2016), it is supposed to increase labor force participation regardless of productivity). At the second stage, the log wage is regressed to this Heckman correction, together with a set of dummy variables for age, state and year, and the residuals (corrected) are used to obtain the values of productivity z for those in labor force. At the third stage, based on these residuals a simple GMM time-series procedure is used to split the variation in these residuals onto the permanent income components and measurement error. The details of the estimation are given in Appendix ....

Then, I use the same residuals to estimate distribution of singles. It is done in two steps. First, I estimate the distribution of z non-parametrically: given the grid values at each age and z that are observed in the data I can assign weights according to proportion of singles with z that are closest to a certain grid point. This gives me probabilities of each productivity grid point at each age.

Then, I estimate a heteroskedastic Tobit regression of log-assets conditional on z, treated people with assets less than $\bar{a}$, that includes zero, as censored observations. I prefer parametric approach as assets data are noisy, and treating them non-parametrically produces undesirable patterns. The regression specification is

$$\log a_t^* = \alpha_0 + \alpha_1 \cdot t + \alpha_2 \cdot z + \alpha_3 \cdot z \cdot t + \sigma_t \cdot \varepsilon_t, \quad \sigma_t = e^{\beta_0 + \beta_1 \cdot t}, \quad a_t = a_t^* \cdot \mathbb{I}(\log a_t^* \geq \bar{a}), \quad (1.22)$$

and I take $\bar{a} = 0$ in the estimation.[11] The model is estimated via standard MLE.

For males, the standard errors of productivity shocks and the distribution of singles are estimated similarly, but without the Heckman correction. For the distribution of singles, women with and without kids were split, and the share of single mothers was estimated non-parametrically (as just percentages in the data).

As SIPP data are monthly, yearly per-hour earnings were assembled out of monthly earnings and hours, and average net worth during a year was used for assets.

[11] Income and assets are measured in thousands of dollars, so this treats all people with net worth below $1000 as having zero assets.

1.4.3.2 ACS: Income Trends

The income trends are estimated on ACS separately, where the data is treated in the same way as in Section 1.2. To get rid of the intensive margin of labor supply, the per-hour earnings are converted to yearly assuming that everyone works 2080 hours per year.

The trend is assumed to be non-parametric. The earnings are regressed on a set of dummy variables for each age, 21–50 for females and 23–50 for males, past this point it is assumed to be flat. The regression additionally controls for race, state, survey year and metropolitan area status. I ignore the female labor force participation margin. Theoretically, ignoring this selection causes my estimated to overestimate the real trend, on the other hand, as there is skills depreciation from being out of labor force, the agents in simulated model will be on average below the trend, and I view these two factors as compensating each other. Appendix ... provides the regression specification.

1.4.4 Internally Estimated Parameters

Things to be estimated in the model are:

1. Preference parameters: additive utility from having a child ϕ_0, weight of child's consumption in utility α, productivity of female labor at home κ, subsistence constraint for the child's consumption $\bar{q}$
2. Characteristics of unobserved match quality ψ: initial distribution parameters $\mu_{\psi,0}$ and $\sigma_{\psi,0}$, the variance of match quality shocks σ_{ψ}.
3. Reduced-form preference shifters: disutility of divorce ϕ_d, disutility of marrying a single mother for male ϕ_r, disutility of not entering a shotgun marriage (social stigma) ϕ_s.

4. Abortion access and costs: probability to get abortion access p^a and utility costs of abortion ϕ_a.

5. Probabilities to meet a partner p_t^{meet} and to have an unplanned pregnancy p_t^{preg}. I parametrize them with values at three age points: $(p_{21,30,40}^{\text{meet}})$ and $(p_{21,28,35}^{\text{preg}})$ and interpolate with quadratic function in between these points.

In total this gives 12 choice parameters and 6 transition probabilities. I define the resulting parameter vector to be

$$\Theta = \left[\phi_0, \alpha, \kappa, \bar{q}, \mu_{\psi,0}, \sigma_{\psi,0}, \phi_d, \phi_r, \phi_s, p^a, \phi_a, p_{21}^{\text{meet}}, p_{30}^{\text{meet}}, p_{40}^{\text{meet}}, p_{21}^{\text{preg}}, p_{28}^{\text{preg}}, p_{35}^{\text{preg}}\right], \tag{1.23}$$

which is 18-dimensional.

To discipline these parameters, I use overidentifying set of moment restrictions derived from the ACS. They include timings of divorce and fertility over duration of marriage, and percentage married, divorced and single with and without kids by age, with few other auxiliary things for pinning down preferences.

I use three external targets that are not available in ACS: share of child-related expenditures in labor earnings from Lino (2001), percentage of unplanned pregnancies aborted to match Finer and Zolna (2016) and ratio of number of abortions at 30s over number of abortions at 20s from Jerman, Jones, and Onda (2016).

The total number of targets used is 95. Table 1.6 describes the targets and rough identification directions, and following section describes identification in more details.

1.4.5 Identification

Each parameter affects multiple targets simultaneously, and this is the reason a proper estimation procedure as opposed to simple calibration is used. Nevertheless, for each

Table 1.6: Estimation targets and parameters related to them.

Target	**Informative about**
% divorced x years after marriage if kids-first, % divorced x years after marriage if marriage-first, $x \in \{1, ..., 10\}$	Match quality shocks σ_ψ, divorce costs ϕ_d, social stigma ϕ_s
% of kids-first and % of marriage-first in female population at age a; % of kids-first in population of married once & with kids at age a; $a \in \{23, ..., 35\}$	Unplanned pregnancy probabilities p_t^{preg}, meeting probabilities p_t^{meet}, fertility parameters $(\alpha, \phi_0, \bar{q})$
% never married without kids at age a, $a \in \{23, ..., 35\}$	Meeting probabilities p_t^{meet}, match quality initial distribution $(\mu_{\psi,0}, \sigma_{\psi,0})$
% never married with kids at age a, % divorced with kids at age a, % divorced without kids at age a, $a \in \{28, ..., 35\}$	Meeting probabilities, step children penalty ϕ_r
% of women with more than one marriage at 40	Meeting probabilities p_t^{meet}
% of couples with kids x years after marriage, $x \in \{4, ..., 8\}$ (if still married)	Fertility parameters $(\alpha, \phi_0, \bar{q})$
% in labor force if with kids and married at 30	Labor productivity at home κ
% of child expenditures in total earnings*	Fertility parameters (α, q)
% unplanned pregnancies aborted*, ratio of abortions at 30s to abortions at 20s*	Abortion access and costs (p^a, ϕ_a)

Notes: * denotes external targets, the sources are described in text. All other targets are computed on ACS following the methodology of Section 1.2.

parameter there is an idea about what set of targets is the most informative about it.

Meeting probabilities p^{meet} are disciplined by share of never-married people over age and the share of kids-first and marriage-first couples. Unplanned pregnancy probabilities p_t^{preg} are pinned down with share of kids-first couples, especially relative, share of never married women with kids and, less importantly, by percentage of abortions.

The size of match quality shock σ_ψ is identified by steepness of divorce profile by marriage duration, looking especially at the marriage first group as the least vulnerable to divorce. The overall size of the divorce rates is informative about divorce cots ϕ_d, and the difference between kids-first and marriage-first is easily affected by the size of social stigma ϕ_s, among other factors that I discuss later.

The initial distribution of match quality is determined by percentage of never married people over age with and without kids. The latter group is particularly important as single in the model they certainly met at least one partner. Together with the share of women with more than one marriage at 40 these numbers are also informative about the meeting probabilities.

Steepness of age profile of fertility, represented by share of the marriage-first people in general population, is informative about the role of child's consumption in utility, α. It is also affected by the expenditure share of couples, but the latter is determined more directly with the subsistence constraint parameter $\bar{q}$, although the separate identification of two parameters is a little subtle. The constraint $\bar{q}$ is also affected by the share of kids-first couples, as it is the most direct factor making raising children alone undesirable.

Overall level of fertility from the share of marriage-first couples and percentage of couples with kids by years after marriage are informative about overall benefits from having kids ϕ_0. Additionally, the size of ϕ_0 versus the scale of love shock is identified by comparing the share of divorced people with and without kids.

Productivity of female labor at home κ is almost solely determined by the level of female labor supply. Similarly, the share of unplanned pregnancies aborted determines abortion access p^a, and the age profile of abortions is informative about their utility costs ϕ_a.

Utility loss for having stepchildren ϕ_r is determined by percentage of divorced and never married women with kids, especially relative to those without kids, as the dynamics of their relative proportion is informative about changes in the remarriage chances.

1.4.6 Simulated Method of Moments

For every combination of parameters Θ, I solve the model, obtain decision rules, simulate a sample of agents and track their decisions. Based on these decisions, I get simulated data, from which I compute the targets, replicating the way they computed in the data as close as possible. Based on the targets in the data and in the model, I compute the weighted GMM-style distance, and this number represents the overall fit of the model. I use optimization routine to select parameters Θ maximizing the overall fit of the model, i.e. minimizing this distance. Gourieroux, Monfort, and Renault (1993) provides a canonical discussion of this approach.

Formally, let the vector of the data targets be t and the simulated values of the stargets from the model be $m(\Theta)$. The simulated method of moments distance function is a scalar

$$d(\Theta) = [m(\Theta) - t]' \cdot W \cdot [m(\Theta) - t] \, .$$

The weighting matrix corresponds to standard errors of the targets in the data, inverse and squared. In a canonical GMM framework the correlation of the targets should also be computed, however, following Altonji and Segal (1996), I ignore the covariances and assume the matrix is diagonal, prioritizing finite sample properties of the estimates over theoretical statistical efficiency.

I use standard errors obtained from ACS, except for external moments (marked with stars in Table 1.6). For the external moments I arbitrarily set standard error of 0.001, which corresponds to standard error of the ACS numbers of similar magnitude. Finally, as this is central in my model, I artificially multiply the standard errors of shares of people divorced by the years after marriage in KF and MF groups by 1/4 to prioritize fitting these targets. As in classic GMM, slightly arbitrary weighting does not change the consistency of the estimates and can potentially improve their finite-sample performance, (Shephard 2019) uses similar techniques when bringing together ACS and PSID moments.

The model simulates lifecycle of $15{,}000$ women. I did not find random sampling important for the targets I use as most of them are conditional on age or particular marriage duration, so for the sake of faster computations I treat women in each period as separate independent observations. To mitigate the concerns, I compute the moments three times with different sequences of the random draws and average among them.

For the optimization procedure I follow Arnoud, Guvenen, and Kleineberg (2019). There are many discrete decisions and there is noise coming from simulations, that makes the distance function $d(\Theta)$ non-smooth, although most of the approximated underlying decisions are expected to respond smoothly on changes in parameters.

Therefore a two-step optimization procedure TikTak is used: it first performs global search and then runs many local optimizers. First, I take $20{,}000$ candidate values for Θ from quasi-random Sobol sequence for potential parameters values (rescaled to fit some reasonably wide bounds). Among them, I pick 250 points with the lowest value of the distance to a sequence $\{\Theta^{1i}\}_{i=1}^{250}$.

Then I run sequence of local optimization procedures. At the first stage I take the best of these 250 points as a starting point. At the stage $i = \{2, ..., 250\}$, the starting point is a weighted average of the best point found at stage $i - 1$ and the Θ^{1i}, where the weight of the best point is growing with i.[12]

For the local optimizers, I use non-gradient regression-based nonlinear least squares algorithm DFO-LS, that is developed in Cartis et al. (2019). Other potential choice is Nelder–Mead, the gradient-based methods are found to be extremly inefficient because of the stochastic noise in the function.

This algorithm is easily parallelizable, if in the weighted average instead of picking the point from stage $i - 1$ the optimizer just uses the best point found so far. As the time it takes to evaluate the function at one point on GPU is approximately 1 minute, running running 15–20 concurrent optimization routines simultaneously (with each evaluating

[12] I use $w_b = \max\{0.1, \min\{(i/250)^{0.5}\}, 0.995\}$ following the original paper.

function 120–180 times) delivers reasonably stable and replicable results within less than 24 hours.

1.5 Estimates and Fit

In this section I present the estimates in the model on two subsamples: high school graduates and college graduates.

Table 1.8 presents parameter estimates for low and high-education samples. Table 1.7 presents the model fit and references the fit graphs representing the model fit. Additionally, Table A.1 presents external parameter estimates for income process and distribution of singles.

The fit for both groups is exceptionally good, especially given the large number of targets. For the college graduate, the only important issue is fertility timing: due to the absence of taste shocks, many couples are close to indifference between when to have children, and in particular, a number of couples, especially elder ones close to the fertility limits, try to conceive quickly after they are married. This is an artifact of the model rather than desirable property. Uncertain conception probability mitigates this slightly, but the most obvious solution is just to remove the first three years after marriage from the targets, which I did.

Another important discrepancy is the share of kids-first and marriage-first couples for the high school graduates, although the overall pattern is matched well. This happens because a significant share of singles marry and have children earlier in life, and in the model the earliest moment married couple can have children is 22. The estimator solves this by inflating the meeting probabilities in early life, but this creates an undesirable pattern (u-shaped parabola) for the rest of the life.

Table 1.7: Model Fit

	College		High School	
	Model	**Data**	**Model**	**Data**
% divorced 1–10 years after marriage if KF and MF	Figure A.1		Figure A.3	
% KF and MF at 23–35, in population and relative	Figure A.1		Figure A.3	
% with kids 4–8 years after marriage	Figure A.1		Figure A.3	
% divorced with and without kids at 28–35	Figure A.2		Figure A.4	
% never married with kids at 28–35	Figure A.2		Figure A.4	
% never married without kids at 23–35	Figure A.2		Figure A.4	
% with more than one marriage at 40	6.9	11.9	11.2	17.1
% in labor force at 30 if married and kids	72.8	74.0	59.7	54.7
mean % of child expenditures in total earnings	40.8	40.0	40.1	40.0
% unplanned pregnancies aborted	39.9	40.0	38.2	40.0
abortions in 30s as % of abortions in 20s	42.2	38.5	38.7	38.5

Notes: KF refers to the kids-first women, MF refers to the marriage-first women. 23–35 refers to all ages from 23 to 35 and so on.

1.6 Why Marriages Differ?

What in the model leads the kids-first couples divorce more often? There are several answers that I explore throughout this section, but the first and the most direct force is the pregnancy shocks. When an unplanned baby appears, the value of disagreement for the woman drops because of multiple factors in the model. The main factors determining responses to the shock are the social stigma and the risk to become a single mother, associated with increased expenditures and worsened marital perspectives. This alters the bargaining of the new couple, shifting the people's options towards agreement. As a result, some people marry precisely because they had a child, these people can be referred to as compliers.

Table 1.8: Estimated parameters.

Parameters	Description	College	High School
(ϕ_0, α, κ)	Fertility preferences	$(0.36, 0.70, 8.13)$	$(0.39, 0.55, 7.88)$
q	Required childcare costs	12.75	2.17
σ_ψ	Match quality shock size	0.103	0.187
$(\mu_{\psi,0}, \sigma_{\psi,0})$	Match quality initial distribution	$(-0.33, 0.28)$	$(-0.51, 0.41)$
$(p^{\text{meet}}_{21}, p^{\text{meet}}_{30}, p^{\text{meet}}_{40})$	Meeting probabilities (quadratic)	$(0.27, 1.05, 1.03)$	$(0.64, 0.34, 1.11)$
$(p^{\text{preg}}_{21}, p^{\text{meet}}_{28}, p^{\text{meet}}_{35})$	Unplanned preg. probabilities	$(0.029, 0.024, 0.022)$	$(0.09, 0.12, 0.09)$
(p^a, ϕ_a)	Abortion access and costs	$(0.89, 3.4)$	$(0.94, 1.75)$
ϕ_d	Utility costs of divorce	2.43	2.25
ϕ_s	Shotgun marriage stigma	0.85	1.16
ϕ_r	Utility loss from stepchildren	10.13	9.11

Notes: The quadratic polynomials for the meeting probabilities are clipped to fit $[0, 1]$ interval.

1.6.1 Agreement Thresholds

From the prospective of the distribution of couples, the unplanned pregnancy lowers the agreement threshold: minimal level of match quality required to agree to enter the relationship. In this section I discuss the dynamics of this threshold starting from its definition.

The right metrics to think about bargaining problems like 1.17 is the egalitarian bargaining surplus, defined as

$$M = \max_{\theta} \min\{V^{f,c}(\theta) - V^{f,s}, V^{m,c}(\theta) - V^{m,s}\}. \tag{1.24}$$

The expression under the maximum operator represents the gain of the party who is less willing to agree. Unlike the Nash bargaining surplus, this object is well-defined and smooth even in the event of disagreement. The θ maximizing this surplus is different from the Nash bargaining solution, but is close to it when M is around zero. The couple agrees to marry if $M \geq 0$ and disagrees if $M < 0$. A very analogous representation applies to the divorce case.

Considering couples with different initial draw of ψ I define $M(\psi)$. The point ψ_m such that $M(\psi_m) = 0$ represents the marriage threshold: the minimal level of relationship quality such that the couple agrees to marry.[13] For established couples and their bargaining problem, a similar point ψ_d such that $M(\psi_d) = 0$ represents the divorce threshold.

The interaction of two thresholds, ψ_m and ψ_d, is informative about marriage creation and dissolution. The lifecycle of marriage can be imagined this way: the married couple gets an initial value of $\psi > \psi_m$. After that, the value of ψ changes over time, and the couple divorces if it ever happens that $\psi < \psi_d$. ψ_d itself moves with couple's shocks and optimal responses to them.

The effect of the marriage threshold is direct: fall in it generates more couples with low ψ, indicating the risky marriages, other things equal. The fact that shotgun marriage couples have lower ψ is not enough for them to divorce more: this reasoning assumes they have the same divorce threshold than the regular couples. If we ignore the assets and productivity heterogeneity, this is true: after having kids, the couples in the model are identical. However, as couples who have kids in marriage choose this based on their characteristics, the "average" divorce threshold for them can be different from the shotgun marriage couples for which the childbearing is more random. [In simulated model, however, this difference in divorce thresholds was not systematic. TBA]

The left panel of Figure A.5 plots the agreement thresholds ψ_m for college females 25 years old with no assets by their productivity z^f, meeting male with median income and zero assets. The bottom line represents the marriage threshold ψ_m for the case of unplanned pregnancy, and the top shows the threshold for the regular case. The line in the middle shows the same agreement threshold for a hypothetical unplanned pregnancy

[13] The simulated model is solved on discrete grid, therefore the exact value can be obtained by simulations.

match not affected by social stigma ϕ_s (considering bargaining problem 1.18 and setting $\phi_s = 0$, while keeping the value functions intact).

The right of Figure A.5 panel serves for additional illustration. It shows literal value functions corresponding to each of the scenarios on the lest. It illustrates that social stigma is a major symmetric factor that affects disagreement values of males and females. Net of the social stigma, disagreement value of female still falls quite a lot, and disagreement value of male falls a little, which is mostly due to exposure to the child support. Unplanned pregnancy also changes the values of agreement: females are strictly worse of in the case of pregnancy, and males prefer having child immediately in marriage if their bargaining weight is sufficiently high.

Figure A.6 presents the same graph for the high school calibration. The qualitative conclusions are very similar, although the magnitudes are slightly different: the proportion of social stigma looks relatively higher. However, the interpretation of this utility difference is not obvious, as the preference parameters for the two groups are different. I explore it more in the next section.

The graphs reveal several things. First, indeed, in the estimated model people who had an unplanned pregnancy agree to marry for the lower values of ψ. Second, social stigma explains significant, but not all of the drop in the agreement threshold. Third, there is mild upward trend in productivity: more productive women are more picky towards their partners, though the magnitude of this seems small relative to the effects of the pregnancy. Fourth, unplanned pregnancy is generally a negative event for females and have uncertain value for males.

1.6.2 Distinguishing Mechanisms

For the further understanding and quantification of the results I consider several counterfactual scenarios, where I solve and simulate the model with parameter changes. I summarize the changes in the following experiments:

- **Baseline (BL)**. Estimated model, for comparison.
- **No stigma (NS)**. Setting $\phi_s = 0$ to remove the pressure to enter shotgun marriage.
- **Fertility control (FC)**. Removing abortion costs ϕ_a and granting full abortion access $p^a = 1$, so females can perfectly choose whether to be a single mother.
- **No remarriage penalty (NR).** Setting $\phi_r = 0$ so women with children have ex-ante the same marital prospectives as without children.
- **Free divorce (FD).** No divorce costs.
- **No divorce (ND).** Infinite divorce costs.

These scenarios are purely counterfactual, and are aimed to asses various potential determinants of differences between kids-first and marriage-first couples. Through the experiments, I look at the following metrics:

- Share of divorced women 10 years after marriage is kids first and marriage first.
- Share of kids-first women at 30 (among those married once and having kids)
- Percentage of unplanned pregnancies aborted.
- Percentage of single mothers among all mothers at 35.

The top of Table 1.9 shows the reaction of the model to the countefactual experiments in both calibrations. Focusing on the differences between the divorce share, there are two most important contributors: social stigma against not marrying in case of pregnancy and fertility control — the ability to terminate the pregnancy in case it happens (or to prevent it from happening). Social stigma alone explains around one-third of the difference for the both groups, and the fertility control explains around two-thirds of the differences for college graduates and a bit less than one-half for the high school graduates. Remarriage penalty is also an important contributor, though it goes in a tricky direction: together with decreasing divorces for kids-first it increases them for marriage-first couples, and this allows the groups to become more similar. This suggests that remarriage prospectives are also an important determinant of the differences in divorce.

To summarize, social stigma and limited costly abortions make kids-first marriages perform worse, and remarriage penalty makes both kinds of childbearing marriages more stable. Interaction of this factors causes the differences in both education groups.

Table 1.9: Counterfactual experiments: understanding the sources of the differences

College graduates						
Experiment	**BL**	**NS**	**FC**	**NR**	**FD**	**ND**
divorced in 10 years, kids-first	19.4	14.3	10.0	14.4	58.7	0.0
divorced in 10 years, marriage-first	5.4	5.4	5.3	11.2	8.5	0.0
kids-first at 30	11.4	9.1	5.6	13.2	21.1	8.5
unplanned pregnancies aborted	39.9	44.1	83.6	0.0	35.8	40.3
single mothers at 35	12.4	13.0	6.7	14.4	17.2	9.2
High school graduates						
divorced in 10 years, kids-first	22.3	20.0	18.6	24.0	33.5	0.0
divorced in 10 years, marriage-first	15.7	15.4	14.8	19.8	15.9	0.0
kids-first at 30	36.7	35.3	32.3	47.9	38.8	32.4
unplanned pregnancies aborted	38.8	42.1	75.3	0.0	41.8	25.0
single mothers at 35	40.9	41.7	36.3	31.6	42.5	43.5

Notes: all numbers are percentages.

Names: **BL** – baseline, **NS** – no social stigma, **FC** – perfect fertility control, **NR** – no remarriage penalty for single mothers, **FD** – costless divorce, **ND** – no divorce at all

1.6.3 Removing Composition Effects

In this section I analyze the response of the whole estimated population to an unplanned pregnancy shock, which can be interpreted as a causal effect, although the definition of causality in family economics is ambiguous (Lundberg, Pollak, and Stearns 2016). Indeed, unlike in classic randomized experiments, "causal effect of marriage" does not immediately correspond to a well-defined counterfactual: one can compare people marrying right now to postponing marriage, or to marrying a different partner, or to never marrying at all. A good thing about the estimated model is that it allows to do most of these comparisons, once we define which one is to look at.

One obvious angle in a context of the model is to consider a causal effect of receiving an unplanned pregnancy shock, i.e. meeting a partner and getting pregnant at a certain moment of time as opposed not not getting a shock at this particular moment and facing all the regular uncertainties later. To do this, I consider the following experiment. I generate a population of single women from the exact distribution used in the model simulation. Then, I alter their sequence of shocks such that all this population meets the first partner at the age of 25 and either gets pregnant or does not get pregnant.

There are multiple ways to compare the two scenarios of getting and not getting pregnant. I pick two of them that I find reasonable. First, a direct way is to consider the outcomes for the population as a whole, keeping in mind that getting a partner draw does not always convert to marriage, and getting pregnant does not always imply childbearing. This gives an idea of a causal effect of an unplanned pregnancy.

A more focused approach is to compare people who agreed to enter the kids-first marriage to their alternative selves — people with the same sequences of random shocks in the scenario where no pregnancy happened. This can be viewed as a causal effect of a kids-first marriage.

Table A.2 shows the outcomes of unplanned pregnancy in terms of divorce, both unconditional (column Offered) and conditional (column All KF) on entering a kids-first marriage. Further, it provides the decomposition, separating those who married because they had kids, would have married anyway and would have never married each other.

The table gives an idea of the causal content of the observations in the empirical part of the paper. Entering a kids-first marriage increases chance of having a divorce in the future about 1.5 times. This, however, is mostly driven by the compliers: those who got pregnant but refused to marry are *less* likely to be divorced in the future, and those who would have married anyway face little impact of the pregnancy.

The share of compliers in all kids-first exceeds a half for college graduates and is around forty percent for high school graduates. This suggests that very large share of kids-first people marry *because* they had a child, which is confirmed by the large shift in agreement thresholds in the previous parts.

The overall impact of unplanned pregnancy in terms of divorce is more subtle: statistically, for college graduates, less people who have unplanned pregnancy get a divorce, but this happens precisely because many of them never get married, as indicated by the percentage of married.[14] For high school graduates this effect of non-marriage is weaker, and therefore unplanned pregnancy itself increases the chances of divorce.

Overall, entering a marriage following an unplanned pregnancy increases divorce chances substantially. Receiving unplanned pregnancy unconditional on its outcome decreases chances of being married in the future and greatly increases chances to be a single mother. Causal effects of shotgun marriage on divorce is of 14 percentage points out of the base of 32% for college graduates and 13 percentage points out of the base of 41% for high school graduates.

[14] One possible alternative comparison is comparing the rates of ever divorced if ever married, but this makes this groups to similar to the KF.

1.6.4 Aggregate Effects

The model allows to quantify the aggregate effects of unplanned pregnancies on the behavior and outcomes. The counterfactuals above talk about what happens if people receive the shock, which is a small share of those who receives marital offers. Less then half of these people actually enter the kids-first marriages.

However, the risks of unplanned pregnancies affect everyone, and not only those who actually enters the kids-first marriages. People change their behavior in response to the chance of pregnancy. In particular, we may expect that if some matches are risky, people will be less picky in general: skipping a potential partner means more exposure to the risk. Figure A.7 provides the evidence of this: if people anticipate an unplanned pregnancy (even if it does not come), they got married earlier and have their children faster. This is especially true for high school graduates.

As general population is larger than just the kids-first couples, the anticipation effects are expected to be more relevant for general population than just the effects of kids-first marriages. Table A.3 confirms this. Column "NE" (never experienced) refers to the baseline model where in simulations no unplanned pregnancies happen, but in the optimal decisions people still anticipate them. Roughly this also corresponds to simulation results of those who never had an unplanned pregnancy. Column "NA" (never anticipated) refers to the model where probability of unplanned pregnancy is zero and all agents know this.

The table shows that elimination of unplanned pregnancies creates some delay in marriage and prevents some of earlier divorces, though the overall effect of them on divorce is around one percentage point for college and around for percentage points for high school agents. It also gives an idea about how pregnancies affect percentage of single mothers: eliminating them drops this number by around one-third for high school and more than half for college. To some extent it is predictable, on the other hand, it gives an idea is large share of single mothers is still generated by divorce of existing couples. The table reports the count of single mothers in total population, the effect of count of them among mothers is somewhat offset by the decline in fertility as seen on the graphs. Note that the model is simulated such that there is some initial count of single mothers in the start of the lifecycle, without it the effects are more drastic.

1.6.5 Childbearing and Divorce Chances

How does divorce risk affect childbearing, and how does childbearing affects divorce risks? Statistically, marriage-first women have lower divorce rate than general population of "not-kids-first" (i.e. marriage-first or childless). Can the model deliver any causal predictions here? Yes, in both ways.

Kids $\Rightarrow$ less divorce. First, other things equal, childbearing decrease divorce chances, at least for those who tried to conceive the child. As the conception is random in the model, it provides a natural comparison: we can take the agents who conceived the child with their counterfactual selves in the case they never had a successful conception.

The experiment is analogous to the one in Section 1.6.3, but without unplanned pregnancies. I take two identical populations in which everyone meets their partner at 25, then in one population the conception probabilities are (unexpectedly) altered to be zero (never conceive) and in another one they are set to one (always conceive if they want to).

Figure A.8 shows the percentage of divorced at 40 among those who agreed to marry at 25. On horizontal access I plot the year the first conception decision is made. Solid line represents the percentage of ever divorced if the conception is successful, the dashed line shows this percentage if the conception (and all subsequent ones) fail. On average, successful conception decreases chances of divorce by around one-third for college graduates and by around one-tenth for high school graduates.

More risks of divorce ⇒ fewer kids. Among couples, those who have kids together have on average higher relationship quality. Figure A.9 shows the average match quality by the fertility status and age. This suggests that couples facing more risks of divorce would prefer delaying their fertility. This is consistent with Alesina, Giuliano, 2005 finding about the fertility decline with introduction of unilateral divorce.

In the context of kids-first and marriage-first division, the marriage-first couples who already had their children have on average larger marriage quality than the childless. This additionally contributes to the differences.

1.7 Can Policies Promote Marriage?

Through the lens of the model, marriage quality is a single most important determinant of marriage decisions. Any policy that aims to affect people marriage decision has the most immediate effect of changing marital decisions for some people who are on the margin of whether to marry each other.

The model allows to infer how large is the share of the marginal marriages. Some people marry because they had an unplanned pregnancy, and this essentially means that they are below the threshold for a regular marriage. The data does not allow to identify how many people are this: at best we can see how many of the kids-first couples divorce. The structural model, essentially, allows to convert the "excess" divorce rate to the share of people who are on the margin.

In principle, the distribution of the shock and hence the agreement thresholds can be inferred from just aggregate divorce and marriage rates, as in Low et al. (2018). This paper, in some sense, gives additional "overidentifying" restrictions to this inference: the distribution should be such that the share of "compliers" is consistent with the differences in divorce rates. On the one hand, this provides additional validation to the previous results, on the other, it endoegenizes more things so it facilitates understanding of additional facts about how fertility affects the decisions.

The first experiment is directly pushing people who had an unplanned pregnancy into marriage. The model provides social stigma parameter as a metaphor for this. I show that pushing people into marriage creates some temporary effects — people who are pushed may not divorce immediately and stay together for some time. However, these effects are really temporary — it pushes some young people to short marriages, but they break up by adult ages.

Then, I consider strengthening the child support as popular and more realistic way to treat people who have kids and are on the margin of breaking up. Theoretically, more responsibility of fathers can make people marry more, as walking away is more costly. However, in practice this effect is negligible from aggregate prospective. What is non-negligible is effect on two margins: women do less abortions if they decide not to marry the potential partner, and more couple with kids break up as post-marriage prospectives are now better for women. This all pushes the count of single mothers, both general and among mothers, up.

Finally, I consider more ways of promoting marriage. Direct monetary incentives, like tax brackets for married couples, have pretty small effect on aggregate even if the benefits are large. This suggests that relative importance of relationship quality — love — is substantially higher than of money. A non-obvious but guaranteed way of promoting marriages in the model is making divorces easier. Indeed, it makes many people on the margin wanting to "try" marriage, and especially those who already have pressure of unplanned pregnancy, as argued by Alessina, Giuliano, 2005. However, on the aggregate level many implications of it are far from desirable: it implies large drop in fertility, which even offsets additional marriage creation.

1.7.1 More Pushing Creates Temporary Marriages

Is it good for the society to push people who had kids to marry? Blind statistical view suggests that having two-parent family benefits at least the child, although more economic prospective suggests that this is not sustainable regulation. Believing in a simple collective environment, if parents caring about the child choose to be apart, they would be worse off staying together. However, the limited commitment setting and search frictions do not guarantee the first-best allocation, and the fact that the child's utility is not modeled properly makes the answers uncertain in the model.

The model includes ϕ_s utility parameter, that in some sense precisely does this. Is social stigma that forces people to marry in case of unplanned pregnancy a negative thing? As seen in Table A.2, large share of the compliers divorce. On the other hand, another large share of compliers stays together in couples. Relative to the situation with no pressure to marry, a large share of these couples would never be formed. So the direction is a priori uncertain.

More practically, what direction is the relation between social stigma and share of single mothers? On the one hand, more stigma decreases the number of people who does not marry following pregnancy, hence it should decrease the number of never married single mothers. On the other hand, more stigma causes creation of more risky marriages, therefore it should increase the number of divorced single mothers. In the world without abortions the second effect is smaller than the first if at least some women stay in their shotgun marriages. In presence of abortions this can go either way and the model is capable of making an assessment.

To get the answers, I change the size of social stigma parameter. See Table A.4 for the main set of results. I compare the models where social stigma is one-half of estimated value, double estimated value and infinity, where the last option means that all couples who face an unplanned pregnancy have to marry each other. The welfare changes in the table reflect that more people actually anticipate to experience the new stigma. I also provide another welfare comparison, where the change in stigma is not anticipated in the utility.[15]

The table provides several dimensions of results. Among the obvious results, pushing more people into marriage in case of pregnancy sindeed makes more people married, though this effect is modest due to the limited scope of the pregnancies. Additionally, as already discussed, this lowers already compromised marriage performance of existing shotgun marriages, increasing the divorce rate for kids-first couples. Then, as more people are pushed towards marriage, less women abort unplanned pregnancies. Finally, the welfare consequences of social stigma are negative even if we do not count the anticipation effects, although to some very small extent the additional pushing benefits women. Small benefits are concentrated among less productive women are are negligible relative to the losses of the men.

There are less obvious results generated by interaction of the channels. First, pushing more people into marriage increases count of single mothers, especially for the less educated population. Second, additional pressure to enter shotgun marriages hurt men relatively much more. Third, and perhaps the most important result, is about the child's well-being. One may think that if parents stay together at least temporary the overall well-being of the child is improved. The experiment reveals that it is false: temporary

[15]This is an additional exercise, where change in social stigma is totally unanticipated and does not affect agents value functions. Namely, I change ϕ_s to new value $\tilde{\phi}_s$ in the bargaining equation 1.18 and in people marriage decision, but people continue to assume that they experience ϕ_s when evaluate their value functions. Because of lack of anticipation, all other outcomes are slightly different in this exercise, but the differences are not important quantitatively, so I do not report them.

marriages do lead to more long-term singleness. If women can avoid dealing with inefficient matches and start searching for a satisfactory partner quickly it brings both them and children large long-term return.

1.7.2 Child Support Has Many Side Effects

The model provides natural ground to study child support. To recall, in the baseline calibration the child support is assigned with probability $p^a_{nm} = 0.284$ in case of a couple with an unplanned pregnancy who disagrees to marry and keeps the child and $p^a_{div} = 0.461$ in case of a married couple with a child divorcing, and the child support itself is set to be 20% of male's labor earnings, see 1.4.2. Child support is modeled as a shift in permanent productivity z, see A.2.2.

The two experiments are eliminating the child support system at all (setting $p^a = 0$, experiment "No CS") and making the enforcement perfect (setting $p^a = 1$, "Full CS"). Table A.6 presents the comparison.

There are several crucial conclusions from the table. First, the child support has relatively modest effect on creation and dissolution of the kids-first marriages, and, if anything, incentivizes people to divorce. Second, the largest margin the child support changes is fertility: more married couples have kids and more women choose to not to abort their unplanned pregnancies. These factors together facilitate induce the economy to have more single mothers when child support gets stronger.

On the welfare side, more child support is generally welfare improving for parents: men lose less than woman gain. What is more surprising, is that the child support in the model makes children worse off. This happens almost precisely because the long-run count of single mothers is larger, and the effects of more resources is offset by effect of more singleness. Of course, this measure is crude as in the model the child's well-being is not fully internalized by both parents, nevertheless, the general dominance of non-monetary factors in marriage/divorce decisions produces this result.[16]

1.7.3 Reducing The Pressure Promotes Efficient Marriages

Two previous results are, to a large extent, negative. This section exploits two things that deliver positive results in more details: removing the social stigma and removing the costs of abortions. Table A.7 presents the results.

Both factors move the economy in desirable direction, unambiguously increasing utilities of both parents and children. Their relative importance vary: for the college graduates, fixing imperfections of fertility control provides relatively larger improvement, for high school graduates, fertility control impact is pretty small and social stigma plays the largest role. Additionally, it fixes the excess divorce rates of kids-first marriages, making two groups more similar (especially for the college graduates).

The main implication of these differences is that the most sensitive margin among the college graduates are women entering the risky marriages because of undesirable consequences of single motherhood, on the other hand. The social stigma pressure is more substantial for the high school graduates, as being single mothers is generally more favorable for them. The idea of single motherhood as a rational choice is similar to Neal, 2004, Chiappori, Oreffice, 2008 and many others.

Note that, on the other hand, option with full fertility control and no social stigma does not make two groups of kids-first and marriage-first couples completely equal: mistimed fertility is still a factor. The results described above suggest that couples with more risky marriages have larger probability to become childless, therefore the marriage-first group — those chosen to have kids together — are by construction more risky that the group of

[16] Similar welfare implications were discussed in Brown, Flinn, 2012 and Forester, 2020, but their channels are somewhat different.

people with generally good marriages who received the fertility shock randomly. The selectivity effect implied by the model is pretty large.

1.7.4 Monetary Incentives Have Little Impact

Both marriage and fertility decisions are rather inelastic with respect to monetary incentives. Here I consider how the outcomes of marriage, fertility and single motherhood are affected by simple lump-sum subsidies. Similar in nature, but more detailed exercise was performed by Low et al. (2018). They focus on changes in TANF-AFDC program for the high school graduates, but they abstract from endogenous fertility. Their general conclusion is similar: policies do not change marriage rates substantially, although endogenous marriage does change the policy responses. My results deliver additional evidence, even though this exercise is considerably more stylized.

I consider three ways of subsidizing couples: in exercise **(AC)** I provide a lump-sum subsidy to all couples regardless of whether they have a child, in **(CK)** I subsidize only couples with kids and in **(AK)** I subsidize both couples with kids and single mothers. Three outcomes I consider are percentage of women married at 30, percentage of women having kids at 30 and percentage of women who are single mothers at 30.

To deliver the uniform measure, I consider the change in outcome per 1% increase in the median resources (labor income and savings) of couple with kids at 30 achieved by the transfer. The actual transfer is a lump-sum equivalent of $500 USD a month, and is given to females in ages 21–40.

Table A.5 presents the results. The most obvious way of promoting marriage — giving people more resources if they marry — is generally very inefficient. To get 1% more married at 30 in the model we need to increase couple's resources by 4–6%. Fertility angle is a bit more elastic than marriage, although the elasticity is still low. Finally, there is substantial fertility response if subsidizing involves single mothers. This once again suggest that the participation constraints matter for the fertility decisions. This response is within existing couples rather than single women choosing non-abortion.

Together, this exercise suggests that marriage promotion is non only unsustainable, but is also hard to achieve. Additional implementation question is revenue-neutrality: in more realistic setting subsidizing couples would mean higher tax burden for singles. This potentially can create some additional pushing towards marriage, though in the model these indirect effects are even lower. In terms of welfare, reallocation from singles to couples is welfare-improving as couples spend money more efficiently due to returns to scale, this, however, is sensitive to the assumptions on how the internals of couples are organized and where exactly does utility come from.

1.8 Conclusions

The model identifies the large relative importance of non-economic gains of marriage; in some sense, love matters much more than money. This does not mean that nothing can be done in terms of the policy, but it does imply that putting together people who are not meant to be together causes large losses. In contrast, allowing people to delay their marriages and be more selective is the uniformly right direction of policies. Frictions associated with imperfect fertility control make women in the model vulnerable to situations when economic incentives matter for a partner's choice, as childcare costs are high and need to be shared, and thus being single mothers is unwanted. Giving people a choice to avoid these situations and skip unlucky matches makes women, men, and their children better off. I see this as the model's crucial insight.

What makes kids-first and marriage-first couples different? Generally speaking, this is generated by the model's reaction to unplanned pregnancies. When a couple that thinks about whether to marry each other realize they have an unexpected child, their disagreement options change, and it makes it hard for the parents to say no to each other.

Two sources of these changes are imperfect control over fertility and exogenous social stigma. Together they explain the major part of the difference in divorce rates by fertility timing, and their relative importance depends on education, but both matter substantially. Another force for the difference that is not directly related to the outside options is the marriage-first group's selectivity: risky couples choose not to have kids or have them later. More quantitatively, the model can suggest that a bit less than a half of the kids-first marriages married *because* of kids, which implies the considerable importance of the estimated mechanism of unplanned pregnancies for the partners choice. First, many of these couples divorce in the future. Second, the whole presence of unplanned pregnancy risks distorts the partners choice.

On the policy side, the model implies that pushing people to be together and creating temporary marriages hurts the parents and does not even benefit children. Distorting partnership choice is inefficient, and partnership choice itself is very inelastic to economic incentives. The choice of whether to keep an unplanned pregnancy is way more responsive to economic incentives than the choice of whether to marry; therefore, more child support enforcement may hurt an average child born in the economy. In contrast, removing choice frictions regarding whether to be a single mother and whether to enter the marriage following a pregnancy provides direct gains to women and indirect gains to men and children. This even has empirical content: in places with more liberal abortion and birth control access one should expect kids-first couples to be more stable. Checking this is possible with some detailed data but is a little outside of the current project's scope.

The directions for future research also include the interaction of unplanned pregnancies with cohabitation. There are strong reasons to believe that for many unmarried cohabiting couples childbearing triggers marriage; the data on changes in people's marital status is also suggestive about this. Some part of the mechanism is captured in this paper; however, developing precise reasoning of why childbearing can cause the contract's change is not trivial. Chapter 2 looks at the marriage vs. cohabitation choice more explicitly in a context of a response to unilateral divorce, but combining it with fertility choices while keeping the model tractable is still an unsolved problem.

Chapter 2

Marriage and Cohabitation Patterns in the US: do Divorce Laws Matter? (joint with Fabio Blasutto)

2.1 Introduction

Unmarried cohabitation is on the rise: the share of women that ever cohabited in the United States moved from 33% in 1987 to 60% in 2010 (Manning 2013). This increase contributed to the overall changes in the structure and behavior of the American family. The higher instability of cohabitation contributes to the rise in the number of single mothers (Bumpass and Lu 2000), which is associated with poor outcomes for children (**?**; McLanahan, Tach, and Schneider 2013). Cohabiting people are less likely to engage in relationship-specific investments, such as intra-household specialization or having joint accounts (Poortman and Mills 2012). Finally, their children's well-being is worse even after controlling for parental resources (Brown 2004). However, it is not clear to what extent cohabitants' outcomes are due to selection versus the direct effect of the form of partnership on the couple's behavior. Quantifying the relative importance of these two mechanisms is only possible if we understand the rationale for the partnership choices. Why do people cohabit instead of marrying? Why is cohabitation on the rise?

Our paper addresses these questions by focusing on a major US policy change that took place mostly during the 1970s. During this period, most of the states made divorce easier by switching from the mutual consent divorce, requiring both spouses to agree to divorce, towards unilateral divorce, in which one spouse's decision was enough to initiate the procedure. The paper explores the role of unilateral divorce in the rise of cohabitation. Since marriage and cohabitation can be viewed as contracts whose attractiveness depends on their termination rights and costs, the switch from mutual consent to unilateral divorce offers a unique opportunity to learn about partnership choices. Understanding these choices is relevant for policy design: for example, protecting the weaker partner by increasing her/his rights within marriage can backfire if it causes the couple to choose a less protective partnership, such as cohabitation.

We answer the question with four contributions. First, we show that after the reform singles become more likely to cohabit than to marry, and newly formed cohabitations last longer. Second, we propose a theory of partnership choice and endogenous breakup/divorce to understand the mechanisms underlying these facts. Third, we quantify the importance of each mechanism by structurally estimating our model to match the empirical findings about the transition of the divorce regimes. Fourth, we perform several counterfactual experiments to understand the role of unilateral divorce in the rise of cohabitation and in changes in the pool of cohabiting couples. Thus, this paper consists of four parts, one for each contribution, which we now describe in more detail.

In the first part of the paper we document the effect of unilateral divorce on the choice between marriage and cohabitation and the duration of newly formed cohabitations. We use data from the National Survey of Family and the Household (NSFH) and from the National Survey of Family Growth (NSFG) to study the choice between marrying and cohabiting. Then, exploiting the exogenous variation coming from the staggered introduction of unilateral divorce over time across the US states, we estimate that couples formed after the policy change are 7-8% less likely to choose marriage over cohabitation than in the pre-reform period. Among the couples formed in the year the law changed, 30% chose cohabitation. Interestingly, the size of the effect depends on how property is divided upon divorce, being strongest in states where each spouse gets half of the wealth and where the judge decides the allocation of assets. This suggests that divorce settlements affect partnership choices when one spouse can divorce unilaterally. Moreover, we analyze how unilateral divorce affected the duration of cohabitation spells: our estimates show that cohabitations formed after the reform last longer because people both marry less and break up less.[1]

In the second part of the paper, we propose a theory to understand the mechanisms underlying the facts documented in the empirical part. We build a dynamic collective model of intra-household decision making and search in the mating market, where agents make decisions according to the realization of idiosyncratic permanent income shocks, their amount of wealth and couple-specific match quality. With some probability, single agents meet a potential partner drawn from an exogenous distribution of match quality, productivity, and wealth. After the draw, they decide whether to marry, cohabit, or stay single. Couples make decisions about consumption, savings, and female labor force participation. Women experience a productivity penalty for not working, and women's time can be used to produce a public good that captures utility gains from children, durable goods, and services.

In the model, cohabitation and marriage differ in their splitting costs and the way property is divided when the partnership dissolves. Moreover, there is a stigma affecting cohabitations, which is modeled as an exogenous disutility flow. It captures the negative judgment towards out-out-wedlock births and premarital sex. In the case of a breakup, assets are split according to individual property rights. In the case of divorce, we assume

[1] Hereafter we refer to the separation from cohabitation as a breakup to avoid confusion with legal separation.

they are divided in half.[2] Additionally, we assume that unlike a breakup, divorce is financially costly. Breakup (unilateral divorce) can be initiated unilaterally, as opposed to mutual consent divorce, which requires both partners' agreement. Following Voena 2015, under mutual consent the couple always cooperates while married and the allocation of resources corresponds to the Pareto-efficient inter-temporal allocation. When just one spouse (cohabitant) can decide to terminate the relationship this causes a lack of commitment,[3] making the intra-household decision power responsive to shocks, as spouses (cohabitants) can credibly exercise the threat of divorce (breakup). Because utility is imperfectly transferable, in our model the Becker-Coase theorem does not hold. Hence, abandoning the mutual consent regime affects the risk of divorce and, in turn, the surplus of marriage.[4]

The barriers to divorce—represented by its costs and the right to veto it—affect the gains of marriage relative to cohabitation through three main channels. First, by acting as commitment technologies, they enforce a better risk sharing and a more efficient household specialization. Second, they increase the risk of being "trapped" in a bad marriage that provides low utility. Since this risk is larger for couples with a low match quality, these couples prefer to cohabit since a breakup is cheaper and easier to obtain. Third, they affect the expected value of marriage by modifying the risk of divorce, as the intra-household allocation during marriage differs from the allocation of resources in divorce, which depends on the mandated equal division of property. The effects of tightening or relaxing the barriers to divorce depend on which channel prevails. For

[2] We estimate the model using community property states data to be consistent with this assumption.

[3] Our modelling of the decision making in the couple builds on existing literature on limited commitment (Kocherlakota 1996b; Ligon, Thomas, and Worrall 2002; Marcet and Marimon 2019; Pavoni, Sleet, and Messner 2018), which has been applied to dynamic collective models in the household by Mazzocco 2007, Mazzocco, Ruiz, and Yamaguchi 2013, Bayot and Voena 2015, Oikonomou and Siegel 2015, Voena 2015, Ábrahám and Laczó 2018, Lise and Yamada 2019, Low et al. 2018, Foerster 2020 and Reynoso 2018 among others.

[4] According to Becker, Landes, and Michael 1977, divorce laws should not affect separation decisions *"if all compensations between spouses were feasible and costless"*. The assumptions underlying the Becker-Coase theorem are discussed by Chiappori et al. 2015 and Fella, Manzini, and Mariotti 2004.

example, the introduction of unilateral divorce has an uncertain impact on the share of couples that cohabit and marry. The outcomes of cohabitation and marriage depend not only on the rules underlying these contracts but also on the match quality through its effect on the couples' stability. In fact, making partnership-specific investments is more comfortable when the risk of splitting is low, which is when the match quality is high. Since a cheap breakup is most attractive to couples whose match quality is low, selection on match quality amplifies the differences in the behavior between married and cohabiting couples.

In the third part of the paper we do a structural estimation of the model to understand the quantitative relevance of the mechanisms that drive partnership choice. The model is estimated by indirect inference using as targets the regression results from our empirical analysis, mating market moments (NSFH), and female labor force participation moments (PSID). The introduction of unilateral divorce is modeled as an unexpected policy change. The estimated model closely replicates the targeted moments. Our over-identification checks support the estimation results by highlighting that the model can match several non-targeted moments, among which the impact of unilateral divorce on cohabitation duration.

According to the estimates, a switch from mutual consent to unilateral divorce causes couples to start cohabiting more by reducing the married couple's ability to cooperate and by increasing the likelihood of a costly divorce.[5] Since cohabiting couples that would have married under the older regime are better matched and hence have a lower risk of dissolution than the average cohabiting couple, the reform increases the stability and the duration of newly formed cohabitations. The possibility of cohabitation has

[5] An increased likelihood of divorce can by itself reduce the ability of the couple to cooperate. Yet it also directly affects the marriage surplus by reducing the possibility of losing assets upon divorce. For example, if there was no wage uncertainty and women always participated in the labor market, unilateral divorce would affect marriage gains via the direct effect only.

been crucial for translating institutional change (unilateral divorce) into social change (female empowerment within the couple). In fact, we find that the average Pareto weight of cohabiting women at the time the couple meets increases because men, fearing a larger loss of assets in a divorce than in a breakup, convince women to cohabit instead of marrying in exchange for more power in the couple. This mechanism is specific to the divorce regime where assets are split evenly. If spouses continue to own their assets separately, men would not need to choose cohabitation to insure their property. Consistent with the empirical evidence, the impact of unilateral divorce on cohabitation likelihood is lower in the model under separate ownership.

The fourth and last part of the paper conducts a series of counterfactual experiments to understand the quantitative importance of the forces that contributed to the rise of cohabitation. To assess the role of unilateral divorce, we perform a counterfactual experiment where unilateral divorce was never introduced. We find that people on average would have spent 1.24 years cohabiting instead of 2.19, while only 29.1% of people would have ever cohabited instead of 43.3%. In the second series of counterfactuals, we find that a decrease in the gender productivity gap and a drop in market prices of home goods increase the share of people that ever cohabited. Both effects are driven by a reduced scope for household specialization, which is better exploited within marriage. We also study various channels of how unilateral divorce affects welfare. The possibility of cohabiting limits the welfare losses for men who can secure their assets. Women suffer more because of couple-specific investments like children, that reduce their value of divorcing more than for men.

Literature. This paper adds to three strands of the literature. First, by documenting how divorce laws influence the choice between marriage and cohabitation, we add to the existing literature that studies the effects of unilateral divorce. This policy change has been shown to affect the rate of divorce (Friedberg 1998, Wolfers 2006), female labor supply (Stevenson 2008, Voena 2015), savings (Voena 2015), marriage rates (Rasul 2003; Rasul 2006), children's well-being (Gruber 2004), family violence (Stevenson and Wolfers 2006), marriage-specific capital (Stevenson 2007), assortative mating (Reynoso 2018), the rise in serial monogamy (De La Croix and Mariani 2015), and prostitution (Ciacci 2017), among the others. We complement the findings of Rasul 2003; Rasul 2006 by showing that the decrease in marriage rates after the introduction of unilateral divorce is not only driven by more people staying single, but also by more people choosing to cohabit. This suggests that marriage and cohabitation are substitutes.[6] Our paper builds on Voena 2015, who studies how the interaction of unilateral divorce with property rights upon divorce affected married couples' household behavior. We extend her work both by considering cohabitation as an alternative relationship and by analyzing selection into partnership. This paper also extends the work of Fernández and Wong 2017 by showing that not considering cohabitation as an alternative to marriage biases upwards the negative impact of unilateral divorce on men's welfare. The intuition is that men can limit the losses stemming from the increased risk of divorce by cohabiting.

Second, our paper adds to the literature that studies the choice between marriage and cohabitation. A first subset thereof has focused on identifying the gains from marriage and cohabitation, highlighting the role of commitment (Matouschek and Rasul 2008), specialization within the couple (Gemici and Laufer 2014), learning about match quality (Brien, Lillard, and Stern 2006), income dynamics (Blasutto 2020), assets (Lafortune and Low 2017; Lafortune and Low 2020) and investment in children (Lundberg and Pollak 2015). We extend these works by showing how an increase in the ease of divorce decreases the couple's ability to cooperate and makes divorce allocations more relevant for partnership choices, since the likelihood of divorce increases. Consequently, the

[6]Cohabitation can also be a substitute for being single or dating, as Rindfuss and VandenHeuvel 1990 point out. Moreover, Blasutto 2020 and Brien, Lillard, and Stern 2006 claim that cohabitation can also be a complement for marriage, which allows the couple to learn about its match quality before making the binding decision of getting married.

relative power of potential partners and the rules about the division of assets upon divorce become crucial. These results highlight a new role for partners' relative power and assets in partnership choices, which is analyzed within a framework that extends the theory of Blasutto 2020 and Gemici and Laufer 2014 by including saving decisions.[7]

Another subset of these papers studies the effect of changes in cohabitants' rights on partnership choices and cohabiting couples' behavior, highlighting the role of alimony rights ((Chiappori et al. 2017; Goussé and Leturcq 2018)), taxation (Leturcq 2012) and division of assets at breakup (Fisher 2012; Goussé and Leturcq 2018; Chigavazira et al. 2019). We extend this literature by showing that the introduction of unilateral divorce impacts both the decision to cohabit and cohabitation's stability, even though cohabitants' rights are not directly affected.[8] Further, the effects on the intention to cohabit depends on property division rights, which indicates that partnership choices depend on divorce allocations. This evidence suggests that the design of changes in family law should treat marriage and cohabitation as substitutes.

Finally, this paper is tied to the extensive literature that studies the changes in the character of the American household over the last decades. Various studies explored the role of health improvements, wage distribution and dynamics, norms and technology in the rise in female labor force participation (Fernández, Fogli, and Olivetti 2004; Greenwood, Seshadri, and Yorukoglu 2005; Albanesi and Olivetti 2016; Greenwood et al. 2016), the changes in household formation and dissolution (Greenwood et al. 2016; Ciscato 2019), the rise in positive assortative mating (Fernandez, Guner, and Knowles 2005; Greenwood

[7] Lafortune and Low 2020 also highlight the role of assets: our model features their intuition that assets can act as a commitment technology, but our framework also allows assets to influence partnership choices via a direct effect of the risk associated with divorce. Thanks to this mechanism, we can explain why unilateral divorce caused cohabitation to increase more in community property states than in title-based ones.

[8] Matouschek and Rasul 2008 study the effect of a decrease in the cost of divorce, proxied by unilateral divorce, on marriage and divorce rates using a framework where cohabitation is a choice. Since they abstract from intra-household bargaining, they cannot capture the effect of property rights upon divorce.

et al. 2016; Ciscato 2019) and the increase in the age at marriage (Santos and Weiss 2016). We extend this literature by showing that the introduction of unilateral divorce was followed by a rise in cohabitation. Advances in the home production technology and the reduction in the gender wage gap also contributed to the rise.

The paper is organized as follows. Section 2 offers an overview of US divorce laws. Section 3 documents the effect of introducing unilateral divorce on partnership choices. Section 4 presents and develops the theoretical model. Section 5 describes the model's estimation, while section 6 discusses the main mechanisms of the model. Section 7 reports the results of the welfare analysis. Section 8 performs a series of counterfactual experiments, while Section 9 contains the conclusion.

2.2 US Divorce and Cohabitation Laws: an Overview

Divorce Laws. Between the late 1960s and early 1980s, most US states experienced fundamental changes in the divorce law. These changes affected both the right to initiate a divorce without the other spouse's consent and the division of assets upon divorce.

Before the 1960s the vast majority of US states had a mutual consent divorce regime.[9] Both spouses' agreement was needed to obtain a divorce for mundane reasons (i.e., without misconduct by either spouse). However, divorce was still permitted for grounds showing guilt of misconduct by either of the two spouses: for those cases, the innocent party's agreement alone was enough to have a divorce granted. Examples of guilt or misconduct are adultery or abandonment.

From the late 1960s and early 1980s, most US states switched to a unilateral divorce regime. Under this regime divorce can be filed by one spouse without the consent of the other. More detailed chronology about the introduction of unilateral divorce in different states can be found in table B.1in the appendix.

[9] All the states apart from New Mexico, Oklahoma and Alaska.

Another dimension along which divorce laws differ across states and over time is property division. In the United States, there are three types of regime:

1. *Community Property*. Under this regime the couple jointly owns family wealth. This implies that when divorce occurs, each spouse gets precisely half of the total family wealth.

2. *Equitable distribution*. Under this regime, the court decides how to split family wealth between the two spouses. This decision is driven by the principle of equity, which is ambiguous. In some cases, the wealth is divided exactly in half; in others, a larger share is allocated to the party that contributed the most to its accumulation.

3. *Title Based Regime*. Under this regime, wealth is split according to the title of ownership, as the spouses own their assets separately.

The option of signing prenuptial agreements gives the couple the power to agree to split the assets differently, avoiding the legal prescription, but legal scholars believe that their effect is quite limited. In fact, these contracts could not be enforced by courts until the 1970s. After the introduction of the Uniform Premarital Agreements Act of 1983, it has been easier to enforce these contracts even though today prenuptial agreements are signed in a minority of marriages (5-10%) according to Rainer 2007, which might be due to social stigma or lack of information on their benefits (Mahar 2003).

Breakup/Divorce laws compared. The regulation of cohabitation in the US is limited, and small changes have been made since the 1960s, when *"Cohabitation created no rights or obligations"* (Garrison 2008). The research by Garrison 2008 also analyzes the effects of the *Marvin vs. Marvin* case (1976), where palimony — a compensation from one member of an unmarried couple to another after breakup — was awarded to the female partner: *"[the case has] not produced results markedly different from those permissible under pre-Marvin* *case law."* Finally, she argues that claims for financial relief have rarely reached the courts because: $i)$ cohabitation is usually very short and not committed; $ii)$ cohabitants are younger and poorer than marrieds; $iii)$ cohabitants do not usually adopt sharing behavior, unlike in the Marvin cases. Similarly, Bowman 2004 claims that remedies based on the contract had a limited application.

Hence, breakup resembles unilateral divorce because one partner can end cohabitation without the other partner's consent. Concerning property division rights, cohabitation de facto falls under the title-based property regime. One crucial difference between divorce and breakup is that the former requires the couple to undergo a legal process, which implies monetary and time costs, while the latter does not.[10] The lower costs of a breakup are consistent with the findings of Avellar and Smock 2005, who show that for women the drop in income following the couple's breakdown is larger for a divorce than for a breakup. To further support the claim that divorce is more costly than a breakup, in appendix B.2 we select from the PSID a sample of couples that divorced/broke up to study how their net-worth changes after splitting. The point estimates of several event studies indicate that richer couples' divorce results in a loss of assets, while we could not observe the same pattern for the divorce and breakup among poorer couples.

2.3 Data and Empirical Evidence

Is the introduction of unilateral divorce related to the rise of cohabitation? Figure 2.1 suggests that the link between these two events merits investigation. The left panel shows a negative correlation between the share of couples that decide to marry as opposed

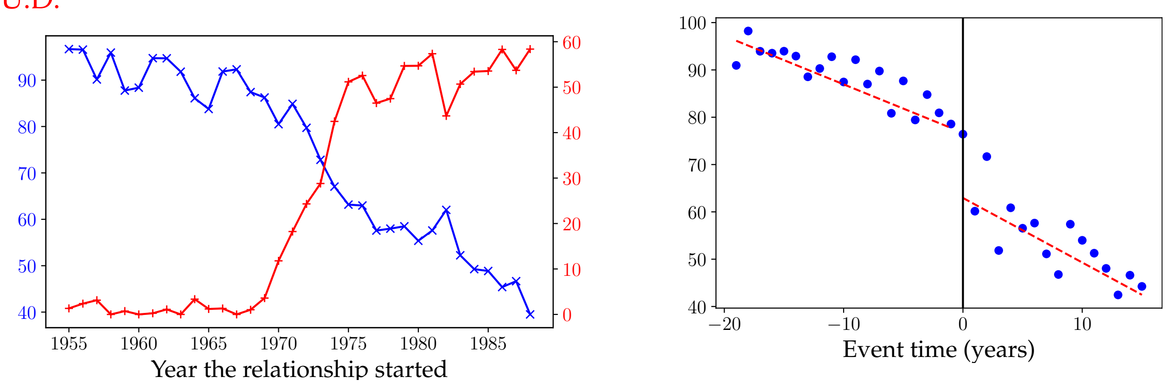
[10]While Garrison 2008 argues that claims for financial reliefs after a breakup are rare, the breakup is treated like a divorce under the doctrine of common law marriage. Under this legal framework, a couple is considered as married without having formally registered their relationship. Lind 2008 explains that the existence of the implied contract is presumed once continuous cohabitation and reputation (holding out as husband and wife) are proven. However, it is still possible that the couple — even if cohabiting for many years—is not considered to be in a marriage agreement, with marital rights and obligations. These rules create uncertainty regarding recognizing common law marriage for some couples, especially those close to a breakup, where the two partners might disagree about the existence of an implied marital agreement.

to cohabit, and the share of couples that are formed under a unilateral divorce regime. Even more interestingly, the right panel shows that the decrease in the share of couples that decide to marry instead of cohabiting over time accelerates once unilateral divorce is introduced. Since these two graphs do not control for possible confounders and do not provide a credible counterfactual, in this section we tackle these issues to offer more convincing evidence on the effect of unilateral divorce on $i)$ partnership choices and on $ii)$ the pool of people who cohabit.

Figure 2.1:
Newly formed relationships (either married or cohabiting) and unilateral divorce (U.D.)

(a) % new couples choosing marriage instead of cohabitation, % relationships starting under U.D.

(b) % new couples choosing marriage instead of cohabitation around U.D.



NOTES. The left panel shows in blue the evolution over time of the % of relationships formed in year t such that the couple chose marriage as opposed to unmarried cohabitation. The red line represents the % of relationships formed in t in a state that already adopted unilateral divorce by year t. The right panel shows the % of relationships where the couple chose to marry instead of cohabiting in a year whose distance in time from the introduction of unilateral divorce in that state is equal to d years. The red dotted lines are obtained by running linear regressions on a dummy for marriage, using the event time as the only regressor. All the variables presented in this figure are constructed with a sample of first and second relationships (which can be either marriage or cohabitation) from the 1988 wave of the NSFH: we provide further details about the survey and the sample construction in section 3. All the variables depicted in the two figures are constructed using sample weights.

2.3.1 Dataset

We begin by describing our data. We use the wave I (1987-1988) of the National Survey of Family and the Household (NSFH), and the National Survey of Family Growth (NSFG), 1988 wave. Both surveys were designed to study the causes and consequences of changes happening in families and households within the United States. This is reflected in detailed questions regarding the retrospective family history of respondents, including information about both marriage and cohabitation. Moreover, primary respondents are asked a large set of questions regarding their socio-economic background and the demographics of the household.[11] While the NSFH I is the first of three longitudinal waves, NSFG is made of several repeated cross sectional samples.[12] A drawback of using this data is that we know the state of residence of the respondents only at age 16 for the NSFH and at birth for the NSFG.[13] Since we also know whether people lived all their life in the same state, we can overcome this and perform our empirical analysis both on the universe and on the subsample of never movers. We will show that point estimates turn out to be statistically indistinguishable between the two samples. Further details regarding those two surveys can be found in Bumpass, Sweet, and Call 2017 and Mosher and Bachrach 1996. We use this dataset to build two samples, the one of *first and second relationships* and the one of *first cohabitations*, which are described below.

First and Second Relationships Sample. We build a sample to analyze the type of relationship that respondents decided to have, which can be either marriage or cohabitation. The sample is made of first and second relationships.[14] One first relationship is defined observing the first time (if ever) a certain person started cohabiting or married. This observation is associated with the date at which the relationship starts, the characteristics of the respondent member of the formed couple, and with a *type*, which can be either mar-

[11] One adult per household was randomly selected as the primary respondent, while in the NSFG respondents are all women of 15-44 years of age.

[12] We decided not to use the other two other waves of the NSFH because in the second wave all currently cohabiting households were dropped from the survey. Moreover, the 1988 wave of NSFG is the only one with publicly available information about the residence of the respondents, which is crucial for identifying the divorce regime that applies to the respondent.

[13] We do not have the choice of using other surveys for our analysis, since they either lack the state of residence variable, or they miss information about cohabitation history.

[14] Dating is not considered, since we cannot observe this state. Hence, people dating will fall under the category of singles.

riage or cohabitation. Note that the type of relationship of couples that cohabited before marriage is “cohabitation": the transition from cohabitation to marriage is analyzed using the sample of *first cohabitations*. Second relationships are defined in a similar fashion, but they include only respondents that ended the relationship with their first partner and started a new one with a different person. The way this sample is built implies that for some respondents we will have zero corresponding observations in this sample, while for others we will have one or two. We did not consider third or higher order relationships since these individuals would be further away from the age at which we knew their state of residence. Finally, we consider only relationships that lasted at least one month and started when the respondent was 20 years old or older. Relationships that started before 1955 are dropped to minimize the recall bias. In table 2.1 we report the descriptive statistics of this sample.

Table 2.1:
Descriptive statistics, relationship sample

Statistic	N	Mean	Median	St. Dev.
Unilateral Divorce Dummy	10,533	0.349	0	0.477
Age Relationship Starts	10,533	25.471	23	7.214
Married	10,533	0.650	1	0.477
College	10,533	0.252	0	0.434
Female	10,533	0.655	1	0.475
Birth year	10,533	1,950.016	1,952	10.630
NSFH Dummy	10,533	0.733	1	0.442

First Cohabitation Sample. This sample is built to analyze the decisions of cohabiting couples to breakup or to marry. It is composed of the first non-marital cohabitation experienced by respondents. This sample includes couples that cohabited before marriage, but it also includes cohabitations experienced by people with the following marital history: marriage without premarital cohabitation, divorce, cohabitation with a different person. Each observation of this sample is associated with a starting date, a possible ending date, and an outcome, which can be still cohabiting, married or breakup. In table 2.2 we report the descriptive statistics of this sample.

Table 2.2:
Descriptive statistics, cohabitation sample

Statistic	N	Mean	Median	St. Dev.
Unilateral Divorce Dummy	5,675	0.454	0	0.498
Age Cohabitation Starts	5,675	23.701	22	6.976
Year Cohabitation Starts	5,675	1,978	1,980	7.160
College	5,675	0.162	0	0.368
Female	5,675	0.758	1	0.428
Cohabitation Duration (months)	5,675	24.170	13	29.513
Year of birth	5,675	1,954	1,956	13.790
NSFH Dummy	5,675	0.562	1	0.496
Censored	5,675	0.102	0	0.303
Married	5,675	0.490	0	0.500
Separated	5,675	0.408	0	0.491

2.3.2 Empirical Evidence

Does unilateral divorce affect the partnership choice of couples? We exploit the timing in the adoption of unilateral divorce as a source of exogenous variation in the right to divorce.[15] This strategy has already been used several times in the literature to study the non-neutrality of the rights to divorce on various economic and demographic outcomes.[16] According to Gruber 2004, who reviews the legal literature about the topic, the introduction of unilateral divorce was not intended as a tool of social policy, but rather a way to reduce the legal burden of divorce trials. This reasoning is consistent with the fact that this change was not initiated by the most liberal states: New York

[15] See table B.1 for the timing of adoption of unilateral divorce.
[16] Among the others, see Wolfers 2006, Stevenson 2008, Voena 2015, Reynoso 2018 and Ciacci 2017.

was the last state to introduce unilateral divorce in October 2010, almost 40 years later than Kentucky. Moreover, Reynoso 2018 shows that there is no geographic correlation in adoption.

Relationship Choice

What is the effect of unilateral divorce on the partnerships that couples choose? To answer this question, we estimate equation (2.1), where i is the newly formed couples, t is the calendar time, and s is the state:

$$\text{married}_{i,t,s} = \beta_0 + \beta_1 \cdot \text{Unilateral}_{t,s} + \gamma' \mathbf{X}_i + \delta_s + \nu_t + \epsilon_{i,t,s}. \tag{2.1}$$

The dependent variable is a dummy that takes value 1 if the couple i, established at time t in state s is a marriage, and 0 if it is cohabitation. The vector $\mathbf{X}_i$ includes a set of socio-demographic controls, while δ_s are the state fixed effects and ν_t are the time fixed effects. The variable $\text{Unilateral}_{t,s}$ is a dummy that takes value 1 if unilateral divorce was in place in state s at time t: β_1 is the coefficient that is informative about the effect of unilateral divorce on partnership choice. The results of the estimation are reported in table 2.3 for different samples. Column (1) reports the results for the full sample described in section 2.3.1, while column (2) is restricted to observations for which we know that the person lived their own life in the reported states, ensuring that they did not migrate. Finally, columns (3) and (4) restrict the sample to respectively the NSFH and NSFG surveys only.

Table 2.3:
OLS Regression. Observation: first and second relationships

	Dependent variable: Married (0/1)			
	Full Sample	Resident	NSFH	NSFG
	(1)	(2)	(3)	(4)
Unilateral Divorce	-0.069^{***}	-0.088^{***}	-0.077^{***}	-0.067^{*}
	(0.020)	(0.021)	(0.025)	(0.037)
State Fixed effects	Yes	Yes	Yes	Yes
Birth Year dummies	Yes	Yes	Yes	Yes
Year established Fixed Effect	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes
Observations	10,533	6,846	7,722	2,811
R^2	0.146	0.166	0.163	0.139

NOTES: standard errors are clustered at the state level. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5% and ***1%.

The results reported in table 2.3 suggest that unilateral divorce decreased the share of couples that are married by $7-8\%$ depending on the specification. These results are robust to an alternative specification that includes state specific linear trends (table B.5), to the use of a multinomial logit that takes into account the triple choice between staying single, cohabiting and marrying (table B.9), and to dropping California from the sample (table B.7). Moreover, table B.10 shows that the shift towards cohabitation holds both for households where the respondent has some children and where she/he is childless and does not want any children. The limitations of using two-way fixed effects estimators is highlighted by a recent literature (Goodman-Bacon 2018 and de Chaisemartin and D'Haultfœuille 2020) that casts doubts on their validity when treatment effects are heterogeneous across time. We address these issues following the recommendation of Goodman-Bacon 2018 and use an event study design as a robustness check. The results, reported in figure B.2, show that the effect stays significant and is even slightly larger.

We then examine the heterogeneity hidden behind the effect of unilateral divorce. While in some states assets are split in the same way in both breakup and divorce, which is the case of *title-based regime* states, in others this rule is different, which is the case of *community property* and *equitable distribution* states. Analyzing this heterogeneity is interesting for understanding how much the asset sharing rule is important for understanding relationship choices. We hence estimate equation (2.2)

$$
\begin{aligned}
\text{married}_{i,t,s} = \beta_0 + &\beta_1 \cdot \text{Unilateral}_{t,s} \cdot \text{No Title Based}_{t,s} \\
&+ \beta_2 \cdot \text{Unilateral}_{t,s} \cdot \text{Title Based}_{t,s} + \\
&\quad \beta_3 \cdot \text{Title Based}_{t,s} + \gamma' \mathbf{X_i} + \delta_s + \nu_t + \epsilon_{i,t,s},
\end{aligned}
\tag{2.2}
$$

whose indexes and controls are the same as in equation (2.1), with the difference that now we capture the interaction of unilateral divorce with asset division regimes by interacting $\text{Unilateral}_{t,s}$ with $\text{Title Based}_{t,s}$ and $\text{No Title Based}_{t,s}$, which indicates whether state s at time t had or not a title-based regime. In table 2.4 we report the results of the estimation of equation 2.2. Similarly to table 2.3, column (1) reports the results for the full sample described in section 2.3.1, while column (2) is restricted to the observations for which we know that the person lived all their life in the reported states, which ensures that they did not migrate. Finally, columns (3) and (4) restrict the sample to respectively the NSFH and NSFG surveys only.

Table 2.4:
OLS Regression. Observation: first and second relationships

	Dependent variable: Married (0/1)			
	Full Sample	Resident	NSFH	NSFG
	(1)	(2)	(3)	(4)
UnDiv*NoTit	−0.074***	−0.090***	−0.084***	−0.068*
	(0.020)	(0.022)	(0.025)	(0.039)
UnDiv*Tit	−0.015	−0.053	−0.014	−0.046
	(0.031)	(0.037)	(0.040)	(0.048)
Tit	−0.014	−0.011	−0.011	−0.017
	(0.021)	(0.026)	(0.027)	(0.037)
State Fixed effects	Yes	Yes	Yes	Yes
Year established Fixed Effect	Yes	Yes	Yes	Yes
Birth Year dummies	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes
Observations	10,533	6,846	7,722	2,811
R^2	0.147	0.166	0.164	0.139

NOTES: standard errors are clustered at the state level. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5% and ***1%.

The results show that the effect of unilateral divorce on the likelihood that a couple chooses marriage over cohabitation in non-title-based states is significant with a magnitude between -7% and -9% depending on specification. At the same time, it is not significant and smaller in title-based states. These results suggest that having a sharing rule decided by the law is not enough to replace the mutual consent regime as an alternative commitment technology. These results are consistent with the view that the richest partner is less inclined to marry when divorce becomes unilateral, since they stand to lose more than their partner would upon divorce. This does not happen in a mutual consent regime, since they could exercise their right to veto the divorce. In a title-based state, this threat to the richer member of the couple does not exist. Hence marriage surplus with respect to cohabitation does not vary significantly. These results are robust to an alternative specification that includes state specific linear trends (B.6), to the use of a multinomial logit that takes into account the triple choice between staying single, cohabiting and marrying (B.9), and to dropping California from the sample (B.8).

Cohabitation Duration

What is the effect of unilateral divorce on cohabitation duration? How much of the change is due to a variation in the risk of breakup versus the risk of marriage? To answer this question, we construct a model of cohabitation duration with multiple risks, namely breakup and marriage. Our model builds on Jenkins 1995, who shows that a logistic regression can be used for studying the duration of events by reshaping the dataset to obtain unit of time per spells observations, where the dependent variable takes the value 1 whenever the event of interest occurs. The natural extension of this model to a multiple risk environment would be to use a multinomial logit. However, the problem with this model is that it assumes independence of irrelevant alternatives, which is particularly unappealing for our problem, since it would imply that the relative probability of choosing marriage over breakup stays the same after cohabitation is no longer an option. Hence, we chose to model cohabitation duration with a multinomial probit, where the independence of irrelevant alternatives does not need to be satisfied. We then study the choice of cohabiting couple i, at calendar time t in state s and at duration d estimating the following model:

$$\begin{aligned} Y^{\text{Marry}}_{i,s,t,d} &= \beta^{\text{Marry}} \cdot \text{Unilateral}_{s,t} + \gamma^{\text{Marry}'}\mathbf{X_i} + \alpha_d + \delta_s + \nu_t + \epsilon^{\text{Marry}}_{i,s,t,d}, \\ Y^{\text{Cohabit}}_{i,s,t,d} &= \beta^{\text{Cohabit}} \cdot \text{Unilateral}_{s,t} + \gamma^{\text{Cohabit}'}\mathbf{X_i} + \alpha_d + \delta_s + \nu_t + \epsilon^{\text{Cohabit}}_{i,s,t,d}, \\ Y^{\text{Breakup}}_{i,s,t,d} &= \beta^{\text{Breakup}} \cdot \text{Unilateral}_{s,t} + \gamma^{\text{Breakup}'}\mathbf{X_i} + \alpha_d + \delta_s + \nu_t + \epsilon^{\text{Breakup}}_{i,s,t,d}, \end{aligned} \tag{2.3}$$

where

$$\begin{pmatrix} \epsilon^{\text{Marry}}_{i,s,t,d} \\ \epsilon^{\text{Cohabit}}_{i,s,t,d} \\ \epsilon^{\text{Breakup}}_{i,s,t,d} \end{pmatrix} \sim \mathcal{N}(\mathbf{0}, \mathbf{\Sigma}), \tag{2.4}$$

and

$$Y_{i,s,t,d} = \begin{cases} \text{Marry} & \text{if} \quad Y^{\text{Marry}}_{i,s,t,d} > Y^{\text{Cohabit}}_{i,s,t,d} \text{ and } \quad Y^{\text{Marry}}_{i,s,t,d} > Y^{\text{Breakup}}_{i,s,t,d} \\ \text{Cohabit} & \text{if} \quad Y^{\text{Cohabit}}_{i,s,t,d} > Y^{\text{Marry}}_{i,s,t,d} \text{ and } \quad Y^{\text{Cohabit}}_{i,s,t,d} > Y^{\text{Breakup}}_{i,s,t,d} \\ \text{Breakup} & \text{otherwise.} \end{cases} \tag{2.5}$$

Note that $\text{Unilateral}_{s,t}$ does not have the subscript d since this variable takes value 1 if cohabitation started under a unilateral divorce regime and 0 otherwise. The model described above is estimated with Bayesian techniques via Markov chain Monte Carlo following the procedure of Imai and Van Dyk 2005, which is implemented using the standard options provided by the R package *MNP* developed by Imai et al. 2005. In table 2.5 we report results from the full sample in column (1), from the resident only sample in column (2) and from the observations coming from only the NSFH and NSFG surveys respectively in columns (3) and (4). Table 2.5 reports the parameters of the multinomial probit and the average relative risk that the event of interest (marriage of breakup) is realized.[17] The results show that unilateral divorce caused an increase in cohabitation duration, which comes from a reduced hazard both of marriage and of breakup. While the result about the risk of marriage is not unexpected in light of the estimation results described above, the reduced risk of breakup brings new insights about the possible mechanisms underlying partnership choices. In fact, the decrease in the risk of breakup is consistent with a selection effect: some cohabiting couples would have married if mutual consent divorce was still in place. If the match quality of cohabitations is lower than that of marriages,[18] unilateral divorce drives down the risk of breakup because of a selection effect. In appendix B.7 we provide a robustness check for the duration analysis of cohabitation. More specifically, we estimate two linear models: in the first one the dependent variable is a dummy taking value 1 if in that month the couple married (table B.11), while in the second one the dependent variable is a dummy taking value 1 if that month the couple married (table B.12). The samples and the controls are the same used for the multinomial probit reported in table . This additional analysis confirms that cohabiting couples formed after the introduction of unilateral divorce last longer because of a lower risk of breaking up and marrying.

[17] These risks are computed relatively to the probability to continue cohabiting.
[18] This seems plausible because the risk of divorce is much lower than the risk of breakup.

Table 2.5:
Multinomial Probit. Observation: person-month of cohabitation

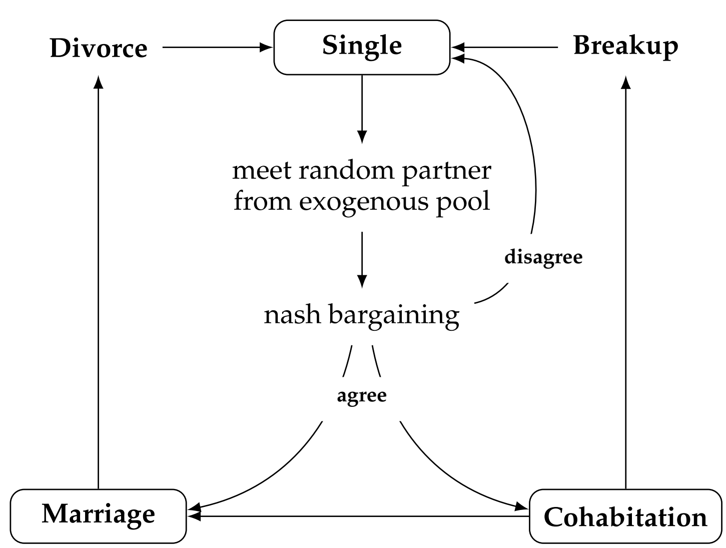
	Full Sample	Resident	NSFH	NSFG
	(1)	(2)	(3)	(4)
	Risk of Marriage relative to Cohabitation			
Unilateral Divorce	-0.24^{***}	-0.25^{***}	-0.28^{***}	-0.28^{***}
	(0.06)	(0.08)	(0.09)	(0.09)
Average Relative Risk	0.64	0.63	0.59	0.6
	Risk of Breakup relative to Cohabitation			
Unilateral Divorce	-0.19^{***}	-0.16^{***}	-0.08	-0.24^{*}
	(0.07)	(0.06)	(0.05)	(0.14)
Average Relative Risk	0.67	0.71	0.83	0.62
State Fixed effects	Yes	Yes	Yes	Yes
Year Fixed effects	Yes	Yes	Yes	Yes
Age Polynomial	Yes	Yes	Yes	Yes
Pice-wise Duration	Yes	Yes	Yes	Yes
Observations	138012	81920	77826	60186
Censored spells(%)	10.18	10.98	11.6	8.38

NOTES: the values reported in the table are the mean and the standard deviation (in parenthesis) of the posterior distribution of parameters obtained using the Markov chain Monte Carlo estimation described by Imai and Van Dyk 2005. Coefficients' distributions whose interpercentile range do not contain 0 are denoted by the following system: *90%, **95% and ***99%.

2.4 Theory

To identify the channels through which unilateral divorce impacts partnership choice, we develop a dynamic life-cycle model of partnership formation and dissolution, savings, female labor force participation and home production. Couples act cooperatively, and according to the divorce regime they can be subject to limited commitment, which means that there might be renegotiations in response to changes in the outside options, which are assumed to be divorce or breakup. Time is discrete and in each period men and women draw their productivities. If single, with some probability they meet a potential partner: after drawing a match quality shock they decide whether to marry, cohabit or stay single. Couples observe the match quality shock, their productivity and assets, and decide whether to stay together or to split. Cohabiting couples can also decide whether to marry. Both singles and couples make consumption and saving decisions, using their money for private or public good expenditure. Couples also make female labor participation decisions and women's time can be used to produce public goods, but this comes at the cost of a loss in productivity.

Figure 2.2



2.4.1 Preferences

Women f and men m derive utility from consuming a private good c and a household public good Q. The public good can be interpreted in terms of both the quantity and quality of children, as well as the goods and services produced within the household, such as washing clothes or preparing meals. Preferences are separable in the two goods and across time. Agents derives utility from a couple specific love shock ψ, which evolves over time and can be interpreted as the value of love and companionship in a couple. The intra-period utility of a single agent $s \in (f, m)$ is:

$$u(c_t^s, Q_t^s) = \frac{c_t^{s\,1-\sigma}}{1-\sigma} + \alpha \frac{Q_t^{s\,1-\xi}}{1-\xi},$$

where the superscript s on Q accounts for the fact that there is no partner to share the public good. The utility for an agent $s \in (f, m)$ in a couple is:

$$u^C(c_t^s, Q_t) = \frac{c_t^{s\,1-\sigma}}{1-\sigma} + \alpha \frac{Q_t^{1-\xi}}{1-\xi} + \psi_t,$$

where the match quality ψ evolves according to the following law of motion:

$$\psi_t = \psi_{t-1} + \epsilon_t, \text{ where } \epsilon_t \overset{\text{i.i.d.}}{\sim} \mathcal{N}(0, \sigma_\psi^2).$$

The love shock at first meeting can have a different variance, denoted by $\sigma_{\psi,I}^2$. Note that if the couple is cohabiting, the utility of the two partners is decreased by γ. This parameter captures the stigma associated with premarital sex, premarital cohabitation and out-of-wedlock births. This assumption fits the fact that for people born in 1940-1955 (whose behavior will be used to build the target moments for the structural estimation) conservative attitudes towards premarital sex were common.[19]

[19]The shame associated with an out-of-wedlock birth, whose interaction with technology is studied by Fernández-Villaverde, Greenwood, and Guner 2014, can be a factor leading young women to prefer

2.4.2 Wages

The labor income for agents $s \in \{f, m\}$ depends on their age t and on a permanent income component z_t^s:

$$\ln(w_t^s) = f_t^s + z_t^s,$$

where f_t^s is a gender specific function that captures the evolution of productivity over age. The permanent income component z_t^s evolves over time as:

$$z_t^s = z_{t-1}^s - (1 - P_t^s)\mu + \zeta_t^s, \text{ where } \zeta_t^s \overset{\text{i.i.d.}}{\sim} \mathcal{N}(0, \sigma_\zeta^{2s}), \text{ and } \zeta_1^s = z_1^s. \tag{2.6}$$

where P_t^s is a dummy of labor force participation. Men and single women are always assumed to participate in the labor market, hence $P_t^m = 1$.[20] Parameter μ is the loss in productivity that affects women that are not participating in the labor market. It can be interpreted as a reduced form way of capturing both the missed opportunity to accumulate human capital while working and the skill atrophy from interruptions Adda, Dustmann, and Stevens 2017. Modeling the loss in productivity for not working is an important feature of our model as it creates an incentive to join the labor force for women that expect to divorce or breakup soon.

2.4.3 Home Production

In our model each agent has one unit of time. Singles and men in a couple supply inelastically a fraction $1 - \phi$ of their time to the labor market, while women in a couple

marriage over cohabitation even if the rules governing these two partnerships were identical. Blasutto 2020 can match marriage and cohabitation choices closely using a theoretical framework close to ours, without needing to introduce a stigma towards cohabitation. This result is possible because he analyzes the behavior of people born in 1980-1984, for whom the stigma towards premarital sex and premarital cohabitation is arguably lower than for those born in 1940-1955.

[20] The assumption that men, as opposed to women, always participate in the labor market is rather common in the literature (Ciscato 2019; Low et al. 2018; Voena 2015) and it is in line with the gender roles typically observed in the period under analysis. In our PSID sample only 5% of men between 20 and 60 do not supply working hours in the market.

can be out of the labor force, devoting their time producing the home good Q. The public good can also be produced buying d goods in the market. Following Greenwood et al. 2016 we define the production function of home goods for couples as:

$$Q_t = [(\underbrace{d_t}_{\text{money}})^{\nu} + \kappa(\underbrace{\phi}_{\text{men's time}} + \underbrace{(\phi + (1 - P_t^f)(1 - \phi))}_{\text{women's time}})^{\nu}]^{\frac{1}{\nu}}, \text{ where } 0 < \nu < 1, \tag{2.7}$$

while for singles of gender $s \in \{f, m\}$

$$Q_t^s = [(\underbrace{d_t^s}_{\text{money}})^{\nu} + \kappa(\underbrace{\phi}_{\text{time}})^{\nu}]^{\frac{1}{\nu}}. \tag{2.8}$$

The parameter ν captures the degree of substitutability between women's time and the use of market goods in the production of home goods.[21] This structure implies that when the relative price of d_t decreases and when wages go up,[22] women spend less time producing household goods and their employment outside the home increases.

2.4.4 Budget Constraints

The budget constraint of a single agent of gender $s \in \{f, m\}$ is:

$$a_{t+1}^s = Ra_t^s + w_t^s(1 - \phi) - c_t^s - d_t^s, \text{ with } a_{t+1}^s \geq 0, \tag{2.9}$$

where a^s are agent's savings and w^s is the wage. c^s and d^s are the private good consumption and the expenditure used to produce the public good. The budget constraint for a couple is:

$$a_{t+1}^f + a_{t+1}^m = Ra_t + w_t^m(1 - \phi) + P_t^f w_t^f(1 - \phi) - c_t^f - c_t^m - d_t, \text{ with } a_{t+1} \geq 0, \tag{2.10}$$

[21] Market goods d include both durables goods, such as the washing machine, and services that can be bought on the market, such as a nanny that takes care of children.

[22] The relative price of d_t is normalized to 1 in equations (2.7) and (2.8)

When a couple divorces in t, we assume

$$a_t^m + a_t^f = \delta a_t,$$

where δ is the fraction of total assets a_t left after divorce. We assume $\delta = 1$ for breakup.[23] An important feature of our model is the role of property rights, which defines how assets are divided upon divorce/breakup. Since we use data from community property states to estimate the model, this regime applies to divorce. Accordingly, upon divorce each spouse keeps half of the assets, while the division of assets upon breakup is a couple's decision. We describe the details of this choice in this section, where the problem of the cohabiting couple is presented.

2.4.5 Problem of the Singles

We start by describing the problem for a single agent $i \in \{f, m\}$ in t. The agent makes consumption, saving and expenditure decisions. In $t+1$ she meets a potential partner j of the opposite sex with probability λ_{t+1} and she can decide to enter a partnership, which also depends on whether the potential partner will agree. If the two decide to marry, the variable M_{t+1} will take value 1, while $C_{t+1} = 1$ if the couple decides to cohabit. Otherwise, M_{t+1} and C_{t+1} will be equal to 0. The state variable of a single is $\omega_t^i = \{a_t^i, z_t^i\}$, while her choices are represented by the vector $\mathbf{q}_t^i = \{a_{t+1}^i, c_t^i, d_t^i\}$. We denote by $V_t^{i,S}(\omega_t^i)$

[23]The assumption that divorce erodes a fraction of wealth is common to Cubeddu and Ríos-Rull 2003. In appendix B.2 we provide evidence that divorce results in a loss of net worth for rich but not for poor households. Moreover, we do not find evidence of a loss of net worth following breakup for rich and poor households. In practice, the cost of breakup is positive because of psychological distress associated with separation and because looking for new accommodation takes time. However, these costs are common with divorce and hence they do not help explaining why couples should choose one partnership over the others. When we tried estimating the model allowing for a positive cost of breakup, this parameter was not identified.

the value function of agent i, which we define as

$$\begin{aligned} V_t^{iS}(\omega_t^i) = &\max_{\mathbf{q}_t^i} u(c_t^i, Q_t^i) + \beta E_t \Big\{ (1-\lambda_{t+1}) V_{t+1}^{iS}(\omega_{t+1}^i) + \\ &\lambda_{t+1}\big\{(1-M_{t+1})(1-C_{t+1}) V_{t+1}^{i,S}(\omega_{t+1}) + \\ &M_{t+1} V_{t+1}^{i,M}(\Omega_{t+1}) + C_{t+1} V_{t+1}^{i,C}(\Omega_{t+1})\big\} \Big\}, \\ &\text{s.t. (2.9) and (2.8),} \end{aligned} \tag{2.11}$$

where $V^{i,M}$ and $V^{i,C}$ are the individual values of being married and cohabiting.

2.4.6 Household Planning Problem

The problem faced by the couple depends both on the type of relationship—cohabitation or marriage—and on the divorce regime, which can be either *mutual consent* or *unilateral divorce*. Breakup is always unilateral. Under the unilateral regime, one partner can initiate the breakup/divorce process alone, while under mutual consent the agreement of both partners is needed.

Mutual Consent Regime

Under a mutual consent regime, marriage is denoted by $\hat{M}$. Couples solve a Pareto problem where the weight of the wife is θ^f and that of the husband is $1 - \theta^f$.[24] The state vector is $\Omega_t^{\hat{M}} = \{a_t^m, a_t^f, z_t^f, z_t^m, \psi_t, \theta^f\}$, while the variables over which the couple maximizes are summarized by the vector $\mathbf{q}^{\hat{M}_t} = \{a_{t+1}^f, a_{t+1}^m, d_t, c_t^m, c_t^f, P_t^f, D_t\}$, where D_t is a dummy variable that takes value 1 if divorce occurs and 0 otherwise. The formal

[24] Later in this section we describe how initial Pareto weights are set.

problem solved by a couple who enters period t as married is:

$$\begin{aligned} V_t^{\hat{M}}(\Omega_t^{\hat{M}}) = &\max_{\mathbf{q}_t^M}(1-D_t)\{\theta^f u(c_t^f, Q_t) + (1-\theta^f)u(c_t^m, Q_t) + \psi_t + \beta E_t V_{t+1}^{\hat{M}}(\Omega_{t+1}^{\hat{M}})\} \\ &+ D_t\{\theta^f V_t^{fS}(\omega_t^f) + (1-\theta^f)V_t^{mS}(\omega_t^m))\} \\ \text{if } D_t = 0: &\quad \text{s.t. (2.10) and (2.7)} \\ \text{if } D_t = 1: &\quad \text{s.t. (2.9), (2.8) for } i \in \{f, m\}, \\ &\quad a_t^m + a_t^f = \delta a_t, \\ &\quad V_t^{fS}(\omega_t^f) \geq W_t^{f\hat{M}}(\Omega_t^{\hat{M}}), \\ &\quad V_t^{mS}(\omega_t^m) \geq W_t^{m\hat{M}}(\Omega_t^{\hat{M}}). \end{aligned} \tag{2.12}$$

The individual value of marriage conditional on $D_t = 0$ is $W_t^{i\hat{M}}$ for $i \in \{F, M\}$, and it is defined as

$$W_t^{i\hat{M}} = u(\tilde{c}_t^i, \tilde{Q}_t) + \psi_t + \beta E_t V_{t+1}^{i\hat{M}}(\Omega_{t+1}^{\hat{M}}), \tag{2.13}$$

where $\tilde{\mathbf{q}}_t^{\hat{M}} = \{\tilde{a}_{t+1}^m, \tilde{a}_{t+1}^f, \tilde{d}_t, \tilde{c}_t^m, \tilde{c}_t^f, \tilde{P}_t^f\}$ is the $\arg\max$ of problem (2.12) conditionally on having chosen $D_t = 0$. $V_{t+1}^{i\hat{M}}(\Omega_{t+1}^{\hat{M}})$ can be obtained by the expectation of the sum of the time utilities that the agent gets from $t+1$ to T, where the variables entering the utility function derive from the Pareto problem if the agent is in a relationship, otherwise they are the solution of (2.11), which represents the singles' problem.

Under the mutual consent regime, the allocation corresponds to the Pareto efficient solution if the couple is intact. Intuitively, the fact that Pareto weights stay constant allows for functioning risk-sharing and the female labor force participation decisions are taken cooperatively, ruling out the possibility that women over-supply labor to increase their bargaining power. In this framework, the conditions for divorce are particularly stringent: the couple splits only if both partners are better-off divorcing than staying together for a feasible allocation. Moreover, suppose only one spouse wishes to divorce under the divorce allocation dictated by the law where assets are split equally. In that case, they will "bribe" the other by offering a larger share of assets to make them indifferent between staying married and divorcing.[25]

Unilateral Divorce Regime

Under the unilateral divorce regime marriage is denoted by $\overline{M}$. Couples solve a Pareto problem where the weight of the wife is θ_t^f and that of the husband is θ_t^m. Note that, unlike in the mutual consent regime, Pareto weights can vary over time. The state vector of this problem is $\Omega_t^{\overline{M}} = \{a_t, z_t^f, z_t^m, \psi_t, \theta_t^f, \theta_t^m\}$, while the variables over which the couple maximize are summarized by the vector $\mathbf{q}_t^{\overline{M}} = \{\tilde{a}_{t+1}, \tilde{d}_t, \tilde{c}_t^m, \tilde{c}_t^f, \tilde{P}_t^f\}$.[26] The formal problem of a couple entering t as married is:

$$
\begin{aligned}
V_t^{\overline{M}}(\Omega_t^{\overline{M}}) = &\max_{\mathbf{q}_t^{M}} (1-D_t)\{\theta_t^f u(c_t^f, Q_t) + \theta_t^m u(c_t^m, Q_t) + \psi_t + \beta E_t V_{t+1}^{\overline{M}}(\Omega_{t+1}^{\overline{M}})\} \\
&+ D_t\{\theta_t^f V_t^{fS}(\omega_{t+1}^f) + \theta_t^m V_t^{mS}(\omega_t^m))\} \\
\text{if } D_t = 0: \qquad & \text{s.t. (2.10) and (2.7)}, \\
& \theta_{t+1}^f = \theta_t^f + \mu_t^f, \\
& \theta_{t+1}^m = \theta_t^m + \mu_t^m, \\
\text{if } D_t = 1: \qquad & \text{s.t. (2.9), (2.7) for } i \in \{f, m\}, \\
& a_t^m + a_t^f = \delta a_t, \\
& a_t^m = a_t^f,
\end{aligned} \tag{2.14}
$$

[25]Note that if both partners are better off divorcing under the sharing rule dictated by the law, which corresponds to an equal division in community property states, no bribing happens.

[26]Since we analyze community property states, the assets of husband and wife are jointly owned and hence a_t^m, a_{t+1}^m and a_t^f, a_{t+1}^m do not appear separately as state and choice variables. Under the mutual consent regime we included these as the state and choice varibles because they had a role during divorce (only), since one spouse could bribe the other to divorce.

where θ^f_{t+1} and θ^m_{t+1} adjust such that the following participation constraints are satisfied:

$$\begin{aligned} W^{f\overline{M}}_t(\Omega^{\overline{M}}_t) &\geq V^{fS}_t(\omega^f_t), \\ W^{m\overline{M}}_t(\Omega^{\overline{M}}_t) &\geq V^{mS}_t(\omega^m_t). \end{aligned} \tag{2.15}$$

Note that μ^i_t are the Lagrange multipliers associated with spouses' participation constraints. The individual value of marriage conditional on $D_t = 0$ is denoted by $W^{i\overline{M}}_t$ and it can be obtained following the procedure described in the mutual consent regime section.

Under the unilateral divorce regime Pareto weights vary every time one participation constraint is binding. Whenever a spouse is better off divorcing, the other member will try to convince them not to split by offering them more bargaining power, such that she is indifferent between divorcing and staying married. In this framework risk-sharing is less functional than under the mutual consent regime, since variations in the Pareto weight imply less smooth consumption patterns over time. Labor market specialization is also less functioning, since conditionally on having the same state variables, the risk of divorce is higher, which makes women willing to insure against this event through labor market participation. While cooperation is more effective under mutual consent than unilateral divorce, it is still possible that the individual value of being married under the latter regime is larger. This is possible because of the possibility of exiting the marriage without the consent of the other spouse.

Cohabitation

The problem of cohabiting couples is like that of marriage under the unilateral divorce regime, but it differs in three crucial ways. First, there is no loss of assets upon breakup. Second, the choice set of the cohabiting couple $\mathbf{q}^C_t = \{a_{t+1}, d_t, c^m_t, c^f_t, P^f_t, D_t, M_t, \chi_{t+1}\}$ and the state variables $\Omega^C_t = \{a_t, , z^f_t, z^m_t, \psi_t, \theta^f_t, \theta^m_t, \chi_t\}$ are different. Note that M_t is a dummy that indicates the choice of marrying. Variable χ_t is the share of assets going to the woman in case of breakup.[27] Third, the time utility of the cohabiting couple is decreased by γ. The problem of the cohabiting couple can be found in section B.4 of the appendix.

The fact that there is not breakup cost makes risk-sharing and cooperation less functional compared to marriage. This happens because the couple is left without a commitment-enhancing technology, which would have allowed the couple to improve its ability to commit.[28] On the other hand, assuming no cost of breakup makes cohabitation more appealing to couples whose risk of splitting is high. For example, this is the case of couples with a low match quality.

Property rights upon divorce/breakup differ between marriage and cohabitation. In the former, assets are divided equally when the couple splits, while in the latter assets are divided according to individual property rights. We model property rights at breakup following Bayot and Voena 2015, where upon divorce assets are split following the sharing rule decided by the couple in the previous period.[29] They show that this regime is always preferred to community property if outside options are invariant to property right regimes. This result implies that if $i)$ the costs of breaking up and divorcing were the same and $ii)$ there was no stigma towards cohabitation, the value of cohabitation would always be higher than that of marriage. The benefits of having a positive cost of divorce and the stigma linked to cohabitation allow us to generate a positive number of marriages and match the data.

[27] The way we model the title-based regime follows Bayot and Voena 2015.

[28] Under the limit case of an infinite cost of splitting, as long as the couple stays intact the allocation under the mutual consent and unilateral divorce regimes are the same and correspond to the inter-temporal Pareto-efficient allocation.

[29] Bayot and Voena 2015 study the choice between community and separation of property in Italy. Separation of property resembles the American title-based regime, which also applies to cohabitation.

2.4.7 Partnership Choice and the Mating Market

In each period t singles have a probability λ_t of meeting a potential partner. The productivity and the assets of the potential partner depend on the single agent's characteristics. Formally, the assets of the potential partner p are defined as:

$$\ln(a_t^p) = \ln(a_t^s) + \overline{a}^g + \epsilon^a, \tag{2.16}$$

where a_t^s are the assets of the individual, $\overline{a}_t^g$ is a number that depends on gender and ϵ^a is a normally distributed shock. The productivity of the potential partner is defined as:

$$\ln(z_t^p) = \alpha(\ln(\overline{z}_t^{s^*,i^*}) + \epsilon_t^z) + (1-\alpha)\ln(z_t^s), \tag{2.17}$$

where $\overline{z}_t^{s^*,i^*}$ represents the average productivity of singles of gender s^*, z_t^s is the productivity of the agent net of the gender and education-specific trend, while ϵ_t^z is a normally distributed shock. These assumptions capture in a reduced form fashion that people are mating assortatively both within marriage and cohabitation. Once the meeting occurs, agents must decide whether to stay in a couple and eventually decide which partnership contract to choose, and they must pick a Pareto weight. We now describe how these decisions are taken. Note that for the rest of this section we refer to marriage as M, where $M \in \{\hat{M}, \overline{M}\}$ depending on the divorce regime. The decisions follow a three-steps procedure.

1. The couple considers marriage M (cohabitation C) as a viable alternative if the set of Pareto weights θ^f such that the couple prefers to marry (cohabit) is non-empty.[30] Formally, for relationship $J \in \{M, C\}$ the set is

$$\Theta_t^J(\Omega_t^J, \omega_t^f, \omega_t^m) = \left\{\theta_t^f : V_t^{fJ}(\Omega_t^J) \geq V_t^{fS}(\omega_t^f), V_t^{mJ}(\Omega_t^J) \geq V_t^{mS}(\omega_t^m)\right\}. \tag{2.18}$$

[30]Without loss of generality, we impose $\theta_t^f + \theta_t^m = 1$ at first meeting.

2. If the set for marriage (cohabitation) is non-empty, the Pareto weight for the potential marriage $\theta_t^{M,f}$ (cohabitation $\theta_t^{C,f}$) is set through symmetric Nash Bargaining.[31] Formally $\theta_t^{J,f}$ is set to :

$$\theta_t^{J,f} = \underset{\theta_t^f \in \Theta_t^J}{\arg\max}\, \Upsilon^J(\theta_t^f, \Omega_t^{J-1}, \omega_t^f, \omega_t^m), \tag{2.19}$$

where Ω_t^{J-1} is the state vector of the couple excluding Pareto weights and

$$\Upsilon^J(\theta_t^f, \Omega_t^{J-1}, \omega_t^f, \omega_t^m) = \left[V_t^{fJ}(\Omega_t^{J-1}, \theta_t^f) - V_t^{fS}(\omega_t^f)\right] \times \left[V_t^{mJ}(\Omega_t^{J-1}, 1-\theta_t^f) - V_t^{mS}(\omega_t^m)\right]. \tag{2.20}$$

3. Four possible situations can arise:

- $\Theta_t^M =$ and $\Theta_t^C \Rightarrow$ stay single.
- $\Theta_t^M \neq$ and $\Theta_t^C \Rightarrow$ marry.
- $\Theta_t^M =$ and $\Theta_t^C \neq \ \Rightarrow$ cohabit.
- $\Theta_t^M \neq$ and $\Theta_t^C \neq \ \Rightarrow$ the couple chooses the partnership that gives the largest Nash product. Formally, if $\Upsilon^M(\theta_t^{M,f}, \Omega_t^M, \omega_t^f, \omega_t^m) \geq \Upsilon^C(\theta_t^{C,f}, \Omega_t^C, \omega_t^f, \omega_t^m)$ the couple chooses marriage, otherwise cohabitation.

2.5 Estimation

We estimate the structural model following a two-step procedure. The first step is to set some parameters following the literature or by matching some features of the data without the need to simulate the model. In particular, we estimate the labor income processes of men and women outside the model: this procedure is common in the

[31] The assumption that the initial Pareto weight is pinned down by Nash Bargaining can be found in Mazzocco 2007 and Low et al. 2018.

literature because it reduces the burden on structural estimation.[32] The second step is to estimate by indirect inference the remaining parameters of the model. In this section we detail the steps of the estimation, we discuss the identification of the structural parameters and we present the results.

2.5.1 Income Processes

The income processes of men and women are estimated using the 1968-1993 waves of the PSID, including people between age 20 and 65. We further restrict our sample by retaining men who are household heads or men who are married/cohabiting with the household head or who are household heads themselves. Similarly to Low et al. 2018, we drop observations where the hourly wage is less than half the minimum wage and where the hourly wage changes by more than 125% in two consecutive years. We compute the hourly wage rate of men and women, dividing the annual labor income by the number of yearly working hours supplied. This procedure avoids treating a variation in working hours as a productivity shock. This correction is particularly relevant for the estimation of the income process of women, because their hours worked vary significantly over the life-cycle. The income process of men is estimated by fitting the following linear model:

$$\ln(w^m_{i,t,s,sur}) = \iota^m_0 + \iota^m_1 \cdot t + \iota^m_2 \cdot t^2 + \delta_s + \nu_{sur} + u^m_{i,t,s,sur}, \tag{2.21}$$

where i stands for individual, t for age, s for state and sur for survey year. Moreover, $u^m_{i,t,s,sur} = z^m_t + e^m_{i,t,s,sur}$, where z^m_t follows equation 2.6, while $e^m_{i,t,s,sur}$ is the measurement error. δ_s are state fixed effects and ν_{sur} are year of the survey fixed effects. The results are reported in table B.2. Then, using the residuals $\hat{u}^m_t$, we estimate through GMM 1) the variance of the permanent component of income σ^{2m}_{ζ}, 2) the variance of the measurement

[32] See for example Voena 2015, Reynoso 2018 and Gourinchas and Parker 2002.

error σ_e^{2m} using the following conditions:

$$\begin{aligned} E((\Delta\hat{u}_t^m)^2) &= \sigma_\zeta^{2m} + 2\sigma_e^{2m} \\ E(\Delta\hat{u}_t^m \Delta\hat{u}_{t-1}^m) &= -\sigma_e^{2m} \end{aligned} \tag{2.22}$$

Results are reported in table 2.6.

The estimation of women's income process differs from the men's one since we need to consider the endogeneity of female labor force participation. We do so by using a two-step Heckman selection correction procedure. The first step consists in estimating a probit model where the dependent variable is female labor force participation and the independent variables includes all the regressors in equation (2.21) plus the interaction of a dummy variable for unilateral divorce with the dummy variables for the property rights regimes upon divorce. These variables are used as an exclusion restriction following the work of Voena 2015, who finds that these affect female labor force participation by influencing intra-household bargaining.[33] Women participate in the labor market if

$$\gamma' \mathbf{Z}_{i,t,s,sur} + \pi_{i,t,s,sur} > 0, \tag{2.23}$$

where $\pi_{i,t,s,sur}$ is the sum of the measurement error and the permanent component of income and $\mathbf{Z}_{i,t,s,sur}$ contains the regressors. The second setup is estimating the following linear model:

$$\ln(w^f_{i,t,s,sur}) = \iota^f_0 + \iota^f_1 \cdot t + \iota^f_2 \cdot t^2 + \delta_s + \nu_{sur} + \varphi_{i,t,s,sur} + u^f_{i,t,s,sur}, \tag{2.24}$$

where i stands for individual, t for age, s for state and sur for survey year. Moreover, $u^f_{i,t,s,sur} = z^f_t + e^f_{i,t,s,sur}$. z^f_t follows equation 2.6, while $e^f_{i,t,s,sur}$ is the measurement error. δ_s

[33] Voena 2015 and Reynoso 2018 already used the interaction between grounds of divorce and division of property as an exclusion restriction for female labor force participation.

and ν_{sur} are respectively state and year of the survey fixed effects. The endogeneity of female labor force participation is considered by controlling for $\varphi_{i,t,s,sur}$, the inverse of the Mills ratio of the prediction obtained in the first step. The estimation results of the two steps are reported in tables B.4 and B.3. We then use the regression residuals from the second step $\hat{u}_t^m$ to estimate through GMM 1) the variance of the permanent component of income σ_ζ^{2f}, 2) the variance of the measurement error σ_e^{2f} using the following conditions:[34]

$$\begin{aligned} E(\Delta\hat{u}_t^f|P_t^f = 1, P_{t-1}^f = 1) &= \sigma_\pi^f \frac{\phi(\tau_t)}{1-\Phi(\tau_t)}, \\ E((\Delta\hat{u}_t^f)^2|P_t^f = 1, P_{t-1}^f = 1) &= \sigma_\zeta^{2f} + \sigma_\pi^{2f} + 2\sigma_e^{2f} + \tau_t \frac{\phi(\tau_t)}{1-\Phi(\tau_t)}, \\ E(\Delta\hat{u}_t^f \Delta\hat{u}_{t-1}^f|P_t^f = 1, P_{t-1}^f = 1, P_{t-2}^f = 1)) &= -\sigma_e^{2f}. \end{aligned} \tag{2.25}$$

where $\phi()$ and $\Phi()$ are respectively the density and the distribution function of a standardized normal, while $\tau_t = -\gamma'\mathbf{Z}_{i,t,s,sur}$. Results are displayed in table 2.6.

[34]The conditions are those used by Low et al. 2018.

Table 2.6:
Parameters of the income processes

Parameter	Symbol	Value
f's age return (constant)	ι_0^f	-0.383
f's age return (linear component)	ι_1^f	0.0244
f's age return (squared component)	ι_2^f	-0.0005
Variance of f's permanent income shock	$\sigma_\zeta^{2_f}$	0.0399
m's age return (constant)	ι_0^m	-0.342
m's age return (linear component)	ι_1^m	0.0495
m's age return (squared component)	ι_2^m	-0.0009
Variance of m's permanent income shock	$\sigma_\zeta^{2_m}$	0.0417

NOTES: The parameters are estimated using nonlinear least squares using single, cohabiting and married males and females from the PSID.

2.5.2 Preset Parameters

In this section we describe how we fix the set of preset parameters. Each period in the model lasts 1 year: we chose this length balancing the benefits of having a short period, which fits the fact that cohabitation spells are particularly short, and the computational burden associated with having too many periods. We assume that men (women) start making decisions at age 20 (18). Couples are always formed by men who are 2 years older than women. Agents retire at the age of 62 and the number of periods in the model is $T = 62$. The discount factor β and the relative risk aversion σ of private goods match those in Attanasio, Low, and Sánchez-Marcos 2008. The annual interest rate is set to 2%. The parameters relevant to the production of public goods, ν and κ match those in

McGrattan, Rogerson, and Wright 1997. As far as the pensions are concerned, I follow Heathcote, Storesletten, and Violante 2010: they consider the progressive nature of the US system but they simplify it, assuming that only the last period before retirement is relevant for the amount of the pension that a person receives. Parameter ϕ is set to 0.189 to reflect the relative time that singles spend on house works relative to the time spent on the labor market.[35] Wages are normalized such that average log wages of male at age 30 is 0. The variance of male (female) earnings at age 20 (18), $\sigma^{2_m}_{\zeta,1}$ $(\sigma^{2_f}_{\zeta,1})$ is taken directly from the PSID data. The parameters regarding the mating market, contained in equations 2.16 and 2.17, are pinned down to obtain a realistic degree of assortative mating with respect to assets and wages. In particular, we target the correlation in log wages in the PSID and the share of households with family income above the median whose wealth is also above the median in the Survey of Consumer Finances (SCF). The parameters of the mating market are pinned down to respect a second condition, which is *symmetry*. For example, married men at age t should have on average the same wage and wealth regardless of being simulated for their life cycle, or being partners of women who are simulated for their whole life cycle.[36] Since we set these parameters before the structural estimation occurs, we cannot perfectly match the mating market moment we targeted. The correlation in log wages of couples in the PISD is 0.58 versus 0.62 in the simulated sample,[37] while the share of people with wealth above the median, conditionally on

[35]In the PSID the average yearly time spent on house work by singles is 465.5 hours. Assuming that the yearly hours of full-time work in the labor market is 2000, we get $\phi = 465.5/(465.5 + 2000) = 0.189$. The median number of yearly hours spent in the labor market for single men is 1976, while for single women is 1848. We considered the 1940-1955 birth cohorts of the PSID for these computations because the moments that we use in the structural estimation are based on the behavior of people born in those years.

[36]The agents who belong to our fictional sample are simulated for their whole life cycle and they marry/cohabit with partners that they meet randomly. We follow the partners' behavior while they are in a relationship with the person in our fictional sample. Figure B.6 shows the mean and variance of productivity and wealth by age, both for agents belonging to the "fictional sample" and their "partners." The variables of interest are similar for the two groups, which means that the two groups are symmetric concerning these variables.

[37]We obtain this value by simulating the behavior of agents under the parametrization of deep parameters described later in this section.

having a family income above the median, is 0.76 in the Survey of Consumer Finances and 0.82 in the model.

Table 2.7:
Preset parameters

Estimated Parameters	Symbol	Value	Source
Initial age		18-20	
Retirement age		62	
Number of time periods	T	62	
Years per period		1	
m's average earnings at 30		1	Normalization
Mating market—productivities			PSID
Mating market—assets			SCF
Pensions			Heathcote, Storesletten, and Violante 2010
Var. f's productivity in $t = 1$	$\sigma^{2_f}_{\zeta,1}$	0.54	PSID
Var. m's productivity $t = 1$	$\sigma^{2_m}_{\zeta,1}$	0.54	PSID
Interest rate	$R - 1$	2%	
Relative Risk Aversion private good	γ	1.5	Attanasio, Low, and Sánchez-Marcos 2008
Discount factor	β	0.98	Attanasio, Low, and Sánchez-Marcos 2008

Function	Symbol	Value	Source
$Q_t = [d_t^\nu + \kappa(1 - P_t^f)^\nu]^{\frac{1}{\nu}}$	κ	3.76	McGrattan, Rogerson, and Wright 1997
	ν	0.19	McGrattan, Rogerson, and Wright 1997

2.5.3 Indirect Inference

We use the method of indirect inference (Gourieroux, Monfort, and Renault 1993) to pin down the vector $\vartheta = (\alpha, \lambda, \sigma_\psi, \sigma_{\psi,I}, \delta, \mu, \xi, \gamma)$ of the 8 remaining parameters of the model. We use 31 moments and regression coefficients for the structural estimation, which capture the process of marriage and cohabitation creation and dissolution, as well as female labor supply. More precisely, we include as targets the coefficient of unilateral divorce estimated through equation 2.1,[38] the hazard of divorce (6), the hazard of breakup (3), the hazard of marriage (3), the share of people ever married over time (7), the share of people that ever cohabited over time (7), female labor supply (1),[39] differences in female labor force participation between marriage and cohabitation (2) and differences in log wages between married and cohabiting men (1). We use the retrospective marital history data from the NSFH wave III to construct the moments linked to partnership choice, while all the others are computed using the PSID.[40] The data moments are constructed selecting men and women born in 1940-1955 in community property states.

The first step for the estimation is to solve the model for a vector of parameters ϑ, then simulating income, love shocks and unexpected divorce policy changes for 30000 fictional

[38] Note that the sample used for estimating equation 2.1 in the empirical section and in the structural estimation is different. We will describe within this section how the sample used for structural estimation is constructed.

[39] Female labor supply in the model is constructed by multiplying the indicator of female labor force participation by 2000 hours. The assumption that working full-time corresponds to 2000 hours of work in a year was also used for calibrating ϕ. Alternatively, we could have targeted female labor force participation, picking a number of hours for full-time work such that female labor supply is also matched. Since the amount of part-time work is very different according to the status (married, cohabiting or single) of the women, the number of hours for participating women should have been differed by status. The problem with this approach is that women would have chosen their partnership according to the artificially fixed working schedule that partnerships offer, and not only according to the mechanisms that our model generates.

[40] NSFH wave III is conducted in 2001/2003 following the original respondents of wave 1. This sample does not include respondents under age 45 as of January 2000 unless some particular conditions are met, but this is not an issue for us since the youngest person in our estimating sample was 44 in 2000. One possible issue with this data is that by mistake during NSFH wave II all cohabiting couples were dropped by the sample. We overcome this problem by simulating the same “mistake" on the sample drawn from the simulated data.

individuals to obtain their simulated behavior for the given parametrization. The next step is to perform stratified sampling on the simulated population to obtain the same distribution over gender/age/regime of divorce as in the data used to construct the moments. This allows us to compare the simulated and data moments: the objective is to obtain ϑ such that this difference is the smallest possible. Formally, the problem that we solve is

$$\hat{\vartheta} = \arg\min_{\vartheta} \qquad (\mathbf{m} - \mathbf{m}_\vartheta)'\mathbf{W}(\mathbf{m} - \mathbf{m}_\vartheta), \tag{2.26}$$

where $\mathbf{m}$ is the vector of empirical moments, as described in the section about target moments, while $\mathbf{m}_\vartheta$ is the vector of the moments simulated by the model parametrized with ϑ. $\mathbf{W}$ is a matrix where the diagonal contains the inverse of the variance of the data moments, while all the other entries are zeros. We perform the minimization of this object function using the global optimization algorithm TikTak, which according to Arnoud, Guvenen, and Kleineberg 2019 outperforms an array of global and local optimizers when the target is a difficult objective function. In appendix B.3, we describe how the algorithm TikTak works and how we modify it to allow for the possibility of running it in parallel.

2.5.4 Identification

This section describes how the structural parameters of the model are identified heuristically. The parameter α is identified by total female labor supply. When this parameter is large, the household wants to produce more public goods, which require women's time. Parameter μ affects the gap in female labor supply for married and cohabiting couples. When μ is large, the gap increases because household specialization within cohabitation becomes relatively harder, as this relationship lacks a commitment technology. Parameter λ is intuitively identified by the share of people in a relationship. The parameter σ_ψ has a role in identifying the stability of marriage and cohabitation by modifying the likelihood that marriage surplus becomes negative, but it is mostly identified by the share of people that are choosing marriage over cohabitation. In fact, as this parameter grows larger, money becomes less important than love for total utility. This means that agents care less about insuring against income shocks and labor specialization starts binding less, while the risk of breakup and divorce increases. The parameter σ_ψ alone cannot generate a marriage surplus large enough to match the number of ever married people. For this reason, we introduced parameter γ, thanks to which we can match the share of people ever married and that ever cohabited. Also parameter δ influences the gains of marriage with respect to cohabitation, but it does so in a non-monotonic fashion. On the one hand increasing the cost of divorce enhances commitment, while on the other hand it makes it more costly to end the relationship. Hence, the effect of increasing or decreasing δ depends on its initial value. Since the introduction of unilateral divorce is to a first approximation like a decrease in the cost of divorce, the parameter δ is mostly identified by the coefficient of unilateral divorce of regression 2.1. Parameter $\sigma_{\psi,I}$ is identified by the hazard of breakup and marriage. When this parameter is small compared to the variance of the transitory shocks, agents are not *picky* about sorting into cohabitation, but they move fast to a marriage or they separate within the first periods of the relationship, according to the evolution of the love and productivity shocks. Finally, the parameter ξ influences the surplus of marriage and cohabitation by wealth. In fact, when ξ is small, wealthier agents find the consumption of the public good Q relatively more attractive. Since marriage makes it possible to consume a larger quantity of Q because it protects women that devote time to its production, marriage becomes a relatively more interesting option for wealthier families. Hence, ξ is identified by the difference in log wages of married and cohabiting men.

2.5.5 Model Fit

Table 2.8 reports the results of the structural estimation. The estimated standard deviation σ_ψ of the transitory match quality shock is 0.76, while the standard deviation $\sigma_{\psi,I}$ of the love shock at first meeting is higher with a value of 1.67. The probability of meeting a partner λ is 0.38, while the share of assets left after divorce is 0.80. The weight on the public good α is 1.20, while the loss in productivity parameter μ is 0.07. Finally, the penalty for cohabiting γ is 0.15, while the coefficient of relative risk aversion for the public good ξ is 1.14.

The fit of the model is reported in table 2.9. The model generally matches well the hazard of marriage, breakup and divorce over time, even though it lies outside the 95% confidence interval of data moments. One exception is that the hazard of divorce and breakup are not hump shaped over the duration because our model abstracts from learning, which is necessary to match this pattern in the data Blasutto 2020. The share of people that ever cohabited and married over time is well matched. The data about female labor supply is well matched. The differences in log wages for married and cohabiting men are lower than in the data. Finally, the coefficient of unilateral divorce estimated through equation (2.1) is slightly larger than in the data, but it lies within the 95% confidence interval.

The model is validated according to its ability to reproduce the effects of unilateral divorce on cohabitation duration, the share of income in the couple earned by married women, the average wage earned by women over their working life and the ratio of hazard rates of richer over poorer men.[41] We use two linear models on a sample of cohabitation spells-year to study the role of unilateral divorce (independent variable) on the risk of breaking up and separating. In the first model the dependent variable

[41] Richer men are those whose income is above the median, while poorer men are those whose income is below the median.

is a dummy taking value one in case of a marriage, while in the second model it is a dummy taking value 1 in case of a breakup.[42] The results, reported in table 2.9, show that using both the empirical and the simulated sample the policy decreases the risk of marriage and breakup. Overall, the length of cohabitation increases by 27% in the simulated sample. Women's wages over their life-cycle and the average share of income provided by the wife in the household match the data, which validates the selection of women into the labor force. The fact that the model matches that divorce rates are lower for richer men supports our assumptions regarding the cost of divorce, which influences both the allocation within divorce and the surplus of marriage.

A further test for our model is to check whether the effect of unilateral divorce on the propensity to cohabit is lower under a title-based regime than under a community property regime, as it is in the data. We solve the model assuming a title-based regime and we obtain that the coefficient of unilateral divorce of equation (2.1) is -0.09, while it was -0.16 under community property.[43] This result is consistent with the idea that under community property regime the shift towards cohabitation is larger because men, who are those with the most decision power, start finding cohabitation attractive when the risk of divorce increases. This is because upon divorce they would lose most of their assets, leaving a part of them to their ex-wife. This mechanism bites less under a title-based regime, because men would keep the assets of their property upon divorce.

[42] Since the aim of this exercise is to study how the pool of cohabiting couples changes after the reform, the dependent variable takes value one if the cohabitation spell started under the unilateral divorce regime and zero otherwise. We control for duration and we have age, year the relationship started and state fixed effects.

[43] Note that we do not expect to match exactly the empirical coefficient (2.1) under the title-based regime because we did not re-estimate the model using a sample of residents in title-based states. The parameters used for this exercise are those in table 2.9.

Table 2.8:
Estimated structural parameters

Estimated Parameters		Value
Standard deviation of match quality shock	σ_ψ	0.76
Standard deviation of initial match quality shock	$\sigma_{\psi,I}$	1.67
Probability of meeting a partner	λ	0.38
Assets left upon divorce	δ	0.80
Weight of public good	α	1.20
Loss in productivity while not working	μ	0.07
Relative Risk Aversion public good	ξ	1.14
Penalty of Cohabiting	γ	0.15

Table 2.9:
Model fit and validation

Estimated Moments	Model	Data	95% CI
Hazards over Time	fig. B.3	fig. B.3	fig. B.3
Share Ever Cohabited and Married	fig. B.4	fig. B.4	fig. B.4
FLS in a Couple (hours)	1007	1016	[1002,1029]
FLS if Married/ FLS if Cohabiting (<35 yrs.)	1.02	0.86	[0.78,0.95]
FLS if Married/ FLS if Cohabiting (≥35 yrs.)	0.97	1.00	[0.89,1.13]
Log wages Marriage-Log wages Cohabitation	-0.08	0.12	[0.04,0.12]
Unilateral Divorce coefficient equation (2.1)	-0.16	-0.11	[-0.21,-0.02]
External Moments	**Model**	**Data**	
Unilateral Divorce and linkelihood of marrying	-0.04	-0.08	[-0.20,0.04]
Unilateral Divorce and linkelihood of braking up	-0.06	-0.12	[-0.22,-0.02]
Women wages over their life-cycle	fig. B.5	fig. B.5	fig. B.5
Divorce Rate Rich/Divorce Rate Poor	0.74	0.79	[0.75,0.84]
Share household income earned by women	0.34%	0.35%	[0.36-0.38]

2.6 Mechanisms

The aim of this section is 1) to better understand the quantitative relevance of the mechanisms underlying the introduction of unilateral divorce and the subsequent rise of cohabitation and 2) to quantify the gains of marriage with respect to cohabitation.

We start by analyzing how selection and intra-household bargaining change as a result of the reform. The estimated structural model allows us to study the evolution of the match quality ψ and women's Pareto weight θ_t using a standard event study. Specifically, we estimate the following regression model on simulated data

$$\text{Variable of Interest}_{i,a,t} = \sum_{j=-5}^{5} \beta_j^{Uni} \cdot \mathcal{I}(t=j) + \alpha_0 + \alpha_a + \epsilon_{i,t} \tag{2.27}$$

where a is age, t is the year relative to switching to unilateral divorce ($t = -1$ is omitted) and i is a couple. We estimate the model for ψ and θ using as samples 1) cohabiting couples that just met 2) married couples that just met. Figure 2.3 reports the results. We normalize the coefficient estimates β_j^{Uni} by adding the average of the variable of interest in the year before unilateral divorce is introduced $E[\text{Variable of Interest}|t = -1]$.

Match quality ψ. We start by analyzing panel a. First, note that the average match quality of married couples is higher than for cohabitants.[44] This fact is consistent with a strong selection on marriage and cohabitation with respect to match quality. Marriage guarantees a better commitment and cooperation, but when the match quality is low the best option is to choose cohabitation because breaking up is cheaper than divorcing. The results of the event study show that upon the introduction of unilateral divorce the match quality of newly formed cohabitations increases by a value that is around 35% percent of its structural standard deviation.[45] This result is consistent with selection of relatively high match quality couples into cohabitation after the policy change. This happens because unilateral divorce increases the risk of dissolution of marriage and affects the spouses' incentive to cooperate.

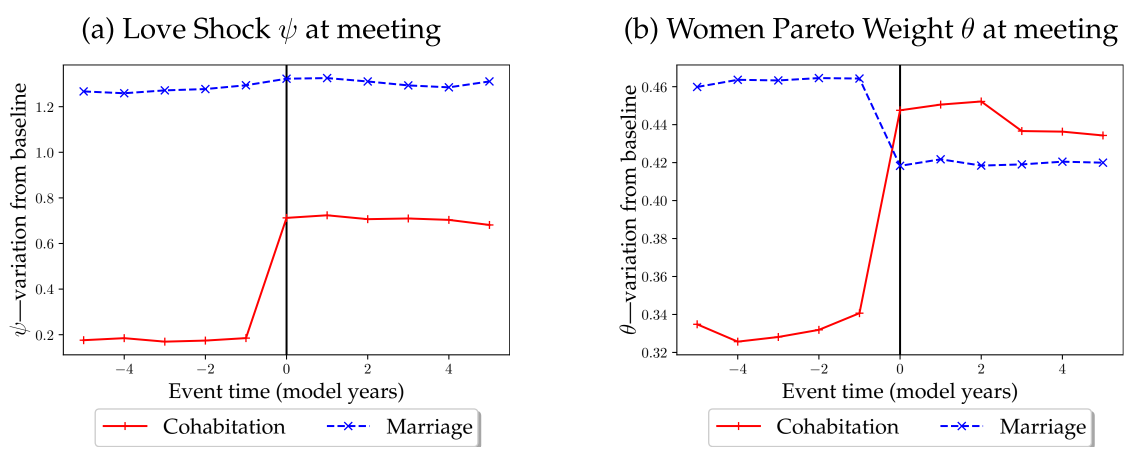
Women's bargaining power θ. Panel b depicts the evolution of women's bargaining power θ at meeting for cohabitation and marriage around the introduction of unilateral

[44] A more in depth analysis reveals that the distribution of match quality at meeting of cohabiting couples dominates that of married couples. See figure B.7.

[45] Note that the observed and structural distributions of the initial match quality are different because couples are not formed when the match quality at meeting is too low.

divorce. The average initial Pareto weight θ increases with respect to baseline for cohabitation after the policy change, while it decreases for marriage. Under mutual consent, marriage protected women against ending up divorced and poor, while cohabitation was chosen only by couples where the man was not able to commit to a long term relationship and the woman had little say about the decision. After the reform, men prefer cohabitation over marriage because the former avoids splitting up assets equally upon breakup, but in exchange women obtains a higher initial Pareto weight θ.[46] Similarly, the Pareto weight of women that marry goes down because men are willing to marry instead of cohabiting only if they can control more resources within the household.

Figure 2.3:
Event Studies Around the Introduction of Unilateral Divorce–Simulated Data



NOTES The figures display the evolution of the love shock ψ and the female Pareto weight θ around the introduction on Unilateral Divorce. The displayed patterns are normalized coefficients from event studies around divorce. The graphs are relative to couples that started a relationship. Note that the sample used to obtain these figures is created simulating 300000 agents behaving following the policy function implied by the model estimated with the parameters of table 2.8.

Risk-sharing and consumption insurance. The veto over divorce in the mutual consent regime and the high cost of divorce are commitment technologies that enforce cooperation

[46] Note that upon breakup men receive on average around 65% of the couple's wealth.

within marriage. What is the quantitative relevance of these mechanisms on married and cohabiting couples' ability to share risk? To answer this question, we study how income shocks affect the changes in consumption over time for men in a couple.[47] First, we obtain paths of consumption and labor earnings of men who are in their first relationship by simulating their choices under different divorce regimes.[48] Then, for each of these samples we estimate the equation below

$$\Delta \log c_{it} = \alpha + \mu \Delta \log(w_{it}) + \nu_t + \epsilon_{it},$$

where c_{it} and w_{it} are the consumption and the labor earnings of men i at age t. ν_t are age fixed effects. Coefficient μ is informative about how much of the change in income translates into changes in consumption. Consequently, a low value of μ corresponds to a high degree of consumption insurance. The results displayed in table 2.10 provide important pieces of information about partnership types and consumption insurance. First, coefficient μ is the largest for cohabitation and the smallest for marriage under mutual consent divorce, as reported in the first row.[49] This means that consumption insurance is the most effective within marriage with mutual consent divorce and the least effective within cohabitation. Does this happen because of a selection effect or because partnership rules directly affect the ability to share risk? Rows 2 and 3 of table 2.10 suggest that selection matters: marriages that were not preceded by cohabitation

[47]Results for women in a couple are displayed in table B.13. We chose to show the results for men in this section since changes in their productivity always translate into changes in disposable income. This does not happen for women who do not participate in the labor market. For this reason, results in table B.13 are largely driven by the different degree of female labor force participation under different divorce regimes and partnership types.

[48]First relationships correspond to the periods in which an agent spends time in a couple with his or her first partner without changing partnership type. The first relationship of a man that cohabited before marrying his first partner is a cohabitation spell that stops when the couple gets married. We restrict our attention to first relationships only because this allows us to perform an exercise where we impose marriage on a couple that decided to cohabit. This exercise allows us to compare marriage and cohabitation controlling for selection.

[49]We only consider individuals who spend their whole life-cycle under the same divorce regime.

display a stronger degree of consumption insurance than those that were preceded by cohabitation. This is because the initial match quality of couples that married directly is higher compared to those who first cohabited. The fact that match quality is higher implies that participation constraints bind more rarely, allowing for a smoother consumption path. Row 4 of table 2.10 shows that if we “force" men who had chosen to cohabit to marry, we find that the amount of consumption insurance lies in between that of marriage and cohabitation. Since this experiment controls for selection, we conclude that partnership rules have a direct effect on couples' ability to share risk. The results relative to consumption insurance and partnership types are driven by the frequency at which Pareto weights are renegotiated. Consistently with these results, figure B.9 shows that the share of periods in which Pareto weights are renegotiated is higher for cohabitation than marriage, and that only some of this difference can be explained by selection. This suggests that consumption insurance is tightly linked to the frequency with which the couples renegotiate the way resources are shared.

Table 2.10:
Partnership type and consumption insurance against income shocks

	Married and Cohabiting Men		
	Married		Cohabiting
	M.C.	U.D.	
Baseline	0.450	0.484	0.498
Only marriages preceded by cohabitation	0.454	0.486	-
Only marriages not preceded by cohabitation	0.449	0.483	-
Marriages with cohabitation selection	0.468	0.496	-

NOTES: the table reports the estimates of coefficients μ obtained from regression

$$\Delta \log c_{it} = \alpha + \mu \Delta \log(w_{it}) + \nu_t + \epsilon_{it}.$$

The sample includes the whole duration of the first relationship of simulated men i. The last row is run on a sample of men who decided to cohabit but we imposed marriage on them instead. This allow us to analyze the insurance within marriage controlling for selection into a relationship.

Consumption smoothing upon divorce/breakup. Is there a link between partnership types and consumption smoothing upon divorce/breakup? To answer this question we analyze the evolution of log consumption around divorce/breakup using a standard event study on the simulated sample. Note that, after the relationship breakdown, we report the log consumption of the household of the partner that is simulated for her/his whole life-cycle. Specifically, we estimate the following regression model

$$\log(c)_{i,a,t} = \sum_{j=-3}^{3} \beta_j^{Split} \cdot \mathcal{I}(t=j) + \alpha_0 + \alpha_a + \epsilon_{i,a,t}, \tag{2.28}$$

where a is age of the person observed after the relationship dissolves, t is the year relative to breakup/divorce ($t = -1$ is omitted) and i is the household. Note that we included age fixed effects. We estimate this model separately for formerly married and cohabiting households under different divorce regimes, following either men or women after the divorce/breakup. Figure B.8 report the results and shows two main facts. First, consumption drops more after divorce than breakup because the former is costly in terms of assets. Second, women lose more because they are less productive than men, especially if they devoted their time to producing home goods while they were in a couple.

2.7 Welfare

Previous research already studied the welfare effects of the introduction of unilateral divorce: both Reynoso 2018 and Fernández and Wong 2017 find that this policy change decreases welfare for both genders and that the loss for women is larger than for men. While we find a similar effect, in this section we claim that accounting for cohabitation results in an even stronger difference by gender in states where assets are split evenly upon divorce. To study well-being under the two divorce regimes we perform an *ex-ante* welfare comparison, where for each gender we compute the expected value of spending the whole life cycle under a certain regime, before the realization of productivity and love shocks. Table 2.11 reports the results, which show that welfare under a unilateral divorce regime is lower than under mutual consent for both genders. The difference is larger for women, who would need to receive almost \$ 13,000 in assets in $t = 0$ to be indifferent between the two regimes, while men would need only \$3,244 to be indifferent between the two. To understand the role of cohabitation in the changes in well-being, we repeat the welfare analysis assuming that cohabitation is no longer a choice.[50] For ease of exposition, we refer to the model with cohabitation as model A, while model B is the one without cohabitation. The results in table 2.11 show that the loss of welfare related to unilateral divorce is similar under models A and B for women, while men lose more under model B. This result suggests that not accounting for cohabitation overestimates men's welfare losses when unilateral divorce is introduced. The intuition is that cohabitation is valuable for men under the unilateral divorce regime when assets are split evenly upon divorce. This is because they stand to lose more upon divorce than upon breakup. In fact upon breakup they can keep the assets of their property.

[50] In practice, we increase the stigma parameter towards cohabitation γ such that cohabitation is never chosen.

Table 2.11:
Welfare by gender and divorce regime

Female		**Male**	
Mutual Consent	Unilateral Divorce	Mutual Consent	Unilateral Divorce
Life-Time utilities in $t = 0$			
-364.62	-368.13	-351.53	-351.88
Welfare Losses with Unilateral Divorce			
			
12933.66 $		3244.04 $	
Life-Time utilities in $t = 0$ when cohabitation is not in the choice set			
-102.2	-105.73	-90.87	-92.19
Welfare Losses with Unilateral Divorce			
			
13990.74 $		6662.11 $	

Welfare losses are obtained by computing the amount of wealth that must be transferred to men and women in $t = 0$ such that their lifetime utility under the unilateral divorce regime equals that under mutual consent. The wealth is measured in 1990 dollars.

2.8 Counterfactual Experiments

The aim of this section is to understand the quantitative importance of the economic mechanisms that contributed to the rise of cohabitation during the last decades. To do so, we examine the results from a series of counterfactual experiments.

Unilateral Divorce. The qualitative impact of unilateral divorce on the choice between marriage and cohabitation has been largely discussed throughout this paper. Here we assess its quantitative relevance by performing an experiment where unilateral divorce is never introduced. Table 2.12 reports the share of people that cohabited at 39 and the average years spent cohabiting under the baseline scenario and the counterfactual.[51] The results show that under the counterfactual only 29% of people would have ever cohabited by the age of 39, while the years spent cohabiting would have fallen from 2.19 to 1.24. The latter effect is the strongest because it captures changes in both partnership choices of singles and in the duration of partnerships.

Shrinking gender wage gap. Table 2.12 reports the results of another scenario where the gender productivity gap is reduced by increasing women's potential wages by 10% and men's wages are reduced by 10%:[52] the share of people that ever cohabited increases from 43.3% to 47.3%, while the number of years spent cohabiting increases from 2.19 to 2.65. In the counterfactual there is less room for specialization in the couple when the two partners' wages are more similar and the opportunity cost of not working for women rises. Hence, in the counterfactual the couple's need for commitment decreases: cohabitation becomes relatively more attractive as it implies no splitting cost. This result is consistent with the work of Anelli, Giuntella, and Stella 2019, who find that exposure to robots causes both a decline in market opportunities of men with respect to women and a decrease (increase) in the likelihood of being married (cohabiting).

[51] We consider the number of years spent cohabiting between the age of 20 and the age of 55.

[52] The increase in women's potential wages might not be realized if they decide not to participate in the labor market.

Decreasing the price of home appliances. In table 2.12 we report one last counterfactual experiment that explores the effects of reducing by 10% the relative price of goods d, used to produce public goods Q. This change is to be interpreted as a result of improved home production technologies, such as the dish washer or the washing machine, which freed up women's time. Previous research already showed the impact of those changes on female labor supply Greenwood, Seshadri, and Yorukoglu 2005, the decline in marriage, the rise in divorce and assortative mating (Greenwood et al. 2016). The counterfactual experiment shows that the share of people that ever cohabited increases from 43.3% to 44.8%, while the years spent cohabiting increase from 2.19 to 2.27. Similar to a reduction in the gender wage gap, improvements in home production technology decrease the need for labor specialization within the household and for a commitment technology to enforce it. Hence, improvements in the technology of home production caused a decline of marriage with respect to singleness, as Greenwood et al. 2016 claim, and a change in the relative convenience of partnership contracts.

No stigma on cohabitation. Table 2.12 reports the results of one last counterfactual scenario where the stigma towards cohabitation γ is set to zero. In the counterfactual, over 80% of people have ever cohabited and agents spend on average more than 11 years cohabiting. These results suggest that norms play an important role in the rise in cohabitation over time. Finally, note that many people continue marrying. In this scenario 44% of people have ever married, which suggests that the economic incentives alone can generate a positive surplus of marriage with respect to cohabitation for specific individuals.

Table 2.12:
Counterfactual experiments

Scenario	% people ever cohabited	Years spent cohabiting
Baseline	43.3	2.19
No Unilateral Divorce	29.1	1.24
$\downarrow$ gender productivity gap	47.3	2.65
$\downarrow$ 10% Price of good d	44.8	2.27
No stigma on Cohabitation ($\gamma = 0$)	82.4	11.40

NOTES. The Baseline scenario reports the model output with the parameters reported in the previous section. The scenario “No Unilateral divorce" assumes that all the agents live under a Mutual consent regime during all their life, while in the lower productivity gender gap scenario women’s productivity is increased by 10%, while men’s productivity is decreased by 10%. The share of people that ever cohabited is measured at the simulated age of 39, while years spent cohabiting are computed between ages 20 and 55.

2.9 Conclusion

In this paper, we show that partnership choices depend on the rights to divorce: the introduction of unilateral divorce in most US states influenced selection into marriage and cohabitation and the duration of these relationships and women’s bargaining power. Using NSFH and NSFG data, we show that the introduction of unilateral divorce is responsible for a 7-8% increase in the likelihood that singles choose cohabitation over marriage, and that newly formed cohabitations last longer. To understand the mechanisms that underlie those changes, we build a dynamic structural model where agents can choose to marry, cohabit, and when to end these relationships. We use regression results from survey data and moments that describe the mating market and female labor supply to estimate our model by indirect inference. The structural estimation reveals that couples choosing cohabitation instead of marriage are those that would have had the highest risk of divorce. Since cohabiting couples have on average a lower match quality than married ones, this selection effect increases the duration of newly formed cohabitations. Moreover, in the US states where assets are split equally, it is men who wish to cohabit after the policy reform. This is becuase they would lose more assets in a divorce than in a breakup. Women are convinced to enter this relationship in exchange for higher bargaining power, even though this makes them worse off if the couple subsequently breaks up. Finally, we show that the magnitude of the overall effect of unilateral divorce on cohabitation is large: a counterfactual experiment reveals that if the law never changed, time spent cohabitating for the birth cohorts used in our estimation would have been 1.24 years instead of 2.19, while the share of people that ever cohabited would have shifted from 43.3% to 29.1%.

Beyond what is studied in this paper, it would be interesting to introduce explicitly fertility in our framework to understand why children born within cohabitation do not perform well later in life. A promising approach would be to follow Kozlov 2021, who distinguishes between fertility as a choice and as an unplanned event. In fact, it might be that children raised by single mothers are outcomes of unwanted births that happen within cohabitation. This situation might happen less frequently within marriage, since it is a more stable and committed relationship than cohabitation.

Chapter 3

Nonsmooth Behavior in Collective Household Models with Limited Commitment

3.1 Introduction

The dynamic limited commitment models of household behavior, originated in Mazzocco 2007 and Voena 2015, are widely used to study issues related to the dynamic behavior of the household. Although the building blocks of the models originate from other papers in lifecycle literature (Attanasio and Weber 2010), there is very little known about the mathematical properties of their optimal solution. Marcet and Marimon 2019 discuss the mathematical representation of the decision problem, their results, however, do not concern practical and computational issues.

To fill the gap, I provide a setup where the exact solution can be obtained. I show that even in a very simple setup discontinuous savings can occur. Then I show how the introduction of random disturbances to utility — taste shocks, in a spirit Iskhakov et al. 2015 — can make savings continuous again by making the binary decisions probabilistic. I test the performance of the method and show how it can be generalized towards a multi-period framework like in the first two chapters of my thesis (Kozlov 2021; Blasutto and Kozlov 2021).

To get exact solutions, I present a simple two-period consumption-savings model. In the first period, a married couple is deciding on their joint savings. After the first period, they realize the value of their random shocks, observe accumulated savings and decide to divorce if the divorce is efficient. If they stay together they continue behaving like a couple, otherwise, they split their savings and enter the second period as two single agents.

In the two-period model, I show that the decision of whether to divorce can depend on savings under the usual parametrization. In particular, the couple may decide to divorce if accumulated savings are large enough or stay together otherwise. The opposite direction is also possible generically. Assuming that the couple has additional returns to scale relative to single agents, this jump in divorce decisions make marginal returns to savings a discontinuous function of the level of savings, which results in discontinuity in optimal savings level and kinks in the value function representing the utility of entering the next period. As a result, the value function is not concave, and the optimization problem can have multiple local maximum points.

After documenting the nonsmooth behavior I argue that it can be mitigated by including a random transitory variation in the potential value of divorcing. To match the existing literature, I call this random variation taste shocks. The important feature here is that the shocks are identical for both partners, i.e. the shocks are couple-specific. When the shocks are introduced, there is always some probability that the couple divorces in the second period, regardless of the value of the inputs. This probability of divorce changes smoothly with savings, unlike the divorce decisions in the baseline version. This makes the value function smooth. When the variance of taste shocks is reasonably large, this also makes the value function concave and eliminates the multiplicity of local solutions. As a result, the savings function becomes continuous. I confirm this with numerical experiments that study the two-period problem and use precise numerical integration.

In real applications, the exact solutions cannot be obtained. Decisions have to be approximated on grids and potentially interpolated. In particular, the intrahousehold allocation that matters for making divorce decisions has to be discretized: instead of any possible allocation of a couple's resources, computational solutions assume there is a finite grid of possible allocations. I show that the taste shocks can easily be adapted to this discrete grid framework in a spirit of change of variables during the integration.

I present a realistic benchmarking exercise where I compare the exact discontinuous solution to the savings problem to its approximate solution on a discrete grid with and without taste shocks. I find that introduction of small taste shocks can improve the quality of approximation almost twice (in terms of mean absolute deviation), although when the scale of taste shocks is too large the problem is altered too much and the resulting solution becomes far from the true one. I propose a heuristic criterion about the right scale of the taste shocks.

The general conclusion of the exercise is that adding a small amount of smoothness makes the approximate solution to a discontinuous problem more precise. However, an important conceptual question is whether the true problem should be formulated as discontinuous, or whether instead one should consider taste shocks as a fundamental feature of behavior and write the models that include them. In the latter case, a degree of smoothness is a calibration parameter, and when it is high enough, a discontinuous problem simply does not arise.

To facilitate the application of the taste shock methods, I then show that the idea can be extended towards multi-period models without any closed form at almost no cost. The mathematical problem stays very similar, and there are no additional complexities when probabilistic divorce decisions of existing couples are introduced. There is, however, a subtle issue when the formation of new couples is considered. The default choice for choosing the initial contract terms for couples is Nash Bargaining. In presence of taste shocks, the Nash Bargaining becomes impractical, as the optimal solution depends on the realization of taste shocks and becomes random. I show that a more natural choice is egalitarian bargaining (Kalai 1977; Bossert and Tan 1995), as in its case equal shifts to the disagreement options do not affect the solution. Under the egalitarian bargaining protocol, for potential partners the marriage "contract terms" driving the resources allocation within a couple are defined and fixed, and with the taste shocks, each potential match has a well-defined probability to marry, which changes smoothly with the actions of the single agents. This mitigates the potential dependence of marriage prospectives on savings decisions, although I do not provide a simple model with an exact solution that can be used to study this behavior, this is a topic for further investigations.

Concluding, I show that introducing symmetric taste shocks can help to improve precision and performance for collective household models, although the default way that they are formulated in the literature has to be adjusted to include the taste shocks naturally. I show that the value functions become smooth when taste shocks are present, and the solutions are more accurate. Finally, I show that the method can be generalized to more complex models naturally.

3.2 Two-period Model

Consider the consumption-savings problem with limited commitment and two periods. There are two agents, m and f, and two periods: 0, 1. In period 0, the agents are married; before the period 1 starts they may decide to break up.

In period 0, the agents have endowment $B_0 = w_0^f + w_0^m + R \cdot a_0$, in period 1, they have accumulated savings s_0 and labor income w_1^f and w_1^m, which are generally stochastic.

They start with positive bargaining weights, such that $\theta^f + \theta^m = 1$. The agents enjoy non-economic gains from marriage of ψ in period 1. They learn these gains before they make their divorce decisions.

The collective household cares about weighted well-being of both agents, whether they are single or married.

Consumption technology within household is summarized by total consumption expenditure function $C(c^f, c^m) \leq c^f + c^m$, where strict inequality means that the couple enjoys returns to scale.

The value function and the budget constraints for this household are

$$V_0 = \theta^f \cdot u(c_0^f) + \theta^m \cdot u(c_0^m) +$$
$$+\beta \cdot \mathbb{E}_\omega \left[(1-d_1) \left\{ \theta^f \cdot (u(c_1^f) + \psi) + \theta^m \cdot (u(c_1^m) + \psi) \right\} + d_1 \cdot \left\{ \theta^f \cdot u(c_1^{f,s}) + \theta^m \cdot u(c_1^{m,s}) \right\} \right],$$

$$C(c_0^f, c_0^m) + s_0 = B_0, \quad C(c_1^f, c_1^m) = w_1^f + w_1^m + R \cdot s_0,$$

$$c_1^{f,s} = w_1^f + 0.5 \cdot s_0, \ \ c_1^{m,s} = w_m^1 + 0.5 \cdot s_0,$$

$$(1-d_1) \cdot \left[u(c_1^f) + \psi - u(c_1^{f,s}) \right] \geq 0, \ \ (1-d_1) \cdot \left[u(c_1^m) + \psi - u(c_1^{m,s}) \right] \geq 0. \tag{3.1}$$

This problem can be approached backwards. One can solve for the optimal period-1 consumption and divorce decisions and write the problem as

$$V_0^* = \max_{c_0^f, c_0^m, s} \theta^f u(c_0^f) + \theta^m u(c_0^m) + \beta \, \mathbb{E}_\omega \, V_1(\omega, s).$$

Then by choosing the optimal allocation of period-0 resources $c = C(c_0^f, c_0^m)$ (see Chiappori and Mazzocco 2017) one can aggregate this problem to

$$V_0^* = \max_{c,s} \left\{ U(\theta, c) + \beta \, \mathbb{E}_\omega \, V_1(\omega, s) \right\}, \ \ \text{s.t.} \ \ c + s = B_0. \tag{3.2}$$

This means that once the value of entering period 1 is computed, the problem aggregates to a standard consumption-savings problem. Therefore the properties of the optimal savings depend solely on the behavior of $V_1(\omega, s)$.

It is possible to establish some general properties of the second-period problem. First, if there exist c_1^f and c_1^m satisfying 3.1 constraints, then $d_1 = 0$. Second, assuming u is a monotonic function, the participation constraints for the case $d_1 = 0$ can be written as

$$c_1^f \geq \underline{c}_1^f \equiv u^{-1}\left[u(c_1^{f,s}) - \psi\right] \geq 0, \quad c_1^m \geq \underline{c}_1^m \equiv u^{-1}\left[u(c_1^{m,s}) - \psi\right] \geq 0. \tag{3.3}$$

Finally, I assume that $C(x, y)$ is monotonic in both arguments.

Claim 1. $d_1 = 0$ if and only if $C(\underline{c}_1^f, \underline{c}_1^m) \leq w_1^f + w_1^m + R \cdot s_0$.

Proof. Follows from monotonicity.

This claim means that if couple has enough resources to provide the threshold level for both partners it will stay together. This also means that $\theta^{f,m}$ are irrelevant for divorce decisions.

Assuming that stochastic components ω have discrete distribution with finite number of points $\mathbb{E}_\omega V_1(\omega, s) = \sum p_{\omega_i} V_1(\omega_i, s)$, and therefore the properties of the expected value depend on the behavior of $V_1(\omega_i, s)$ for fixed ω_i. Therefore agents' wages and non-economic gains ψ are treated as fixed hereafter.

3.2.1 Renegotiation and Savings

In this part I show that renegotiation does not create discontinuous savings decisions. There can be a savings threshold $\bar{s}$ such that either $s > \bar{s}$ or $s < \bar{s}$ can trigger renegotiation, but $\frac{\partial V_1}{\partial s}$ at $\bar{s}$ is continuous. The idea is that the couple's technology C is continuous, therefore small changes in consumption allocation lead to small changes in utility.

To do this, suppose that there is savings level for which participation constraint is exactly satisfied for unconstrained solution. Define unconstrained solution as

$$(\bar{c}_1^f, \bar{c}_1^m) = \arg\max_{c^f, c^m} \left\{ \theta^f \cdot u(c^f) + \theta^m \cdot u(c^m) \right\}, \text{ s.t. } C(c^f, c^m) = B_1 \equiv w_1^f + w_1^m + R \cdot s_0.$$

Without loss of generality, suppose that at point $\bar{s}$ the unconstrained solution for female is exactly on participation constraint, i.e. $\bar{c}_1^f = \underline{c}_1^f$, but $\bar{c}_1^m > \underline{c}_1^f$ (otherwise we are in divorce case, that is considered below). Then suppose that for $s > \bar{s}$ the constraint is binding, i.e. $\bar{c}_1^f < \underline{c}_1^f(\bar{s})$. The logic remains the same if this happens for $s < \bar{s}$ instead.

When the participation constraint is binding, the couple imposes $c_1^f = \underline{c}_1^f$, and c_1^m is picked from the budget constraint. Slightly abusing the notation of inverse function $\hat{c}_1^m = C^{-1}(\underline{c}_1^f, B_1)$.

Therefore we can write the value function in period 1 as:

$$V_1(s) = \begin{cases} \theta^f \cdot u(\bar{c}_1^f(s)) + \theta^m \cdot u(\bar{c}_1^m(s)), & \text{if } s \leq \bar{s}, \\ \theta^f \cdot u(\underline{c}_1^f(s)) + \theta^m \cdot u(\hat{c}_1^m(s)), & \text{if } s > \bar{s}. \end{cases}$$

Since the $\bar{c}_1^f(\bar{s}) = \underline{c}_1^f(\bar{s})$, at point $\bar{s}$ the first order conditions of the unconstrained optimization problem hold, namely:

$$\theta^f u'(\bar{c}_1^f(s)) = \theta^m u'(\bar{c}_1^m(s)) \cdot \frac{\frac{\partial C}{\partial c_1^f}}{\frac{\partial C}{\partial c_1^m}}. \tag{3.4}$$

Taking the derivative of the top part of the expression at $\bar{s}$ we get

$$\frac{\partial V_1}{\partial s}(\bar{s}) = \begin{cases} \theta^f \cdot u'(\bar{c}_1^f) \cdot \frac{\partial \bar{c}_1^f}{\partial s} + \theta^m \cdot u'(\bar{c}_1^m) \cdot \frac{\partial \bar{c}_1^m}{\partial s}, \\ \theta^f \cdot u'(\underline{c}_1^f) \cdot \frac{\partial \underline{c}_1^f}{\partial s} + \theta^m \cdot u'(\bar{c}_1^m) \cdot \frac{\partial \hat{c}_1^m}{\partial s}, \end{cases}$$

In both cases, it is true that $C(c_1^f, c_1^m) = w_1^f + w_1^m + R \cdot s_0$, and therefore differentiating both object with respect to s implies that

$$\frac{\partial c_1^f}{\partial s} \cdot \frac{\partial C}{\partial c_1^f} + \frac{\partial c_1^m}{\partial s} \cdot \frac{\partial C}{\partial c_1^m} = R, \tag{3.5}$$

by combining conditions 3.5 and 3.4 we can simplify

$$\theta^f \cdot u'(\bar{c}_1^f) \cdot \frac{\partial \bar{c}_1^f}{\partial s} + \theta^m \cdot u'(\bar{c}_1^m) \cdot \frac{\partial \bar{c}_1^m}{\partial s} = \frac{\theta^m \cdot u'(\bar{c}_1^m)}{\frac{\partial C}{\partial c_1^m}} \cdot R.$$

Now we use the same idea for the bottom branch: it is still true that $\frac{\partial \bar{c}_1^f}{\partial s} \cdot \frac{\partial C}{\partial c_1^f} + \frac{\partial \hat{c}_1^m}{\partial s} \cdot \frac{\partial C}{\partial c_1^m} = R$, and the condition 3.4 still holds at point $s = \bar{s}$. Therefore combination of these conditions gives the same derivative, and

$$\frac{\partial V_1}{\partial s_+}(\bar{s}) = \frac{\partial V_1}{\partial s_-}(\bar{s}).$$

To get an intuitive sense of the result, assume that $C(x, y) = x + y$. In this case the first order condition is $\theta^f u'(c^f) = \theta^m u'(c^m) \equiv k$, and therefore

$$\frac{\partial V_1}{\partial s}(\bar{s}) = \begin{cases} k \cdot \left(\frac{\partial \bar{c}_1^f}{\partial s} + \frac{\partial \bar{c}_1^m}{\partial s} \right), & s \leq \bar{s} \\ k \cdot \left(\frac{\partial \underline{c}_1^f}{\partial s} + \frac{\partial \hat{c}_1^m}{\partial s} \right), & s > \bar{s}. \end{cases}$$

Both expressions in parenthesis are equal to $\frac{\partial (c^f + c^m)}{\partial s} = \frac{\partial B_1}{\partial s} = R$.

3.2.2 Divorce and Savings

This section shows that $\frac{\partial V_1}{\partial s}$ can be discontinuous if decision about divorce d_1 depends on s. In other case, the function is a weighted average of two terms with continuous derivatives, which are themselves continuous. Therefore the interesting case is some dependence of $d(s)$.

We can summarize d as

$$d_1 = \mathbb{I}\left\{C\left(u^{-1}\left[u(w_1^f + 0.5 \cdot R \cdot s_0) - \psi\right], u^{-1}\left[u(w_1^m + 0.5 \cdot R \cdot s_0) - \psi\right]\right) \leq w_1^f + w_1^m + R \cdot s_0\right\}.$$

Therefore its properties depend on shapes of C and u. In practice, we cannot sign this, but we can expect many patterns where d is non-constant.

The intuition for discontinuous derivatives is the following. Suppose there is a threshold $\bar{s}$ such that $d(\bar{s} + \varepsilon) = 1 - d(\bar{s})$. The value function of couple can be written as

$$V_1(s) = d(s) \cdot V_1^{\text{divorce}}(s) + [1 - d(s)] \cdot V_1^{\text{together}}(s).$$

Therefore derivative is

$$\frac{\partial V_1}{\partial s} = d(s) \cdot \frac{\partial V_1^{\text{divorce}}}{\partial s} + [1 - d(s)] \cdot \frac{\partial V_1^{\text{together}}}{\partial s}.$$

When s passes the threshold, the divorce indicator switches, and therefore the derivative changes discontinuously if $\frac{\partial V_1^{\text{divorce}}}{\partial s} \neq \frac{\partial V_1^{\text{together}}}{\partial s}$. Due to returns to scale we expect that individuals in couples will have higher consumption levels and therefore lower returns to savings than singles, so we expect marginal utility of savings to be higher in the singles case and the inequality to hold.

3.2.3 Numerical Example

Here I present an example of discontinuous derivatives in numbers. Key elements of calibration correspond to Kozlov 2021.

Here $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, $\sigma = 1.5$ and $C(x, y) = [x^{1+\rho} + y^{1+\rho}]^{\frac{1}{1+\rho}}$ with $\rho = 0.23$. I let $\theta^f = 0.3, \theta^m = 0.7$. Suppose wages $w^f = 4$ and $w^m = 5$ in both periods. Suppose also that in the first period the couple has savings $a_0 = 7.75$, $\beta = 1/R = 0.98$, $\psi_1 = -0.0485$.

In this example, the divorce happens after the couple exceeds a certain level of savings. Therefore when approaching divorce threshold, the couple starts saving discontinuously more as savings have higher marginal value when they are not together.

The following example represents problem 3.2 in the form:

$$V_0^* = \max_s V_0(s), \text{ where } V_0(s) = U(\theta, B_0 - s) + \beta \cdot V_1(s),$$

and we study the properties of one-dimensional function $V_0(s)$ (for different amounts of initial resources B_0). Figure 3.1 shows three graphs: the top left graph represents $V_0'(s)$ (solid line on the left axis) and divorce decision for each level of savings $d(s)$ (dots on the right axis) given $B_0 = w^f + w^m + R \cdot a_0 = 17.06$. The top right graph shows the $V_0(s)$ values around the discontinuity point. The bottom panel shows the optimal level of savings (corresponding to the highest point on the top right graph) for different values of B_0 around the initial value of 17.06.

3.3 Taste Shocks in Two-Period Model

The example above shows that behavior can be problematic for usual numerical approximation methods, especially when multiple kinks accumulate. In this section I argue, that introducing a symmetric "disagreement shock" on top of the model fundamentals can produce smooth behavior without altering the essential parts of the model.

The important assumption here is having a symmetric additive shock to utility. This allows the optimal allocation of consumption to be independent on the value of the shock in many cases.

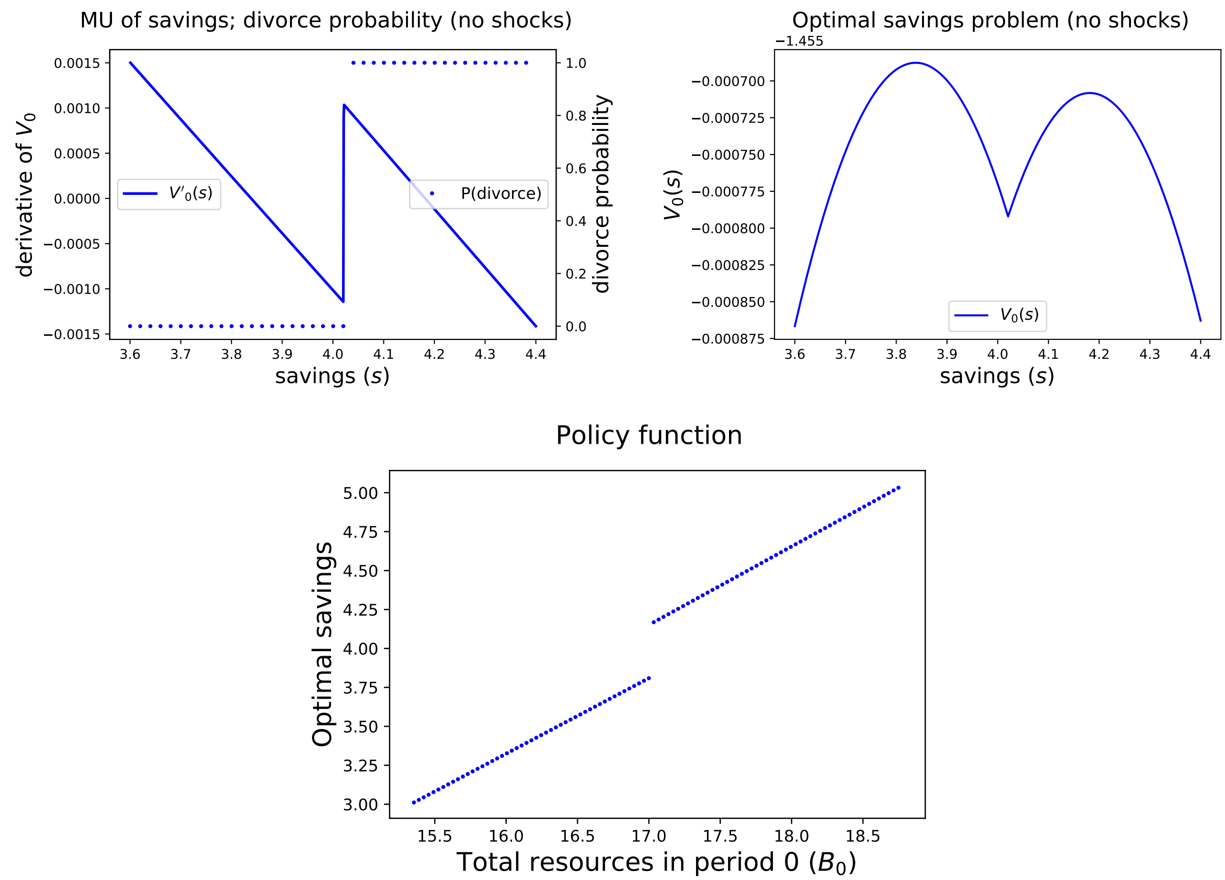


Figure 3.1: Discontinuous derivatives and policy function in collective household model with divorce risk, no taste shocks.

3.3.1 Exact Version

The problem with taste shocks now is

$$V_0 = \theta^f \cdot u(c_0^f) + \theta^m \cdot u(c_0^m) +$$

$$+\beta \cdot \mathbb{E}_\omega \left[(1 - d_1) \left\{ \theta^f \cdot (u(c_1^f) + \psi) + \theta^m \cdot (u(c_1^m) + \psi) \right\} + d_1 \cdot \left\{ \theta^f \cdot u(c_1^{f,s}) + \theta^m \cdot u(c_1^{m,s}) \right\} \right],$$

$$C(c_0^f, c_0^m) + s_0 = B_0, \quad C(c_1^f, c_1^m) = w_1^f + w_1^m + R \cdot s_0,$$

$$c_1^{f,s} = w_1^f + 0.5 \cdot s_0, \quad c_1^{m,s} = w_m^1 + 0.5 \cdot s_0,$$

$$(1-d_1)\cdot\left[u(c_1^f)+\psi-u(c_1^{f,s})-\xi\right]\geq 0,\;\;(1-d_1)\cdot\left[u(c_1^m)+\psi-u(c_1^{m,s})-\xi\right]\geq 0$$

where the last two constraints can be read as $u(c_1^x)+\psi-u(c_1^{x,s})\geq\xi$ if $d_1=0$.

The constraints for the case $d_1=0$ can be summarized in the following way:

$$\xi\leq\min\left\{u(c_1^f)+\psi-u(c_1^{f,s}),u(c_1^m)+\psi-u(c_1^{m,s})\right\}.$$

The divorce condition can be rephrased in the following way: the couple divorces if

$$\xi\leq\psi+\max_{c_1^f,c_1^m}\min\left\{u(c_1^f)-u(c_1^{f,s}),u(c_1^m)-u(c_1^{m,s})\right\}.$$

It is useful to describe the problem in the following way: consider a setup with varying weight $\vartheta\in[0,1]$:

$$(c_1^f,c_1^m)=\arg\max_{c^f,c^m}\left\{\vartheta\cdot u(c^f)+(1-\vartheta)\cdot u(c^m)\right\}\;\;\text{s.t.}\;\;C(c^f,c^m)=B_1. \tag{3.6}$$

This defines two functions $c_1^f(\underset{+}{\vartheta})$ and $c_1^m(\underset{-}{\vartheta})$. The functions are monotonic under the usual assumptions about utility and technology.

Define $M(\vartheta)=\min\left\{u(c_1^f(\vartheta))+\psi-u(c_1^{f,s}),u(c_1^m(\vartheta))+\psi-u(c_1^{m,s})\right\}$.

There exists $\theta^{ebs}=\arg\max_{\vartheta}[M(\vartheta)]$, where ebs refers to egalitarian bargaining solution (Kalai 1977), and function M is a version of Rawlsian social surplus for the couple.

The couple then stays divorces if

$$\xi>M(\theta^{ebs}).$$

The participation constraints are not binding if (assuming $\theta^f+\theta^m=1$)

$$\xi\leq M(\theta^f).$$

Without loss of generality consider the case $\theta^f \leq \theta^{ebs}$.

Therefore for $\xi \in \left[M(\theta^f), M(\theta^{ebs})\right]$ the female participation constraints will be binding. For these values there exists $\theta_\xi \in [\theta^f, \theta^{ebs}]$ such that $\xi = M(\theta_\xi)$. This θ_ξ will correspond to $c_1^f(\theta_\xi)$ and $c_1^m(\theta_\xi)$, both of which satisfy the participation constraints, where $c_1^f(\theta_\xi)$ will satisfy it exactly. It can easily be found as on given $\theta^f \leq \theta^{ebs}$ the M equation to find it is just $\xi = u(c_1^f(\theta)) + \psi - u(c_1^{f,s})$.

This means that the distribution of ξ implies a continuous distribution of $\theta \in [\theta^f, \theta^{ebs}]$. Its cdf can be described as, $\mathbb{P}(\theta \leq t) = \mathbb{P}(\xi \leq u(c_1^f(t)) + \psi - u(c_1^{f,s})) = F(u(c_1^f(t)) + \psi - u(c_1^{f,s}))$.

Therefore the value function of the couple with the taste shocks can be described as:

$$V_1(\xi) = \begin{cases} \theta^f \cdot (u(c_1^{f,s}) + \xi) + \theta^m \cdot (u(c_1^{m,s}) + \xi), & \xi > M(\theta^{ebs}), \\ \theta^f \cdot (u(c_1^f(\theta_\xi)) + \psi) + \theta^m \cdot (u(c_1^{m,s}(\theta_\xi)) + \psi), & \xi \in [M(\theta^f), M(\theta^{ebs})], \\ \theta^f \cdot (u(c_1^f(\theta^f)) + \psi) + \theta^m \cdot (u(c_1^{m,s}(\theta^f)) + \psi), & \xi < M(\theta^f). \end{cases} \tag{3.7}$$

Its aggregated version $\mathbb{E}_\xi V_1$ can be computed using numerical integration, as θ_ξ do not have clear analytical form. However, a great advantage of it is its smootheness: for a continuous distribution of ξ probability of divorce $\mathbb{P}(\xi > M(\theta^{ebs})$ changes continuously with the model inputs, and therefore the derivative $\frac{\partial \mathbb{E}_\xi V_1}{\partial s}$ is continuous.

The derivatives of it object are generally not tractable. The important part is that they are, however, continuous by construction: instead of an indicator, function F changes smoothly. In particular, the divorce probability $1 - F(M(\theta^{ebs}))$ is now a smooth function of savings. Concerning the renegotiation terms in the middle, the previous reasoning can be applied to argue that they do not create discontinuous derivatives. Therefore the function $\mathbb{E}_\xi V_1(s)$ is not expected to have kinks.

I replicate the numerical example above, adding the taste shocks. The taste shocks ξ have logistic distribution such with CDF $F(\xi) = [1 + \exp(-\xi/\sigma_{ts})]^{-1}$, where σ_{ts} is a scale parameter. Figure 3.2 replicates the top part of Figure 3.1 for $\sigma_{ts} \in \{10^{-5}, 10^{-4}, 2 \cdot 10^{-4}\}$. Additionally, Figure 3.3 shows the resulting policy functions for each value of taste shocks.

First, even with very small taste shocks value function no longer has kinks, and its derivatives are continuous. This, however, does not make derivatives monotonic, and does not prevent the problem of multiple local solutions, however, when the variance of taste shocks increases, the function $V_0(s)$ becomes smoother and easier to approximate. Finally, after a certain level of taste shocks the problem of non-monotonic derivative disappears, and the maximum point becomes unique. On the policy function graphs, this corresponds to optimal savings becoming "continuous" on the bottom graph. Note that relative to model fundamentals (say, ψ_1), the size of taste shocks needed is pretty small, although it is a utility parameter and therefore interpretation of its scale is not obvious.

Although this model accomplishes the task well, its implementation is far from being practical. Integration of the function 3.7 has to be done numerically, as the terms inside depend on ξ non-linearly. Integration is needed each time we need to evaluate $\mathbb{E}_\xi V_1(s)$, and therefore finding the policy function (optimizing with respect to s) requires integration at each iteration of the optimizer, which is very time-inefficient.

A natural alternative to generic numerical integration is use of integration rules that cover more "unusual" regions of $V_1(\xi)$. In particular, only the middle case — renegotitaion region — cannot be integrated symbolically because of moving θ_ξ. Therefore one of the natural solutions is to integrate the object with respect to the distribution of θ instead of the distribution of ξ. This involves discretization with respect to θ in some sense, which is a usual practice in solving the multiperiod models numerically anyway. This motivates the following section, where $V_1(\xi)$ is approximated on the θ grid, which in case of exact integration is equivalent to change in variables.

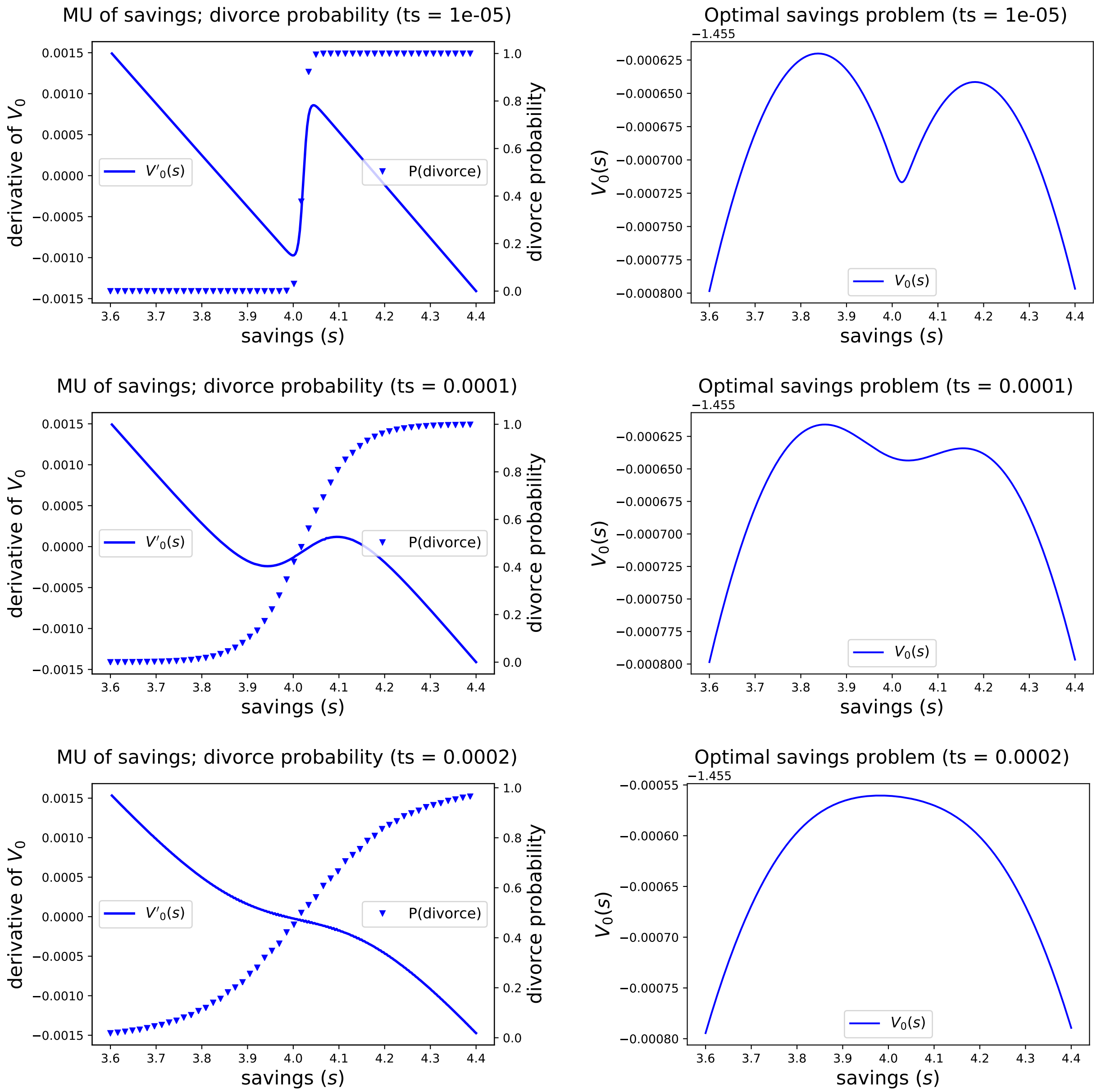


Figure 3.2: Derivatives in collective household model with divorce risk and taste shocks, $\sigma_{ts} \in \{10^{-5}, 10^{-4}, 2 \cdot 10^{-4}\}$.

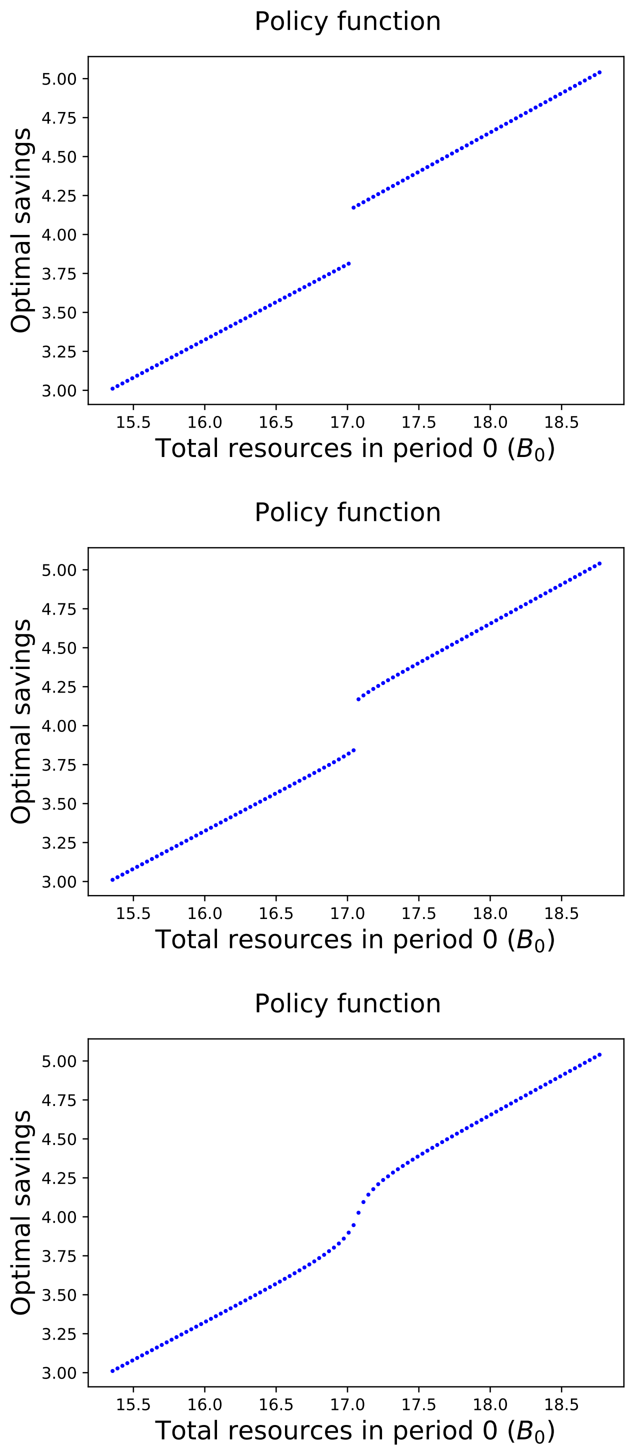


Figure 3.3: Policy functions in the model with taste shocks, $\sigma_{ts} \in \{10^{-5}, 10^{-4}, 2 \cdot 10^{-4}\}$.

3.4 Two-Period Model on a Grid

In practice, solving models wtih multiple periods and multiple potential points in state space requires a degree of discretiztion. In particular, one common approach is to use a grid in θ to describe possible set of consumption allocations within couple. In the context of the model above, this limits the set of potential choices of c_1^f, c_1^m to satisfy the participation constraint. In this particular version this seems artificial, as we can recover the value of consumption that exactly satisfies the participation constraint. In more quantitative models which involve continuation values, discrete choices and other features, this may not be feasible.

I present the gridded model with taste shocks, and the version without taste shocks can be obtained immediately with setting $\xi = 0$ as a particular case, or, more precisely, by considering sequence of distributions of taste shocks with decreasing variance. I will point out the differences of no taste shocks case where they are important, but as a baseline consider the model as in the previous section with random ξ.

The crucial part of approximation of $\mathbb{E}_\xi V_1(s)$ is introduction of a grid for θ. This adds a level of discreteness to a previously continuous dimension, but this discreteness is compensated with continuous distribution of the taste shock. Moreover, the number of approximation points is flexible, and therefore the accuracy can be improved.

Still, the discretized version involves much less smooth functions than the exact version in previous section. In particular, it would be too ambituous to use numerical derivatives, as locally the behavior of functions can be terrible. Nevertheless, the previous model refers to the solution which is generally unfeasible, and its purpose is to provide a benchmark for the best possible scenario with unlimited computational resources.

The purpose of taste shocks here, however, is to improve the approximation of the true model. We approximate the pictures from Section 2 here, and try to improve the performance of its discertization without taste shocks by adding smoothness. We do not generally aim to approximate versions in Section 3, we just apply its ideas to a model with more restricted choice set.

Here, as always, I assume $\theta^f + \theta^m = 1$, but will use both labels when writing the function for convenience. When I use one-dimensional θ I refer to θ^f.

Let $T = \{\theta_1, ..., \theta_N\} \subset [0, 1]$ be a grid with finite number of points. For each $\vartheta = \theta_i$ we can get solutions of problem 3.6: $c_1^f(\theta_i)$, $c_1^m(\theta_i)$. Redefine new θ^{ebs} to be on the grid:

$$\theta^{ebs} = \arg\max_{\vartheta \in T} M(\vartheta).$$

I show the approximation for the case where initial bargaining weigh $\theta^f < \theta^{ebs}$. Denote the initial weight as θ^{sq} (referring to status-quo).

Assume also that $\theta^{sq} \in T$ to is on the grid. There is a finite number of gridpoints between θ^{sq} and θ^{ebs}, let them be $T^K = \{\theta^1, \theta^2, ..., \theta^K\}$, where $\theta^1 = \theta^{sq}$ and $\theta^K = \theta^{ebs}$. All other fundamentals remain the same.

With further abuse of notation, let $M^k = M(\theta^k)$ and $F^k = F_\xi(M(\theta^k))$ (where F_ξ is the cdf of the taste shock). For the case without taste shocks, we can use $F^k = \mathbb{I}(M^k \leq 0)$.

Then, probability that the couple divorces is probability that $\xi > M^K$, which is $1 - F^K$. Probability that no renegotiation is needed is F^1. Finally, probability that θ^k is picked is the probability that $M^{k-1} < \xi < M^k = F^k - F^{k-1}$ for $k > 1$.

Under this setup, the couple has discrete distribution of T^k, or, more generally, on T, where probability of each point is given by $F(M(\theta^k))$. A great feature of these probabilities is that they change continuously (for the case $\xi \neq 0$), including its change with s. A potential source of discontinuity, however, is that now M^K, θ^K and K may change with s, and therefore the functions could jump discretely. But as these functions approximate continuous objects, large enough number of approximation points is expected to mitigate this concern. In addition, small jumps in θ^K correspond to even smaller jumps in F^K by the nature of common cdfs.

Therefore we can approximate the value function as the following sum[1]:

$$\mathbb{E}_\xi V_1 = g^K + \Big[\theta^f \cdot (u(c_1^{f,s})) + \theta^m \cdot (u(c_1^{m,s}))\Big] \cdot [1 - F^K] + \\ \sum_{k=2}^{K} \Big[\theta^f \cdot (u(c_1^f(\theta^k)) + \psi) + \theta^m \cdot (u(c_1^m(\theta^k)) + \psi)\Big] \cdot \big\{F^k - F^{k-1}\big\} + \\ \Big[\theta^f \cdot (u(c_1^f(\theta^1)) + \psi) + \theta^m \cdot (u(c_1^m(\theta^1)) + \psi)\Big] \cdot F^1.$$

It is worth sketching out the version of this function when the variance of the taste shock is zero. Couple divorces if $M^K < 0$, stays together otherwise. Couple continues with original θ^1 if $M^1 \geq 0$. Finally couple renegotiates and picks θ^k if $M^k \geq 0$ and $M^{k-1} < 0$. To be precise, define $k^* = \min_{k \in \{i : M^i \geq 0\}} M^k$, this will return 1 if $M^1 \geq 0$, therefore the first period value function on a discrete grid without taste shocks is

$$V_1 = \Big[\theta^f \cdot (u(c_1^{f,s})) + \theta^m \cdot (u(c_1^{m,s}))\Big] \cdot \mathbb{I}[M^K < 0] + \\ \Big[\theta^f \cdot (u(c_1^f(\theta^{k^*})) + \psi) + \theta^m \cdot (u(c_1^m(\theta^{k^*})) + \psi)\Big] \cdot \mathbb{I}[M^K > 0].$$

To illustrate the impact of gridded approximation I plot the approximated $V_0(s)$ for $N = 5{,}000$ points on Figure 3.4. The version with no taste shock is on the left panel. Its important feature is a large number of spikes, which reflect changes in K, and θ^{ebs} with different s. On the one hand, this is not so far away from the function presented in Figure 3.1. On the other hand, the spikes make mathematical properties bad, we no

[1]Here $g^K = \mathbb{E}[\xi \mathbb{I}(\xi > M^K)]$ is a well-defined function for standard distributions. It captures the expected benefit from having a taste shock and approaches zero when the scale of taste shock becomes small.

longer can use smooth methods and the number of local maximum points is very large. Additionally, the solution region is incorrect, as in the "true" problem the maximum is achieved on the right hump of the graph. Still, this case is exotic as couple in the example is very close to their divorce threshold, so these performance concerns generally cover a small region. The right panel of the graph adds a small taste shock, and one can see that some smoothing happens, although the approximation remains inaccurate.

In practice, the feasible number of grid points is 200 to 500. Relative to the previous example, this would mean that the number of spikes is lower, but the magnitude of jumps around spikes is higher. This makes the previous pictures pretty chaotic: for small changes in inputs they change their appearance from reasonable to terrible. However, the general goal of the exercise is approximating the policy functions for savings on a wide range of input values of B_0 rather than getting each optimization problem precise. Therefore I present the benchmarking exercise where I compare the resulting policy functions with the true discontinuous function on the bottom of Figure 3.1.

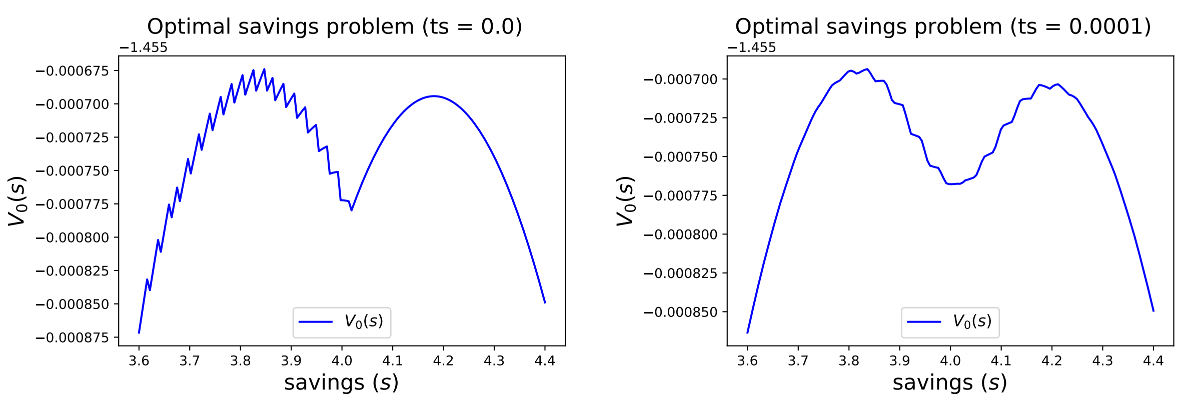


Figure 3.4: Approximating optimal savings problem with discrete grid for θ without and with taste shocks.

Figure 3.5 represents the comparison. I pick $N = 500$, which is an upper bound of what was technically feasible in my Kozlov (2021) paper. I use shock scales of $\sigma_\xi \in \{0, 10^{-4}, 2 \cdot 10^{-4}, 10^{-2}\}$, where the last number is added to see the effects of extra smoothness.

There are several things I can conclude from the graph. First, the general quality of approximations is low even with pretty fine discrete grid. Second, adding taste shocks helps to get closer to the theoretical solution and helps to get more smooth policy function with fewer flat regions and kinks. Third, making taste shocks too large, like in the last picture, can lead to poor approximations as well. The reason for it is that we use discrete grid to, essentially, approximate the continuous problem with taste shocks, which, at its turn, approximates discontinuous problem. When taste shocks get large, the last part of approximation becomes worse. On the positive side, the last problem provides a very accurate apporximation of the continuous problem with the same level of taste shock.

How to determine the "right" magnitude for the taste shocks? It is generally related to the variation of M function (which is itself invariant with respect to taste shocks). Heuristically, the value corresponding to the best approximation in this example is $\sqrt{\text{var}(\xi)} \approx \frac{1}{3} \cdot (M^K - M^{K-1})$, which means that the order of σ_ξ has to be comparable to the order of steps in the Rawlsian surplus for two consecutive gridpoints.

3.5 General Multi-Period Model

Very similar reasoning can be applied to models where the number of periods is more than two. Although it cannot be compared to a precise benchmark, the smoothness and precision still can be increased by introduction of the taste shocks, and the previous case provides a way to achieve this.

First I present the behavior of married couple with somewhat generic value of potential divorce. Then I supplement it with an analogous description of marriage choice for singles.

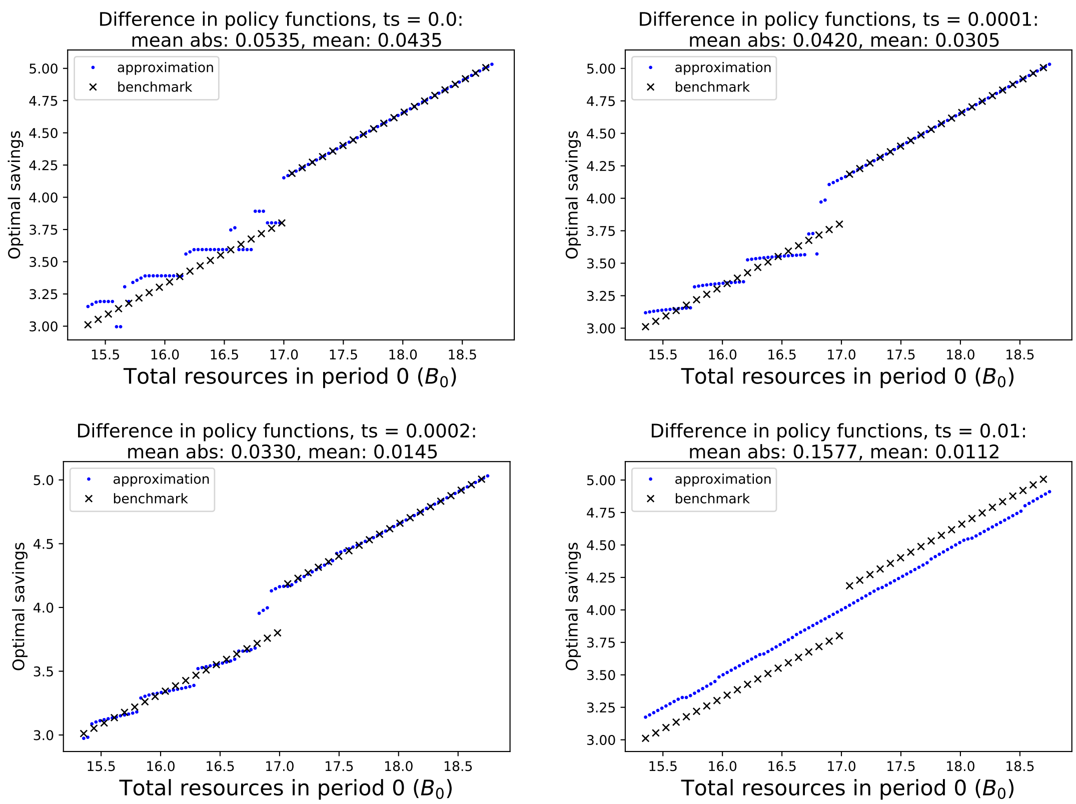


Figure 3.5: Approximating policy function using discrete grid for θ and taste shocks, comaring with no-taste-shocks benchmark.

3.5.1 Married Couple

This is the model of consumption-savings behavior of a married couple. Its state space if random shocks ω (e.g. labor productivity of the spouses and love shock ψ), accumulated savings a and allocation of decision power θ, assuming that $\theta^f = \theta$ and $\theta^m = 1 - \theta$.

Following Chiappori and Mazzocco 2017, assume that the intrahousehold problem is solved, and the couple's problem is reduced to the choice of total consumption expenditures in this period c and savings for the next period s. To be precise, let

$$U(c, \theta) = \max_{C(c^f, c^m) = c} \left\{ \theta \cdot u(c^f) + (1 - \theta) \cdot u(c^m) \right\},$$

and $c^f(c,\theta)$ and $c^m(c,\theta)$ correspond to its optimal solutions.

3.5.1.1 No Taste Shocks

Assuming that the couple is together in period t, the consumption-savings problem and value function are given by

$$[\tilde{c},\tilde{s}](a,\omega,\theta) = \arg\max_{c,s,d} \left\{ U(c,\theta) + \beta \cdot \mathbb{E}_{\omega'|\omega}\, \mathcal{V}^{fm}_{t+1} \right\}, \text{ s.t. } c+s = B(a,\omega),$$

$$(1-d_{t+1})[V^m_{t+1}(s,\omega',\theta') - V^{m,d}_{t+1}(s,\omega')] \geq 0, \;\; (1-d_{t+1})[V^m_{t+1}(s,\omega',\theta') - V^{m,d}_{t+1}(s,\omega')] \geq 0,$$

where

$$\mathcal{V}^{fm}_{t+1} = \left\{ (1-d_{t+1}) \left[\theta^f \cdot V^f_{t+1}(s,\omega',\theta') + \theta^m \cdot V^m_{t+1}(s,\omega',\theta') \right] + d_{t+1} \left[\theta^f \cdot V^{f,d}_{t+1}(s,\omega') + \theta^m \cdot V^{m,d}_{t+1}(s,\omega') \right] \right\},$$

$$V^f_t = u(c^f(c,\theta)) + \beta \cdot \mathbb{E}_{\omega'|\omega}\, \mathcal{V}^f_{t+1}, \quad V^m_t = u(c^m(c,\theta)) + \beta \cdot \mathbb{E}_{\omega'|\omega}\, \mathcal{V}^m_{t+1}.$$

and $V^{m,d}_{t+1}(s,\omega')$ and $V^{s,d}_{t+1}(s,\omega')$ correspond to the continuation values if couple divorces. The divorce decision is taken after s and ω are realized, so optimization with respect to d is a slight abuse of notation. The participation constrains are also have to hold for each combination of ω' and s.

The law of motion of θ is determined by the same renegotiation rules as before: if there exists at least one θ such that participation constraints are satisfied, the couple picks θ' (potentially from a grid) closest to θ such that both constraints are satisfied and the optimal d_{t+1} is 0, otherwise d_{t+1} is 1 and θ is not defined.

The problem has the same features as the two-period one: the term $\mathcal{V}^{fm}_{t+1}$ is non-smooth in s because of jumpy d, and therefore the function that we optimize in consumption-savings problem display the same behavior with kinks.

3.5.1.2 Adding Taste Shocks

I repeat the exercise of putting additive taste shocks to the model, so its new formulation is

$$[\tilde{c}, \tilde{s}](a, \omega, \theta) = \arg\max_{c,s,d} \left\{ U(c, \theta) + \beta \cdot \mathbb{E}_{\omega'|\omega}\, \mathcal{EV}^{fm}_{t+1} \right\}, \text{ s.t. } c + s = B(a, \omega),$$

$$(1-d_{t+1})[V^m_{t+1}(s, \omega', \theta') - V^{m,d}_{t+1}(s, \omega') - \xi] \geq 0, \;\; (1-d_{t+1})[V^m_{t+1}(s, \omega', \theta') - V^{m,d}_{t+1}(s, \omega') - \xi] \geq 0,$$

where

$$\mathcal{EV}^{fm}_{t+1} = \mathbb{E}_\xi \Bigg\{ (1 - d_{t+1}) \cdot \left[\theta^f \cdot V^f_{t+1}(s, \omega', \theta') + \theta^m \cdot V^m_{t+1}(s, \omega', \theta') \right] + \\ + d_{t+1} \cdot \left[\theta^f \cdot (V^{f,d}_{t+1}(s, \omega') + \xi) + \theta^m \cdot (V^{m,d}_{t+1}(s, \omega') + \xi) \right] \Bigg\}.$$

For the rest of this subpart I economize on notation and consider the $\mathcal{EV}$ expression for fixed s and ω' and t. Under usual assumptions, $V^f(\theta)$ is increasing with respect to θ, and $V^f(\theta)$ is decreasing; the divorce values do not depend on θ. Therefore we still can define

$$M(\theta) = \min \left\{ V^f_{t+1}(\theta) - V^{f,d}, V^m(\theta) - V^{m,d} \right\},$$

and $\theta^{ebs} = \arg\max_\theta M(\theta)$. The divorce happens if $M(\theta^{ebs}) < \xi$, otherwise the couple stays together. Then, denoting original $\theta = \theta^{sq}$, in the expression for $\mathcal{EV}$ we have $\theta' = \theta^{sq}$ if $\xi < M(\theta^{sq})$. If $\xi \in [M(\theta^{sq}), M(\theta^{ebs})]$, we have a distribution of $\theta' \in [\theta^{sq}, \theta^{ebs}]$, and its value θ^ξ on this interval is given by the unique solution to equation $V^f(\theta^\xi) = V^{f,d} + \xi$. Therefore the decisions can be summarized as

$$(\theta'(\xi), d(\xi)) = \begin{cases} (\theta, 0) \;\; \xi < M(\theta), \\ (\theta^{\xi}, 0) \;\text{ if }\; M(\theta) < \xi < M(\theta^{ebs}), \\ (\varnothing, 1), \;\text{ if }\; \xi > M(\theta^{ebs}). \end{cases}$$

Computing θ^{ξ} is totally infeasible, because for each θ we not only need this period utilities, which are analytical, but also the continuation values, which are computed backwars. So the choice is again to stick to the grid in θ. Defining $T = \{\theta_1, ...\theta_N\}$, we can define the gridded θ^{ebs} and θ^{sq} and the same sequence of K values in between $\{\theta^1 = \theta^{sq}, \theta^2, ..., \theta^K = \theta^{ebs}\}$. Therefore we can recycle the same notation as in section 3.4, and define $\{M^1, ..., M^K\}$ and $\{F^1, ..., F^K\}$. This would allow to present the smooth version of the continuation value:

$$\mathcal{EV}^{fm}_{t+1} = g^K + \left[\theta^f \cdot V^f_{t+1}(\theta^1) + \theta^m \cdot V^m_{t+1}(\theta^1)\right] \cdot F^1 +$$
$$\sum_{k=2}^{K} \left[\theta^f \cdot V^f_{t+1}(\theta^k) + \theta^m \cdot V^m_{t+1}(\theta^{k-1})\right] \cdot (F^k - F^{k-1}) + \left[\theta^f \cdot V^{f,d}_{t+1} + \theta^m V^{m,d}_{t+1}\right](1 - F^K).$$

This continuation value is continuous with respect to savings (dependency is omitted). The practical solution is to compute it on a fine grid of savings, and then interpolate $\mathcal{EV}^{fm}_{t+1}(s)$ with respect to s.

For the case $\theta^{sq} > \theta^{ebs}$, everything is symmetric. The sequence $\{\theta^1, ..., \theta^K\}$ becomes *decreasing*, although the sequences $\{M^1, ..., M^K\}$ and $\{F^1, ..., F^K\}$ are still increasing. Therefore the expressions are virtually indistinguishable.

3.5.2 Adding Marriage

The previous version was considering a married couple with an abstract value of divorce. The value of divorce can correspond to the value of being single with potential remarriage. Moreover, the agents can start their lives as singles and form new couples after they meet a draw from a pool of potential partners.

The usual choice of the couples formation is the following: when two partners meet and if there exists an allocation of decision power θ such that being together with pooled resources makes both partners better off, and the initial θ is defined with Nash Bargaining. Abusing the notation concerning resources, the solution is typically:

$$\theta^{nbs} = \arg\max_{\theta} \left(V^f(\theta) - V^{f,s}\right) \cdot \left(V^m(\theta) - V^{m,s}\right).$$

For the case of taste shocks, however, Nash Bargaining is not the best choice. One can imagine a similar "hate shock" ζ and

$$\theta^{nbs}_{\zeta} = \arg\max_{\theta} \left(V^f(\theta) - V^{f,s} - \zeta\right) \left(V^m(\theta) - V^{m,s} - \zeta\right).$$

First, the Nash Bargaining solution is only correctly defined where both expressions are positive, and in the case of continuously distributed taste shocks the sign of surplus is random. Second, more importantly, in this case θ will be a continuous function of ζ, with more equal solutions corresponding to smaller values of ζ.

A tractable alternative is to use

$$\theta^{ebs} = \arg\max_{\theta} \min\left\{V^f(\theta) - V^{f,s} - \zeta, V^m(\theta) - V^{m,s} - \zeta\right\}$$

which is independent on ζ. This would mean that for any combination of partner's characteristics we can again define the marriage surplus M^{ebs}. Therefore the probability the a match marries each other is probability that ζ is below M^{ebs}, and it is continuous and smooth in the inputs of V, and hence do not create potential for discontinuity.

To write this a little bit more formally, consider the single female who faces potential matches with assets a^q and resulting couple's characteristics ω^q, where each match happens with probability p^q. If the female saved s, and them match q is realized and they agree to be together, they form a couple and each partner $x \in \{f, m\}$ gets value $V^x_{t+1}(s + a^q, \omega^q, \theta^{ebs,q})$. This happens with probability $\mathbb{P}(\zeta < M^{ebs,q}) \equiv F^q$, which is itself computed based on V of single and married agents.

Therefore the value function of single female here is

$$V^{f,s}_{t+1}(a, \omega^s) = \max_{c,s} u(c^f) + \beta\, \mathbb{E}_{\omega^q, \omega^{s\prime}|\omega^s} \sum_q p^q \cdot \left[F^q \cdot V^f_{t+1}(s + a^q, \omega^q, \theta^{ebs,q}) + (1 - F^q) \cdot V^{f,s}_{t+1}(s, \omega^{s\prime}) \right],$$

subject to the usual budget constraint $c + s = B^{f,s}(a, \omega^s)$.

In this form, each potential couple has a non-zero probability of being married, and each potential couple starts with θ^{ebs}, which is a value that in the absence of shocks will never trigger renegotiation (in this sense, we can consider the couple as minimizing the deviation from constant-weight collective household problem).

3.6 Conclusion

By using simple example with natural assumptions common to the existing literature, I show that the collective household model with divorce option features discontinuous behavior: for a small change in inputs the couple can switch from being together to separating or the opposite. This complicates its quantitative analysis, as approximating discontinuous problems is known to be difficult on infeasible. Therefore I present a way to smooth the discontinuous decisions by introducing randomness, which is similar to introducing taste shocks in discrete choice literature.

I develop and present a way of introducing the taste shocks to the collective household model without major changes to its structure. The idea is to utilize the concept of egalitarian bargaining, which allows to condense two participation constraints into one. Then the symmetric taste shock common to both constrains is introduced, which is viewed as a random additional utility of the couple's option to separate. This allows for each couple to have probability of divorce and probability of being together.

By exploiting a tractable case where the exact solutions to the model can be obtained, I show that taste shocks allow to get rid of discontinuous decisions, and, when the feasible approximations on grids are used, adding the taste shocks makes resulting functions both closer to the true solution and smoother. A major precaution is that if the shocks become too large, the problem changes too much from its discontinuous version. Therefore if the shocks are viewed as a non-fundamental way to efficiently approximate the "true" problem with discontinuities, their scale has to be kept low enough. However, if we view shocks as a fundamental feature of decision-making, they provide a way to set up new decision problems that have similar nature but probabilistic decisions instead of discrete ones. Either way, more taste shocks make the models more well-behaved.

Iskhakov et al. 2015 show that taste shocks can be used to smooth problems with the mixture of discrete and continuous choices and to use methods based on Euler equations (like Carroll 2006) to dramatically increase the efficiency of the solutions. This can be viewed as an important first step in this direction: smooth problem potentially has smooth Euler equations.

Deriving Euler equations is possible in this case, (Mazzocco 2007) shows some of the particular cases. The dependencies of bargaining weights of s are generally unknown, they are, however, implicitly given by the participation constraints. Developing this theory is outside of the scope of this paper: although for two-period case it seems relatively tractable, there is a number of obstacles when the problem becomes multi-period. In addition, as shown in Section 3.4, due to gridded approximations in the bargaining power dimension, the problem potentially features large degree of non-convexity in the dimensions other than discrete decisions, therefore the solutions to Euler equations may need careful examination.

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Appendix A

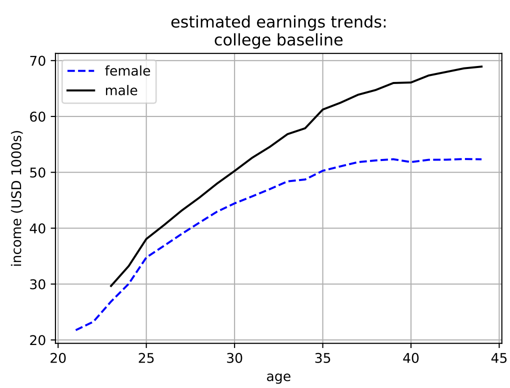
Appendix to Chapter One

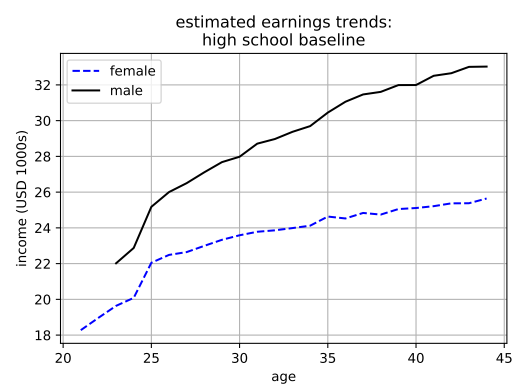
A.1 Figures and Tables

Table A.1: Extrental Estimates.

	College			High School	
Income shocks and initial standard deviation (SIPP, equations 1.12 and 1.14):					
	σ_z	$\sigma_{z,0}$		σ_z	$\sigma_{z,0}$
Female	0.20	0.43	Female	0.18	0.18
Male	0.16	0.42	Male	0.17	0.23

Income trends (ACS, equation 1.15):

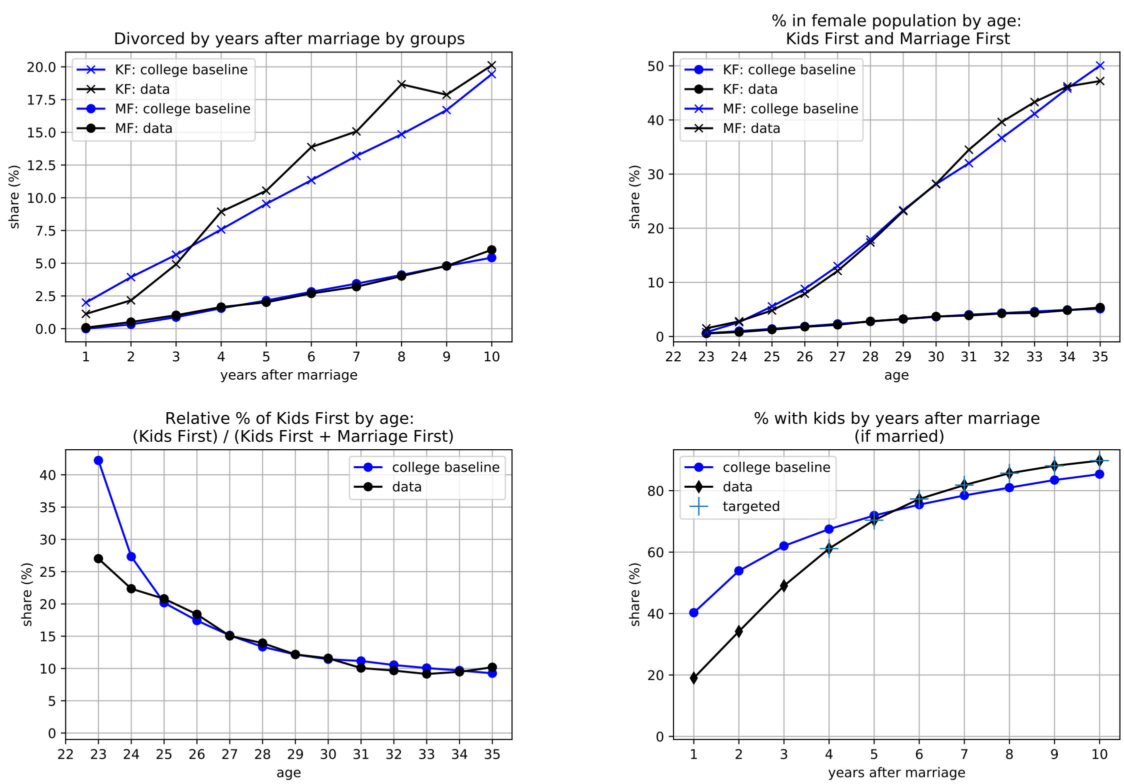




Marriageable singles' log-assets distribution (SIPP, equation 1.22):

	College		High School
	$(\alpha_0, \alpha_1, \alpha_2, \alpha_3; \beta_0, \beta_1)$		$(\alpha_0, \alpha_1, \alpha_2, \alpha_3; \beta_0, \beta_1)$
Female	$(0.50, 0.22, 0.89, 0.09; 1.15, -0.014)$	Female	$(0.53, 0.065, 1.72, 0.005; 0.81, 0.005)$
Male	$(1.07, 0.20, 1.31, 0.06; 1.06, -0.011)$	Male	$(-0.57, 0.16, 2.48, -0.059; 1.17, -0.011)$

Figure A.1: Model fit: main targets, college graduates



Notes: all points are targeted on the first three graphs.

Figure A.2: Model fit: quantities of singles, college graduates

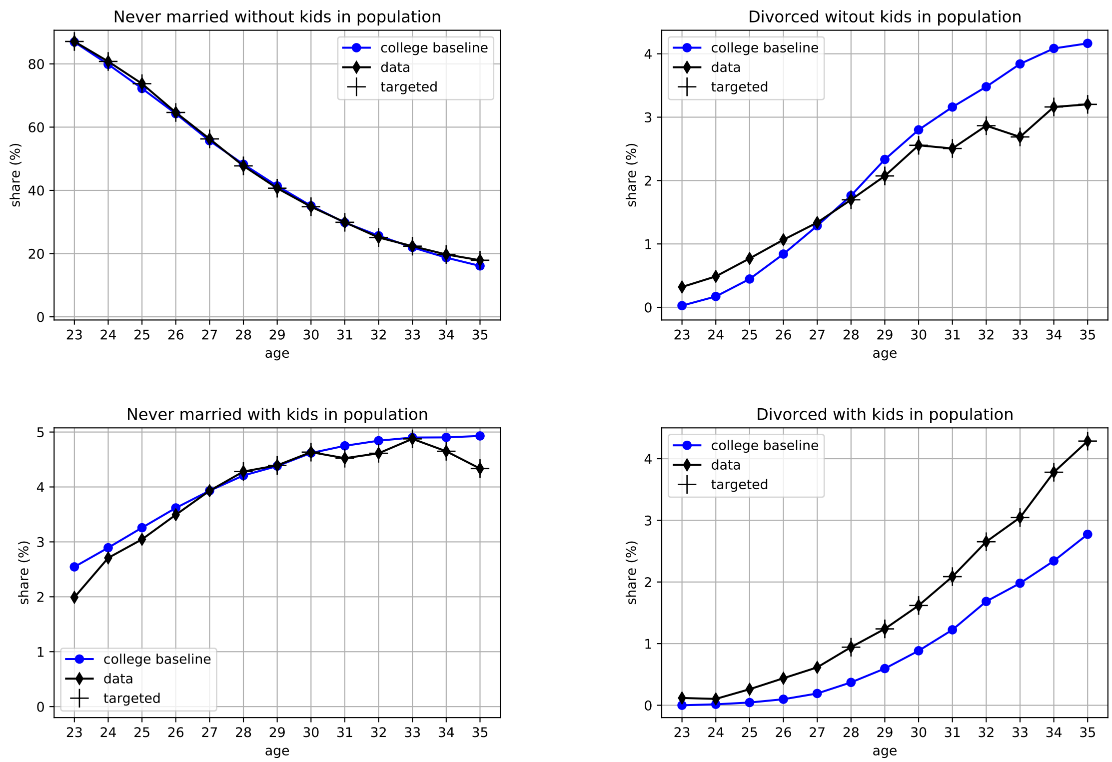
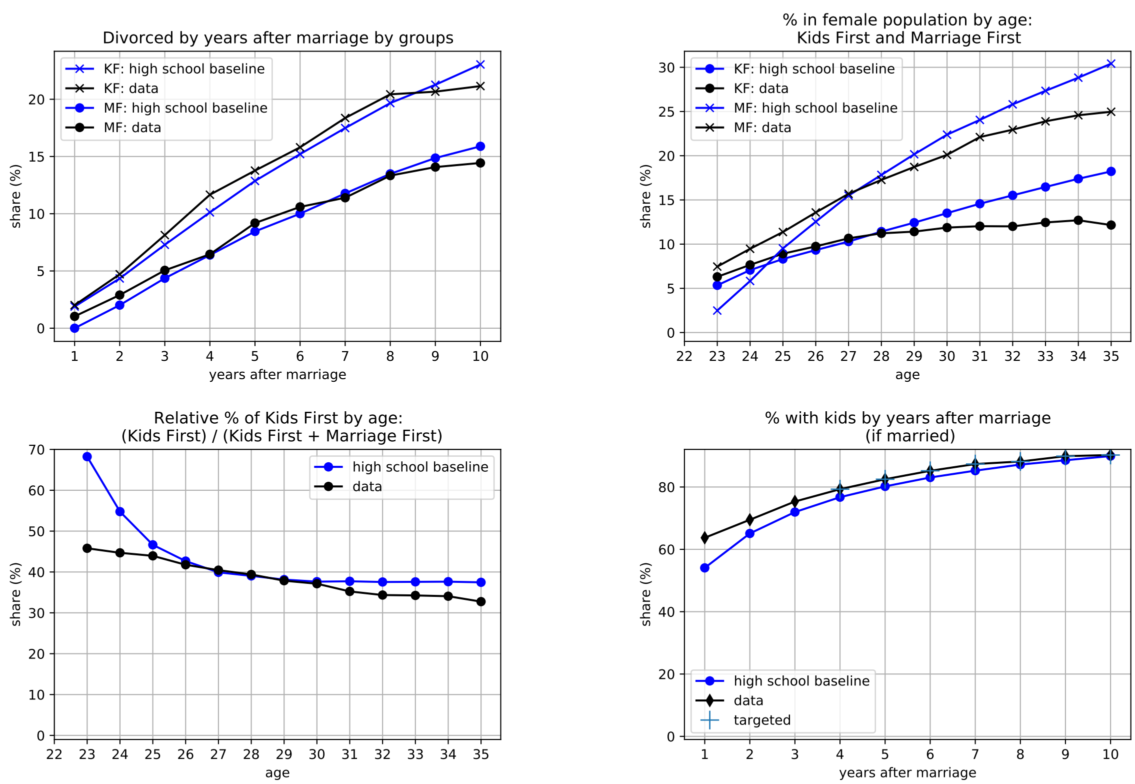


Figure A.3: Model fit: main targets, high school graduates



Notes: all points are targeted on the first three graphs. Nothing is targeted on the last graph, as the preference parameters are fixed at the college graduates' levels.

Figure A.4: Model fit: quantities of singles, high school graduates

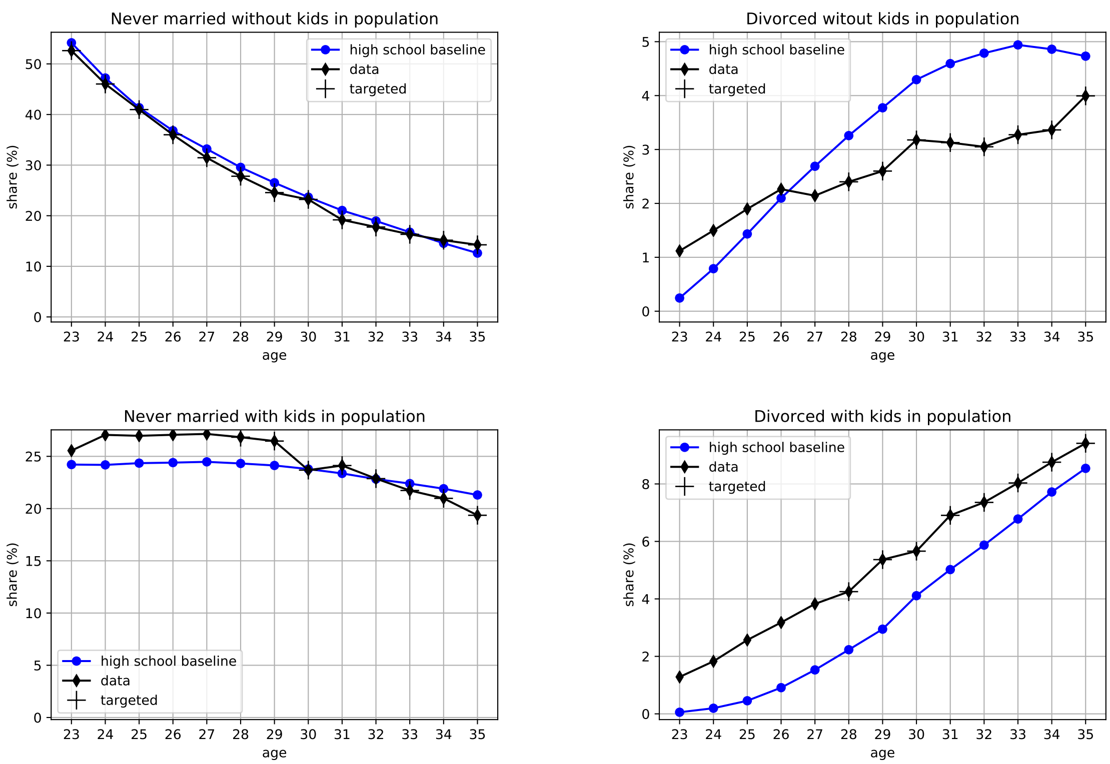


Figure A.5: Agreement thresholds and impact of unplanned pregnancy

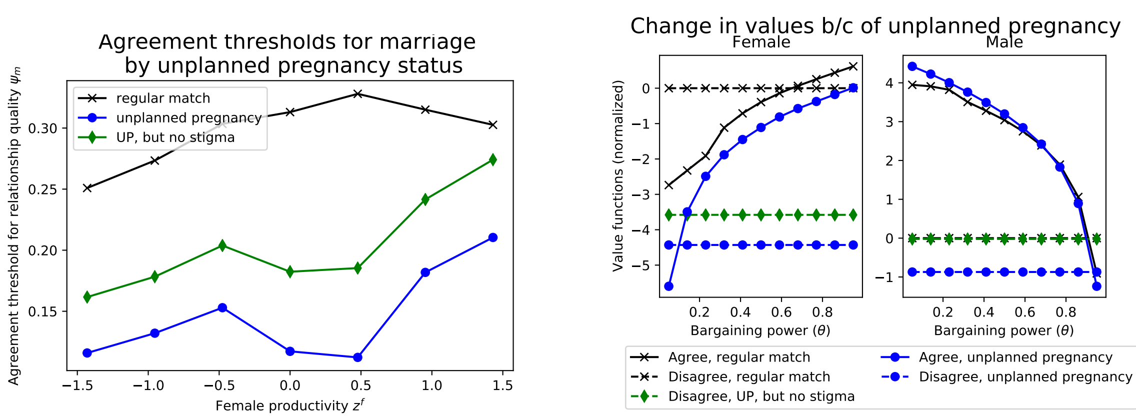


Figure A.6: Agreement thresholds and impact of unplanned pregnancy, high school version.

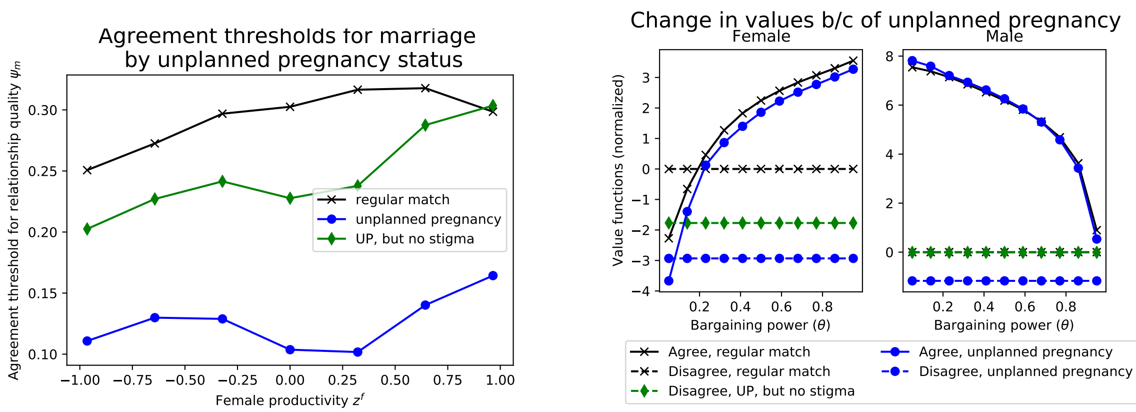
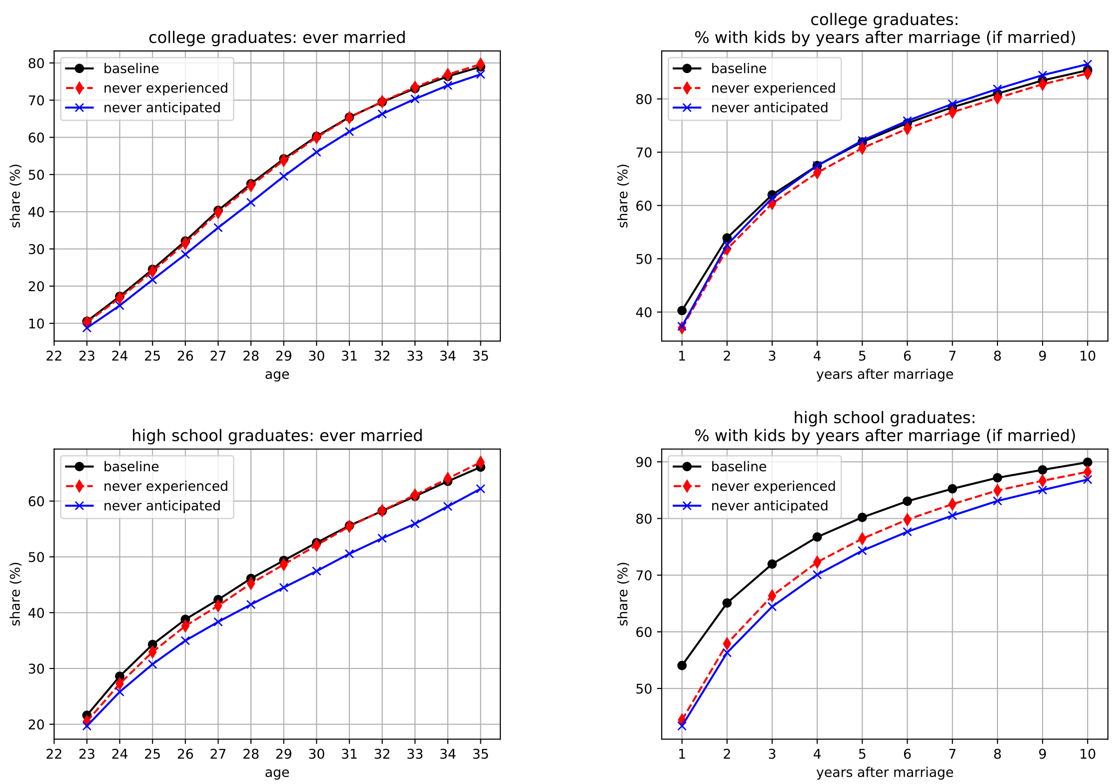


Figure A.7: Anticipation of unplanned pregnancies.



Notes: **never experienced** refers to the calibration where unplanned pregnancies do not happen, but agents still anticipate them. **never anticipated** refers to the calibration where unplanned pregnancies do not happen and everyone knows this.

Table A.2: Causal effects of unplanned pregnancy and their decomposition.

	Offered	**All KF**	**Compliers**	**Always**	**Never**
Marry if pregnant	+, −	+	+	+	−
Marry if not pregnant	+, −	+, −	−	+	−
College graduates					
Share in population	100	31.1	16.5	14.6	68.9
Ever divorced by the age of 50					
...if pregnant at 25	19.6	35.3	45.6	23.6	12.5
...if not pregnant at 25	21.0	23.8	19.1	29.1	19.8
Married to any partner at 50					
...if pregnant at 25	64.0	70.7	62.5	80.0	61.0
...if not pregnant at 25	80.5	82.2	80.0	84.7	79.7
Single mother at 50					
...if pregnant at 25	33.1	29.3	37.5	20.0	34.8
...if not pregnant at 25	13.1	13.0	13.5	12.5	13.2
High school graduates					
Share in population	100	36.4	12.1	24.2	63.6
Ever divorced by the age of 50					
...if pregnant at 25	37.4	54.2	69.2	46.7	27.9
...if not pregnant at 25	42.0	47.2	39.1	51.3	39.0
Married to any partner at 50					
...if pregnant at 25	65.5	66.7	59.2	70.4	64.8
...if not pregnant at 25	73.1	74.1	71.8	75.3	72.5
Single mother at 50					
...if pregnant at 25	32.1	33.3	40.8	29.6	31.4
...if not pregnant at 25	22.3	23.1	23.7	22.7	21.8

Notes: this compares two identical populations, in which everyone met their first potential partners at 25 and either gets or does not get an unplanned pregnancy. **All KF** refers to subpopulation of those who agreed to enter the marriage following the pregnancy. Among them, **Compliers** are those who disagreed in case of no pregnancy and **Always** are those who agreed under both scenarios. Group **Never** represents those who disagreed both with and without the pregnancy. This is the calibration for the college graduates, the numbers are percentages.

Table A.3: Effects of unplanned pregnancies and their anticipation.

	High School			**College**		
	BL	**NE**	**NA**	**BL**	**NE**	**NA**
% ever married at 25	34.3	33.0	30.8	24.5	24.0	21.7
% ever married at 35	66.1	67.0	62.2	79.0	79.7	76.9
% ever divorced at 30	9.8	9.4	8.3	4.6	4.4	3.8
% ever divorced at 50	35.3	36.9	34.5	23.2	23.3	21.8
% single mothers at 35	29.8	22.8	21.9	7.7	3.8	3.7
Welfare compared to BL (1000s of 2017 USD in savings)						
median male at 23			93			60
median female at 21			75			75

Notes: **BL** is the baseline estimation, **NE** is when unplanned pregnancies are anticipated, but never experienced, **NA** is when unplanned pregnancies are neither anticipated nor experienced. Welfare computing details are given in Appendix A.4.

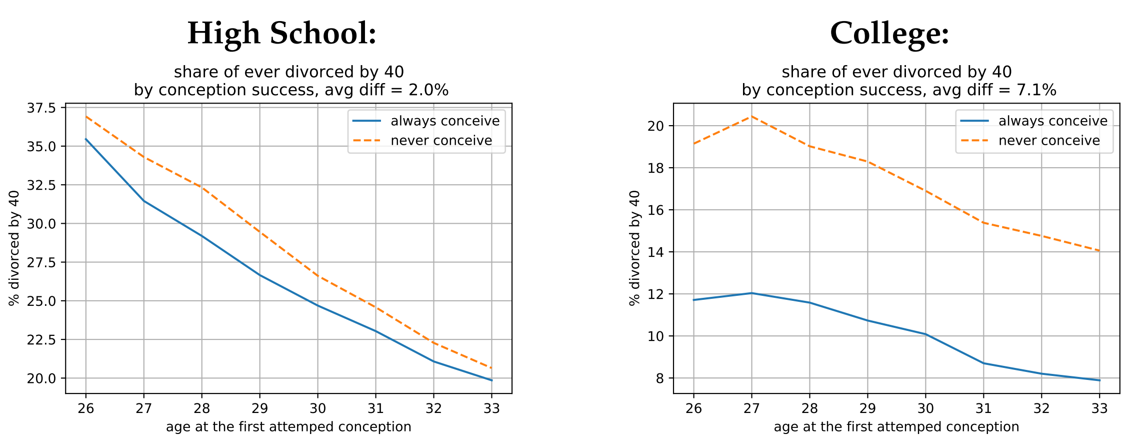


Figure A.8: How fertility changes divorce risks.

Table A.4: Experiment: more pushing into shotgun marriage.

	High School				College			
Parameter ϕ_s:	$\times 0.5$	**Base**	$\times 2$	∞	$\times 0.5$	**Base**	$\times 2$	∞
% of single mothers in population								
...at 35	29.1	29.8	31.0	34.1	7.8	7.7	7.7	10.2
% ever married								
...at 25	33.3	34.3	36.8	42.0	24.3	24.5	25.3	28.5
...at 35	65.2	66.1	69.1	75.7	78.5	79.0	80.1	85.0
% divorced if kids-first								
...10 years after	22.3	23.0	30.1	48.2	17.4	19.4	23.9	57.8
% unplanned pregnancies aborted								
...total	47.2	38.2	27.2	0.0	44.1	39.9	34.7	0.0
Welfare compared to Base, 1000s USD								
median male at 23	25.0	—	−46.8	−134.5	9.3	—	−19.1	−68.7
median female at 21	10.1	—	−17.0	−25.6	3.4	—	−6.3	−18.9
Welfare compared to Base, 1000s USD — unanticipated change								
median male at 23	3.3	—	−6.2	−134.5	0.7	—	−1.9	−68.7
median female at 21	−0.3	—	−0.5	−25.6	−0.3	—	0.2	−18.9
Child consumption equivalent, 1000s USD								
ever born, median	21.2	20.9	20.5	19.5	62.3	62.0	61.5	59.4
born at 30, median	27.8	27.0	26.4	24.5	65.7	65.5	65.4	64.4

Notes: this experiment changes the magnitude of social stigma parameter ϕ_s. Details on how welfare comparison and child consumption equivalent defined are given in A.4.

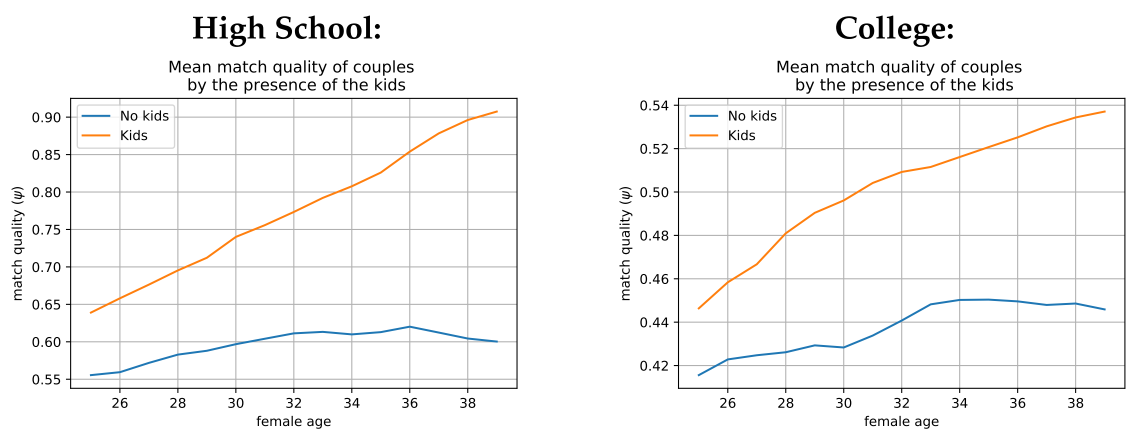


Figure A.9: How divorce risks affects fertility.

Table A.5: Effects of subsidizing couples.

	High School				College			
	(base)	**elasticities:**			(base)	**elasticities:**		
Subsidy schemes:		**AC**	**CK**	**AK**		**AC**	**CK**	**AK**
ever married at 30	(52.0)	0.17	0.10	-0.09	(60.3)	0.25	0.05	0.01
with kids at 30	(60.7)	0.38	0.72	1.41	(37.0)	0.36	0.88	1.09
single mothers at 30	(28.1)	-0.09	0.01	0.77	(5.2)	-0.02	0.01	0.07

Notes: (base) is the base value of each outcome in each education group.
AC is a lump-sum subsidy to couples without kids and with kids.
CK is a lump-sum subsidy to couples with kids.
AK is a lump-sum subsidy to couples with kids and single mothers.
Elasticities are computed as

$$\epsilon = \frac{\Delta \text{ Outcome (percentage points)}}{\Delta \text{ Median resources (\%)}}.$$

For the median resources I use median labor earnings plus savings of a couple with kids at 30. The actual amount of subsidy is equivalent to 6000 of 2017 USD annually and has age limits of 21–40.

Table A.6: Impact of child support

	College			High School		
Child support regime:	**No**	**Base**	**Full**	**No**	**Base**	**Full**
divorced in 10 years if KF	18.9	**19.4**	19.8	22.4	**23.0**	24.2
divorced in 10 years if MF	4.9	**5.4**	6.6	14.1	**15.9**	18.4
KF women in population at 30	3.6	**3.6**	3.6	13.4	**13.5**	13.7
MF women in population at 30	27.2	**28.1**	29.3	21.0	**22.4**	22.9
single mothers at 35	7.4	**7.7**	9.6	27.8	**29.8**	34.6
unplanned pregnancies aborted	41.0	**39.9**	28.2	44.9	**38.2**	17.0
Welfare compared to Base (1000s of 2017 USD in savings)						
median man at 23	2.6	—	−4.8	4.6	—	−9.7
median woman at 21	−4.1	—	7.7	−8.3	—	22.3
Child Consumption Equivalent, 1000s USD						
child ever born, median	61.9	61.9	61.4	21.5	20.9	19.6
child born at 30, median	64.7	65.8	65.8	28.6	27.0	26.2

Notes: **No** refers to the scenario with absent child support, **Base** is the one with limited enforcement used in the estimated model, **Full** is fully enforced child support. Details on how welfare comparison and child consumption equivalent defined are given in A.4.

Table A.7: Fertility control and removing the stigma perform the best.

	High School				**College**			
Experiment	**Base**	**FC**	**NS**	**Both**	**BL**	**FC**	**NS**	**Both**
% of single mothers in population								
...at 35	29.8	24.2	28.7	23.0	7.7	3.9	8.0	3.8
% ever married								
...at 25	34.3	32.3	32.4	30.6	24.5	22.3	23.9	21.6
...at 35	66.1	65.9	63.9	61.3	79.0	77.7	77.8	76.8
% divorced 10 years after marriage if...								
...kids-first	23.0	20.0	20.1	16.3	19.4	10.0	14.3	8.4
...marriage-first	15.9	15.2	14.8	13.9	5.4	5.3	5.4	5.3
% unplanned pregnancies aborted								
...total	38.2	69.8	47.2	79.4	39.9	83.6	44.1	87.5
Welfare compared to Base, 1000s USD								
median male at 23	—	36.2	23.7	73.7	—	51.1	7.5	74.9
median female at 21	—	15.5	51.5	104.7	—	23.1	22.7	60.6
Child consumption equivalent, 1000s USD								
ever born, median	20.9	23.0	21.4	23.6	61.9	64.5	62.3	64.7
born at 30, median	27.0	29.2	28.2	30.6	65.8	67.3	65.7	67.0

Notes: **FC** shows an experiment when women can choose to terminate any unwanted pregnancy at no costs. **NS** removes the social stigma setting $\phi_s = 0$. **Both** does both experiments together. Welfare details are given in Appendix A.4, 500 is an upper bound for welfare changes.

A.2 Additional Model Details

A.2.1 Single Males

The single males face less consequences of unplanned pregnancies, as they do not have to make an abortion decision. Yet, they may be required to pay the child support and suffer from the same social stigma in case of refusal to enter a shotgun marriage. This depends on the female's match-specific decision to keep the pregnancy, so the value of refusal in this case:

$$\mathbb{E}_{csm}\, V_t^{m,s}(a, z^m) = \begin{cases} p^{cs,n} \cdot V_t^{m,s}(a, z^m - CS^m) + (1 - p^{cs,n}) V_t^{m,s}(a, z^m), & \text{kept pregnancy} \\ V_t^{m,s}(a, z^m), & \text{abortion} \end{cases} \tag{A.1}$$

Finally, the pool of potential partners for them is different, as there are chances they meet a single mother. In case this happens and they agree to marry, they face a one-time utility costs ϕ_r, that is capturing disutility of having a step child.

Let Γ^M denotes potential woman matches without kids, and Γ^{Mk} denote marriageable single mothers. Also, let p_t^{sk} denote the share of single mothers in population. To ease the notation, let $p^{\text{meet,np}} = (1 - p_t^{\text{sk}}) \cdot p^{\text{meet}} \cdot (1 - p^{\text{preg}})$, denote probability to meet a childless woman and not to have an unplanned pregnancy, similarly $p^{\text{meet,p}} = (1 - p_t^{\text{sk}}) \cdot p^{\text{meet}} \cdot p^{\text{preg}}$ if for an unplanned pregnancy and $p^{\text{meet,sk}} = p_t^{\text{sk}} \cdot p^{\text{meet}}$ is for meeting a single mother.

The problem for single males is similar:

$$\begin{aligned}
V_t^{m,s}(a, z^m) = \max_{a', c^m} \Bigg\{ \; & u(c^m) + && \text{(A.2)} \\
& \beta \cdot \mathbb{E}_{z^{m\prime}|z^m} \Bigg((1 - p_t^{\text{meet}}) \cdot V^{m,s}(a', z^{m\prime}) + && \text{(no partner met)} \\
& p_t^{\text{meet,np}} \cdot \int \Big[m^{M,np} \cdot V_{t+1}^{m,c}(a' + a^M, \omega^M, \theta^{M,np}) + && \text{(met, no pregnancy, agree)} \\
& \qquad (1 - m^{M,np}) \cdot V_{t+1}^{m,s}(a', z^{m\prime}) \Big] d\Gamma^M + && \text{(disagree)} \\
& p_t^{\text{meet,p}} \cdot \int \Big[m^{M,p} \cdot V_{t+1}^{m,ck}(a' + a^M, \omega^M, \theta^{M,p}) + && \text{(met, shotgun marriage)} \\
& \qquad (1 - m^{M,p}) \cdot \big\{ \mathbb{E}_{csm}\, V_{t+1}^{m,s}(a', z^{m\prime}) - \phi_s \big\} \Big] d\Gamma^M + && \text{(disagree, social stigma)} \\
& p_t^{\text{meet,sm}} \cdot \int \Big[m^{M,sm} \cdot \Big\{ V_{t+1}^{m,ck}(a' + a^M, \omega^M, \theta^{M,sm}) - \phi_r \Big\} + && \text{(met a single mother)} \\
& \qquad (1 - m^{M,sm}) \cdot V_{t+1}^{m,s}(a', z^{m\prime}) \Big] d\Gamma^{Mk} \Bigg) \Bigg\} && \text{(disagree)} \\
\text{s.t. } \; & a' + c^m = R \cdot a + W_t^m(z^m) && \text{(evolution of the assets).}
\end{aligned}$$

A.2.2 Divorce Values and Child Support

When couple divorces, the assets are split evenly. This follows Voena (2015), which provides a broader discussion of this assumption. Shortly, it is justified by the fact that most of the state either follow equal division of marital property or impose on average a division that is approximately equal, and the fact that people accumulate most of their wealth in marriage as they marry being relatively young. I did not find this to be particularly important for the qualitative results, although the property division obviously affects the divorce rates.

Instead, I assume that upon divorce both spouses incur fixed utility costs ϕ^d. Therefore the divorce values are based on couple's state, and for the couples without children are given by

$$V_t^{f,d}(a,\omega) = V_t^{f,s}(0.5\cdot a, z^f) - \phi_d, \quad V_t^{m,d}(a,\omega) = V_t^{m,d}(0.5\cdot a, z^m) - \phi_d. \tag{A.3}$$

If couple with a child divorces, the child custody is always given to mother, and the father does not get any utility from the absent child. The father, however, can be forced to pay child support. The permanent nature of productivity shocks z allows to model child support as reallocation in productivities. The child support is assumed to be related solely to the male's labor income.

The child support is awarded following a divorce with probability $p^{cs,d}$, which is different between married and unmarried couples. If the child support is awarded, the evolution of productivity is $\tilde{z}_t^f = z_t^f + CS^m(z_t^m)$ and $z_t^m = z_t^m - CS^f(z_t^f, z_t^m)$ for women and men respectively. Whether the child support is awarded is not known at the moment of divorce or marriage decisions. This realization does not keeps track of child's age, assuming the child support is paid indefinitely long, however, the fixed chances to avoid child support balance this. Productive males who lose the most because of indefinitely long payment period are also the most protected as they are less likely to pay relative to the case where establishing child support were up to decision of women.

To determine the exact change in z, assume that child support is proportion κ of male's labor income, then the productivity loss for male $CS^m(z^m)$ sovles

$$\exp(z_t^m - CS^m + T_t^m) = (1-\kappa)\cdot \exp(z_t^m + T_t^m),$$

and the productivity gain of female $CS^f(z_t^f, z_t^m)$ solves

$$\exp(z_t^f + CS^f + T_t^f) = \exp(z_t^f + T_t^f) + \kappa \cdot \exp(z_t^m + T_t^m).$$

Given the values for the child support, the (expected) values of the divorce for a couple with a child are

$$V_t^{f,dk}(a,\omega) = p^a \cdot V_t^{f,sk}(0.5\cdot a, z^f + CS^f) + (1-p^a)\cdot V_t^{f,sk}(0.5\cdot a, z^f) - \phi_d, \tag{A.4}$$

$$V_t^{m,dk}(a,\omega) = p^a \cdot V_t^{m,s}(0.5 \cdot a, z^m - CS^m) + (1-p^a) \cdot V_t^{m,s}(0.5 \cdot a, z^m) - \phi_d. \tag{A.5}$$

In the actual solution the resulting transition of z is approximated by two-point binary distribution over the nearest grid values.

A.2.3 Functional Forms

The model assumes a set of standard CRRA utility and production functions.

Consumption's utility is standard:

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma}. \tag{A.6}$$

When two spouses live in the couple, they can spend less money to achieve consumption levels c^f, c^m then alone because of household's returns to scale. I assume that total couple's consumption expenditures are

$$c = C(c^f, c^m) \equiv \left[(c^f)^{1+\rho_c} + (c^m)^{1+\rho_c}\right]^{\frac{1}{1+\rho_c}}. \tag{A.7}$$

In a spirit of Chiappori and Mazzocco (2017), couple's intrahousehold problem can be simplified to picking just a total consumption expenditures. To see this, one may consider the problem

$$U(c) = \max_{c^f, c^m} \left\{ \theta^f \cdot \frac{(c^f)^{1-\sigma}}{1-\sigma} + \theta^m \cdot \frac{(c^m)^{1-\sigma}}{1-\sigma}, \quad \text{s.t.} \quad c = \left[(c^f)^{1+\rho_c} + (c^m)^{1+\rho_c}\right]^{\frac{1}{1+\rho_c}} \right\}.$$

After doing some algebra, it can be shown that there are functions $A(\theta)$, $k_f(\theta)$ and $k_m(\theta)$ such that

$$U(c) = A(\theta) \cdot \frac{c^{1-\sigma}}{1-\sigma}, \;\; c^f = k^f(\theta) \cdot c, \;\; c^m = k^m(\theta) \cdot c,$$

and therefore utility of the couple can simply be represented as a function of total expenditures and bargaining weights, which simplifies the optimization considerably.

When the children are present, parents produce child's consumption q as a public good. Both parent's money x and female time l^f contribute to the its production, so

$$q = f(x, l^f) \equiv \left[x^\lambda + \kappa \cdot (1 - l^f)^\lambda\right]^{\frac{1}{\lambda}} \tag{A.8}$$

This function is built in such a way that if female works full-time ($l^f = 1$), q just represents the monetary expenditures x. This also helps to interpret the subsistence constraint, as we require $q \geq \bar{q}$.

The utility of having a child consists of fixed utility benefit and part that is dependent on the child's consumption, so

$$\phi(q) = \phi_0 + \alpha \cdot \frac{q^{1-\phi_1}}{1-\phi_1}. \tag{A.9}$$

For the skills depreciation functions, the model assumes discrete choice of labor supply, which only has an extensive margin: whether or not to participate in the labor market. Participating corresponds to $l^f = 1$ and $\delta(1) = 0$, and non-participating is $l^f = \underline{l}$ and $\delta(1) = \underline{\delta}$.

A.2.4 Other Details

All agents retire at the age of T^R, where they get a fixed retirement income of b, unconditional on their past productivity. I found this to be of minor importance for the results, as all the transitions I focus only happen early in life.

I introduce non-linear taxation, that depends on couple's or single's total labor earnings and number of children, following the approximations obtained by Guner, Kaygusuz, and Ventura (2012). The approximations are based on social security data and capture not solely the tax schedule, but also the average utilization of the major welfare programs, including EITC and TANF.

A.3 Solution Technique

To solve the model, all state variables and transition probabilities are discretized, and the value function iteration starting from the very last period is used. An important complication is that there is no guarantee that value functions are convex or even monotonic, although the latter can be proved in simple cases. The discreteness of marriage, divorce, fertility and labor supply decisions and the collective nature of the couple's decisions make modern Euler-equation based methods (like Iskhakov et al. (2015)) difficult to apply. Adding taste shocks as a smoothing device can potentially be done, but it is not enough to obtain tractable Euler equations as the envelope theorem is not applicable to the individual values of couple's decisions. Therefore the preferred approach is maximal discretization, and the consumption-savings problems are solved by brute force global search. The details of the method are described in Appendix A.3.

In total, the model takes around three minutes to be solved and simulated on a Macbook Pro, 2015. As the routines for optimization, marriage and renegotiation are very parallelizable, it can be efficiently solved on GPUs. The code is done in Python using Numba–Cuda package and Cupy package. Running time is then 30–70 seconds, depending on the GPU model.

As the model has a finite lifespan and no interaction of people of different ages, apart from a fixed difference in ages (which is just equivalent to renumbering the periods), it can be solved using a standard backward induction, starting from zero value at the last period of the life. Large dimensionality of state complicates the analysis, for each age and agents' type the value function is a 5-dimensional object, where the dimensions are assets, female and male productivity, match quality and (one-dimensional) bargaining power. Productivities and match quality, however, are exogenous objects and are referred to as ω.

The solution assumes discrete grids for assets a (60 points), female productivity z^f (7 points), male productivity z^m (5 points), couple's match quality ψ (15 points) and female bargaining weight θ (15 points). These grid points represent the nodes at which the value functions are stored, the decisions regarding savings and bargaining power are allowed to be off-grid, and for them I introduce finer grids for savings s (500 points) and decision weights θ (150 points), where the value functions at these point are computed by the linear interpolation of the coarser grid values.

To discretize the standard random walk process for z and ψ I used a non-stationary Rouwenhorst (1995) method. Fella, Gallipoli, and Pan (2019) show that it has the best performance for the lifecycle model applications. An important feature of the method is the grid that depends on time, as the standard deviation of the random walk variable increases over time. The case of random walk with drift for the skills depreciation when females are out of labor force requires being handled separately, I discuss this in A.3.2.

A.3.1 Tauchen Method

This is what I refer to as Tauchen method (Tauchen 1986). For a random variable x and the n-node grid $[y_1, ..., y_n]$ probability to get to the node k is a probability that x is closer to y_k than to anywhere else, assuming the grid is ordered, this becomes $p_k = \mathbb{P}\left(\frac{y_{k-1}+y_k}{2} \leq x \leq \frac{y_{k+1}+y_k}{2}\right)$ for $k \in \{1, ..., n\}$, assuming $y_0 = -\infty$ and $y_{n+1} = +\infty$.

This idea is not specific to the normal distribution and can be used with an arbitrary CDF.

A.3.2 Approximations for Skills Depreciation

In case of being out of the labor force, the equation 1.14 represents a random walk with drift. Rouwenhorst (1995) approximation is not tractable for this case. If done, it will also require having different grid nodes for those in and out labor force.

Therefore, these transition matrices are derived separately using a somewhat synthetic approach: I keep the same Rouwenhorst nodes as for those in the labor force and combine them with Tauchen approach for obtaining the transition probabilities. I did not find the result to be particularly sensitive to the choice approximation method, therefore I used the best method whenever I could and the tractable one whenever the approach is not obvious.

A.3.3 Partners' Distribution

Take females, for example. Given the grid for $z^m = \{z_1^m, ..., z_{n_z}^m\}$ in this period, I apply Tauchen method to (non-parametrically estimated) distribution of the single male's productivity at this age $F_t^{z,m}(z)$, and get probabilities to draw a partner with each level $\{p_1, ..., p_{n_{z,f}}\}$. The assets distribution from equation 1.16 can be represented as

$$a = \exp\{\mu_t^a(z) + \varepsilon_t^a \cdot \sigma_t^a(z)\} \mathbb{I}(\log a^* \geq \bar{a}), \;\; \varepsilon_t^a \sim \mathcal{N}(0,1).$$

I apporximate no ε_t^a with q-point distribution.[1] For each z_i^m this implies q assets levels $\{a_{i1}, ..., a_{iq}\}$ and corresponding probabilities $\{p_{i1}, ..., p_{iq}\}$. By combining the two discrete distributions, and adding the distribution for initial match quality ψ, which is again a discrete-grid approximation of $\mathcal{N}(\mu_{\psi,0}, \sigma^2_{\psi,0})$, we get a distribution of potential matches in terms of a, z and ψ. Essentially, this can be interpreted as singles drawing potential couple's state $\omega = (z^f, z^m, \psi)$ from some discrete distribution and additionally drawing a one of the random q assets positions, so the single agent has $n_{z^f} \times n_{z^m} \times n_\psi \times q$ potential discrete transitions.

A.4 Details on Welfare Comparisons

A.4.1 Assets Variation

The welfare comparison is done in a manner familiar to classic microeconomics, but everything is converted to amounts of money in savings for a single person with no savings in the beginning of their life.

Essentially, for changes which make the person better off, the measure I use asks having how much money on savings account in the beginning of the life is equivalent to having the change. This resembles equivalent variation measure. Namely, if the change is preferred, the assets variation is:

$$AV = a_t^*(z) \text{ such that } V_t^{f,s,\text{no change}}(a = a^*, z) = V_t^{f,s,\text{with change}}(a = 0, z).$$

Otherwise, if the change is not preferred, we cannot deduct the money. Therefore, for the negative changes I define the measure similar to compensating variation:

$$AV = -a_t^*(z) \text{ such that } V_t^{f,s,\text{with change}}(a = a^*, z) = V_t^{f,s,\text{no change}}(a = 0, z),$$

meaning how much money on savings account would compensate the person for the change.

Defining these measures for people in couples is complicated, as the value functions depend on the endogenous bargaining power. For the simpler exposure I omit these

[1] I use slightly arbitrary five-point Tauchen approximation of standard normal with the nodes$\{0, \pm 0.75, \pm 1.5\}$. I find these to be more pretty satisfactory as setting more extreme bounds produces too many partners with zero assets.

comparisons.

A.4.2 Child's Consumption Equivalent

A simple measure for well-being of the child is the average child's consumption Q for the first 18 years of the child's life. At the moment the child is born, it is constructed as

$$\bar{Q}_b = \left[\frac{1-\beta}{1-\beta^{18}} \cdot \sum_{s=0}^{17} \beta^s Q_{b+s}^{1-\xi} \right]^{\frac{1}{1-\xi}}.$$

Since agents can have up to one child, each childbearing woman has the unique value of this measure.

Appendix B

Appendix to Chapter Two

B.1 History of US divorce Laws

Table B.1:
Year Unilateral Divorce was Introduced

State	Year	State	Year
Alabama	1971	Montana	1973
Alaska	1935	Nebraska	1972
Arkansas	No	Nevada	1967
Arizona	1973	New Hampshire	1971
California	1970	New Jersey	2007
Colorado	1972	New Mexico	1933
Connecticut	1973	New York	2010
District of Columbia	No	North Carolina	No
Delaware	1968	North Dakota	1971
Florida	1971	Ohio	No
Georgia	1973	Oklahoma	1953
Hawaii	1972	Oregon	1971
Idaho	1971	Pennsylvania	No
Illinois	No	Rhode Island	1975
Indiana	1973	South Carolina	No
Iowa	1970	South Dakota	1985
Kansas	1969	Tennessee	No
Kentucky	1972	Texas	1970
Louisiana	No	Utah	1987
Maine	1973	Vermont	No
Maryland	No	Virginia	No
Massachusetts	1975	Washington	1973
Michigan	1972	West Virginia	2001
Minnesota	1974	Wisconsin	1978
Mississippi	No	Wyoming	1977
Missouri	2009		

NOTES: The data of this table is taken from table 1, column (1) in (Ciacci 2017)

B.2 Net worth around divorce/breakup

In this section we provide evidence about the evolution of household's net worth around the event of divorce/breakup. Using the 1997-2017 waves of the PSID, we build a sample of 1087 divorces and 1187 breakups that respect the following characteristics: 1) household wealth is observed before and after the relationship breakdown 2) the number of adults in the household moves from two to one after the relationship breakdown 3) the net worth of the household is below the 96% of the relative distribution 4) we exclude households where the head is older than 65 years old.[1] Net worth is constructed using the PSID variables employed by (**?**). We analyze the evolution of net worth using a standard event study on our sample. Note that, after the relationship breakdown, we report the net worth of the household of the partner that the PSID kept interviewing. Specifically, we estimate the following regression model

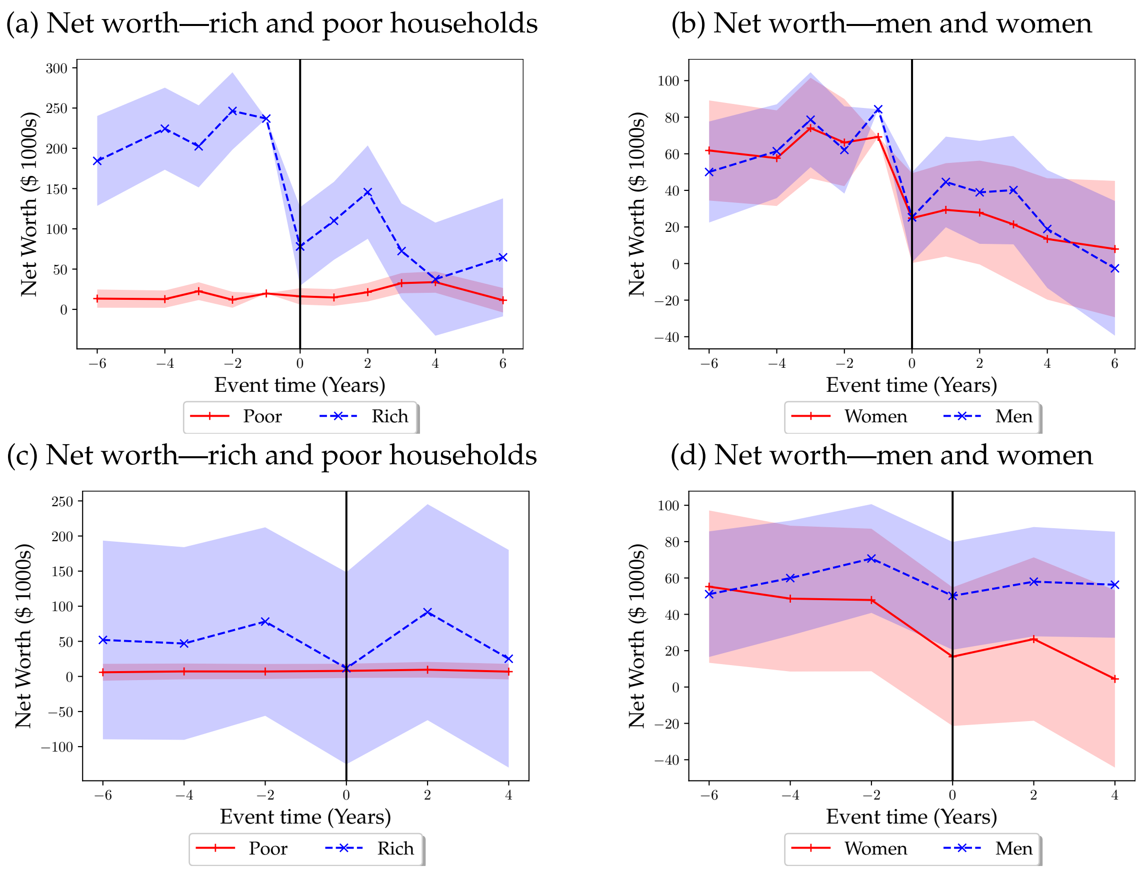
$$\text{Net worth}_{i,a,t,y,ma} = \sum_{j=-6}^{4} \beta_j^{Split} \cdot \mathcal{I}(t=j) + \alpha_0 + \alpha_a + \alpha_y + \alpha_{ma} + \epsilon_{i,t}, \tag{B.1}$$

where a is age of the person observed after the couple dissolves, t is the year relative to divorce/breakup ($t = -1$ is omitted), and i is the household, y is the year and ma is the number of years since the start of the marriage/cohabitation. Note that we included year, years since marriage/cohabitation and age fixed effects. We estimate this model separately for formerly married and cohabiting households and we further subdivide our sample considering wealthier/poorer households and men/women.[2] Figure B.1 reports the results. We normalize the coefficient estimates β_j^{Split} by adding the average of net worth at divorce $E[\text{Net worth}|t = -1]$. In panel a we can see a decrease in net worth for richer households: the estimates indicate the year after the divorce the household is left with significantly less than half its original net worth, even though the large standard errors do not allow us to identify the amount of net worth lost because of the divorce. No clear decrease in net worth can be observed for poorer households. Panel c shows that there is not clear loss in net worth for poor and rich cohabiting households. Finally, panels b and d show that no gender-related difference regarding the evolution of net worth can be detected.

[1] We could not distinguish the net worth of the couple/individuals against the other member if we considered households with more adults.

[2] A household is considered wealthy if its net worth before couple disruption is above the 75^{th} percentile of the distribution and poor otherwise.

Figure B.1:
Event studies of net worth around divorce



NOTES. The figures display the evolution of net worth (measured in 1997$). The displayed patterns are normalized coefficients from event studies around divorce. Rich households are defined as those whose net worth is above the median in the first period they were observed. Poor households are those whose net-worth is below the 75^{th} percentile of the distribution. Net worth is constructed using the same PSID variables that (**?**) use.)

B.3 Computational Appendix

(**?**) compares an array of local and global optimizers, which are given the task of finding the global optimum of difficult objective functions. They find that the multi-start algorithm that they propose, called TikTak, outperforms the others in terms of time required to reach the solution and the probability that the algorithm finds the optimum. In light of these findings, we decided to use TikTak for solving problem (2.26). A description of the TikTak algorithm follows:

1. Determine the bounds for each parameter and generate a sequence of Sobol points with length N. Then evaluate the function value at each Sobol point.

2. Sort the N Sobol points (s_1 ,..., s_N), with $f(s_1) \leq \cdots \leq f(s_N)$ and keep the first N^* with $N^* < N$. Note that $f()$ is the objective function. We set N^* such that

$N^*/N = 0.15$. Set the global iteration number j to 1, then run a local minimizer starting from s_1. Call z_j^* the fit resulting from the local minimization,[3] and define the set $Z_1^* = \min\{z_1^*\} = z_1^*$.

3. Define a new starting point $\hat{s}_{j+1}$ defined as

$$\hat{s}_{j+1} = (1-\theta_j)s_{j+1} + \theta_j Z_j^*,$$

where

$$\theta_j = \min\big[\max[0, 1, (j/N^*)^{\frac{1}{2}}], 0.995\big].$$

Run a local minimizer starting from $\hat{s}_{j+1}$ and call the local minimum found z_{j+1}^*. Then, define $Z_{j+1}^* = \min\{z_1^*, ..., z_{j+1}^*\}$. Update the global iteration number: $j = j+1$. Repeat step 3 until $j = N^*$.

4. Return $Z_{N^*}^*$.

We adapt the original algorithm such that it can be run in parallel using M nodes. Other than evaluating more points at the same time on different nodes, the only difference is in step 3. In the parallel version of TikTak, Z_j^* is defined as the minimum among the outcomes of the local minimizers that already converged, while at the end of step 3 the global iteration number is updated to j^*, which stands for the number of global minimizations that already started, without necessarily having converged already.

B.4 Problem of the cohabiting couple

Cohabiting couples, denoted by C, solve a Pareto problem where the weight of the wife is θ_t^f and that of the husband is θ_t^m.The state vector is $\Omega_t^C = \{a_t, z_t^f, z_t^m, \psi_t, \theta_t^f, \theta_t^m, \chi_t\}$, where χ_t is the share of assets going to the woman in the event of breakup. The variables over which the couple maximize are summarized by the vector

$$\mathbf{q}_t^C = \{a_{t+1}, d_t, c_t^m, c_t^f, P_t^f, S_t, M_t, \chi_{t+1}\};$$

[3]We use the local minimization algorithm provided by (Cartis et al. 2019), which is a derivative-free optimization (DFO) for nonlinear Least-Squares (LS) problems. This algorithm is robust to noise, which might arise because of the errors coming from the approximation of continuous problems on a discrete grid.

S_t and M_t are dummy variables that take value 1 if the couple respectively breakup or marry and 0 otherwise.[4] The formal problem that a cohabiting couple at t solves is:

$$\begin{aligned}
V_t^C(\Omega_t^C) = \max_{\mathbf{q}_t^C} &(1-S_t)\{\theta_t^f u(c_t^f, Q_t) + \theta_t^m u(c_t^m, Q_t) + \psi_t - \gamma + \beta E_t V_{t+1}^C(\Omega_{t+1}^C)\} \\
\text{if } S_t = 0: \quad & \text{s.t. (2.10) and (2.7)}, \\
& \theta_{t+1}^f = \theta_t^f + \mu_t^f, \\
& \theta_{t+1}^m = \theta_t^m + \mu_t^m, \\
\text{if } S_t = 1: \quad & \text{s.t. (2.9), (2.7) for } i \in \{f, m\}, \\
& a_t^m + a_t^f = a_t, \\
& a_t^f = \chi_t a_t,
\end{aligned} \tag{B.2}$$

where θ_{t+1}^f and θ_{t+1}^m adjust such that the following participation constraints are satisfied:

$$\begin{aligned}
W_t^{fC}(\Omega_t^C) &\geq V_t^{fS}(\omega_t^f), \\
W_t^{mC}(\Omega_t^C) &\geq V_t^{mS}(\omega_t^m).
\end{aligned} \tag{B.3}$$

Note that μ_t^i are the Lagrange multipliers associated with spouses' participation constraints. The individual value of cohabitation conditional on $S_t =$ is W_t^{iC} for $i \in \{f, m\}$, and it is defined as

$$W_t^{iC} = u(\tilde{c}_t^i, \tilde{Q}_t^i) + \psi_t - \gamma + \beta E_t V_{t+1}^{iC}(\Omega_{t+1}^C), \tag{B.4}$$

where $\tilde{\mathbf{q}}_t^C = \{\tilde{a}_{t+1}, \tilde{\chi_{t+1}}, \tilde{d}_t, \tilde{c}_t^m, \tilde{c}_t^f, \tilde{P}_t^f\}$ is the $\arg\max$ of problem (B.2) conditional on having chosen $S_t = 0$. $V_{t+1}^{iC}(\Omega_{t+1}^C)$ can be obtained by the expectation of the sum of the time utilities that the agent gets from $t+1$ to T, where the variables entering the utility function derives from the Pareto problem if the agent is in a relationship, otherwise they are the solution of (2.11). Similarly to the unilateral divorce regime, we assume that the planner evaluates the welfare of the two members of the couple if a breakup happens with the current Pareto weights.

[4]We denote marriage by M, which might fall under unilateral divorce regime $\overline{M}$ or mutual consent $\hat{M}$.

B.5 Estimation of Income Processes

Table B.2:
OLS Regression. Observation: males in year t.

	(1)
DEP. VARIABLE: MALE LOG EARNINGS	
ι_1^m	0.05
ι_2^m	-0.00
ι_0^m	-0.34
Survey Year Fixed Effects	✓
State Fixed Effects	✓
Observations	98118
R^2	0.152

NOTES: Standard errors are obtained through bootstrapping and they are reported in summary table 2.6.

Table B.3:
OLS Regression. Observation: Females in Year t.

	(1)
DEP. VARIABLE: FEMALE LABOR EARNINGS	
ι_1^f	0.02
ι_2^f	-0.00
ι_0^f	-0.38
Survey Year Fixed Effects	✓
State Fixed Effects	✓
Observations	86891
R^2	0.085

NOTES: Standard errors are obtained through bootstrapping and they are reported in summary table 2.6.

Table B.4:
Probit Regression. Observation: Females in Year t.

	(1)
DEP. VARIABLE: FEMALE LABOR FORCE PARTICIPATION	
Unilateral Divorce$*$Community Property	-0.18***
Unilateral Divorce$*$Title Based	-0.08
Unilateral Divorce$*$Equitable Distribution	-0.06
Equitable Distribution	-0.00
ι_1^f	0.01***
ι_2^f	-0.00***
ι_0^f	1.95
Survey Year Fixed Effects	✓
State Fixed Effects	✓
Observations	127728

NOTES: standard errors are clustered at the state level. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5% and ***1%.

B.6 More evidence on the impact of unilateral divorce on partnership choices

Relationship Choice - Linear State Trends

Table B.5:
OLS Regression. Observation: first and second relationships

	Dependent variable: Married (0/1)			
	Full Sample	Resident	NSFH	NSFG
	(1)	(2)	(3)	(4)
Unilateral Divorce	-0.054^{**}	-0.074^{***}	-0.064^{**}	-0.019
	(0.025)	(0.023)	(0.030)	(0.053)
State Fixed effects	Yes	Yes	Yes	Yes
Birth Year dummies	Yes	Yes	Yes	Yes
Year established Fixed Effect	Yes	Yes	Yes	Yes
Linear trend by State	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes
Observations	10,533	6,846	7,722	2,811
R^2	0.151	0.173	0.172	0.153

NOTES: standard errors are clustered at the state level. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5% and ***1%.

Relationship Choice - Heterogeneity by property regime and linear state trends

Table B.6:
OLS Regression. Observation: first and second relationships

	Dependent variable: Married (0/1)			
	Full Sample	Resident	NSFH	NSFG
	(1)	(2)	(3)	(4)
UnDiv*NoTit	-0.071^{***}	-0.082^{***}	-0.076^{***}	-0.033
	(0.021)	(0.017)	(0.027)	(0.053)
UnDiv*Tit	-0.024	-0.062	-0.039	0.003
	(0.037)	(0.038)	(0.045)	(0.047)
Tit	-0.039	-0.038	-0.033	-0.054^{*}
	(0.027)	(0.032)	(0.033)	(0.032)
State Fixed effects	Yes	Yes	Yes	Yes
Year established Fixed Effect	Yes	Yes	Yes	Yes
Birth Year dummies	Yes	Yes	Yes	Yes
Linear trend by State	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes
Observations	10,533	6,846	7,722	2,811
R^2	0.150	0.167	0.170	0.142

NOTES: standard errors are clustered at the state level. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5% and ***1%.

Relationship Choice - California left out of sample

Table B.7:
OLS regression. Observation: first and second relationships. California dropped from initial sample

	Dependent variable: Married (0/1)			
	Full Sample	Resident	NSFH	NSFG
	(1)	(2)	(3)	(4)
Unilateral Divorce	−0.062***	−0.082***	−0.068***	−0.067*
	(0.021)	(0.022)	(0.025)	(0.039)
State Fixed effects	Yes	Yes	Yes	Yes
Year established Fixed Effect	Yes	Yes	Yes	Yes
Birth Year dummies	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes
Observations	9,699	6,206	7,070	2,629
R^2	0.142	0.162	0.156	0.143

NOTES: standard errors are clustered at the state level. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5% and ***1%.

Relationship Choice - Heterogeneity by property regime and California left out of sample

Table B.8:
OLS regression. Observation: first and second relationships. California dropped from initial sample

	Dependent variable: Married (0/1)			
	Full Sample	Resident	NSFH	NSFG
	(1)	(2)	(3)	(4)
UnDiv*NoTit	-0.068^{***}	-0.083^{***}	-0.077^{***}	-0.068^{*}
	(0.021)	(0.022)	(0.025)	(0.041)
UnDiv*Tit	−0.017	−0.057	−0.019	−0.040
	(0.032)	(0.038)	(0.040)	(0.048)
Tit	−0.010	−0.011	−0.003	−0.024
	(0.021)	(0.027)	(0.025)	(0.036)
State Fixed effects	Yes	Yes	Yes	Yes
Year established Fixed Effect	Yes	Yes	Yes	Yes
Birth Year dummies	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes
Observations	9,699	6,206	7,070	2,629
R^2	0.142	0.162	0.156	0.143

NOTES: standard errors are clustered at the state level. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5% and ***1%.

Relationship Choice - Multinomial Logit

So far, our empirical analysis relied on a sample of newly formed partnerships. This implies that we studied the choice between marriage and cohabitation *conditionally* on starting a partnership. Here we provide a complete analysis by studying singles' choice, who can decide every month to stay single, cohabit or marry. We do so by estimating a multinomial logit model on person month data, constructed using the first relationships of respondents of the NSFH and NSFG surveys. We construct the singleness spells by reporting individual choices from age 15 until the moment the first relationship (if it exists) begins. The results in table B.9 show how the introduction of unilateral divorce impacts the relative risk of cohabiting with respect to marrying. The results confirm that unilateral divorce increased the likelihood that individuals cohabit instead of marrying, and that the effect is larger in non title based states. Moreover, the size of the effect is also similar to the results presented in the main text. In fact, an increase in the relative risk of cohabitation with respect to marriage of 30% (equivalent to a relative risk of

1.3) starting from an average number of first relationships that are cohabitations when the law changes of 30%, is equivalent to a decrease in the number of marriages of 9%. Interestingly, the estimated multinomial logit implies a smaller (2%-6%, not reported in the table) and non significant increase in the risk of staying single with respect to marrying.

Table B.9:
Multinomial Logit. Observation: person month, the choices are: staying single, marry or cohabit

	Dependent variable: Relative risk of cohabiting wrt to marrying			
	Full Sample	Resident	Full Sample	Resident
	(1)	(2)	(3)	(4)
UnDiv	1.236**	1.310**		
	(0.106)	(0.141)		
UnDiv*NoTit			1.250**	1.325**
			(0.115)	(0.153)
UnDiv*Tit			1.130	1.313
			(0.179)	(0.273)
Tit			1.074	1.090
			(0.090)	(0.115)
State Fixed effects	Yes	Yes	Yes	Yes
Duration Polynomials	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes
Observations	112,697	70,882	112,697	70,882

NOTES: standard errors are clustered at the state level. The numbers displayed in the table are the exp of the coefficient of the multinomial logit and they indicate the relative risk of cohabiting with respect to marrying. When these numbers are larger than 1 the regressor of interest is associated with a relative increase in the risk of cohabiting. Relative risks that are significantly different from zero are denoted by the following system: *10%, **5% and ***1%.

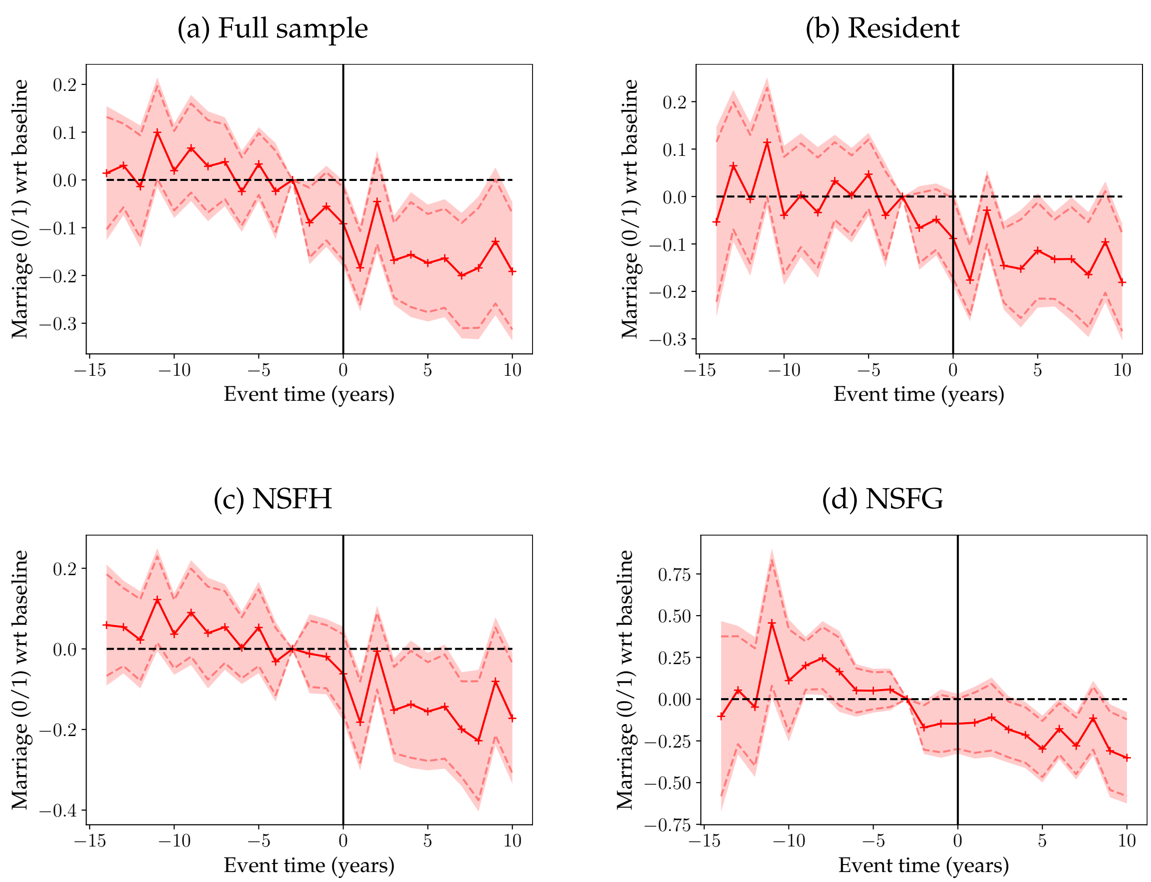
Relationship Choice - Event Study

Two-way fixed effect regressions have been widely used in the literature on the effects of unilateral divorce on economic outcomes. Yet, a recent work by (Goodman-Bacon 2018) shows that this technique is problematic for recovering causal effects when treatment effects are heterogeneous across time. We follow his recommendation to use an event study design as a robustness check for the results in the main text. Specifically, we restrict the sample to states that passed the unilateral divorce law before 1988 to estimate the following equation

$$\text{married}_{i,s,y,b} = \sum_{j=-32}^{55} \beta_j^{Unid} \cdot \mathcal{I}(t = j) + \alpha_0 + \alpha_b + \alpha_y + \alpha_s + \gamma' \mathbf{Z_i} + \epsilon_{i,s,y,b}, \tag{B.5}$$

where i stands for the respondent/household, y for the month the relationship starts, s is the state related to the household, b is the age at birth of the respondent and $\mathbf{Z}_i$ contains some characteristics of the respondent. Figure B.2 plots β_j^{Unid} for the different samples used for the estimation, where $j = -3$ is used as the reference. The results show no pretends and a significant reduction in the share of couples that cohabit after unilateral divorce is introduced: the size of the effect is larger than the one that comes from the two-way fixed effect estimates. This might be due to the fact that the two-way fixed effect estimates over-weights observations that are closer to the policy change, as (Goodman-Bacon 2018) notice. This matters for our case as individuals might not recall the exact date at which the couple started living together. This is consistent with the results reported in figure B.2: β_j^{Unid} are negative (even though not significant) 1 or 2 years before the policy changes.

Figure B.2:
Event studies on share of couples choosing marriage instead of cohabitation, around the introduction of unilateral divorce



NOTES. The figure plots the coefficients β_j^{Unid} obtained from equation B.5. Each panel shows the estimates obtained using one of our four samples. The red area around the lines indicates the 95% confidence interval, while the dotted line indicates the 90% confidence interval.

Relationship Choice and Children

Is there a shift towards cohabitation for both childless couples and couples with children? Using the NSFH sample, in table B.10 below, we show that unilateral divorce is associated with a shift towards cohabitation both for couples whose respondent has some children, is childless, or is childless and does not want to have children. The shift towards cohabitation is lower in absolute value for couples whose respondent has children. This can be because marriage is the best partnership for enhancing cooperation, which is a desirable feature for couples with children since these require large investments in terms of time and money. Our model captures this heterogeneity. Couples with a high relationship quality are less sensitive to the law changes and are also more likely to produce large quantities of public goods, which include children.

Table B.10:
OLS regression. Observation: first and second relationships.

	Dependent variable: Married (0/1)		
	Some children	Childless	Childless+Do not want children
	(1)	(2)	(3)
Unilateral Divorce	-0.077^{***}	-0.108^{**}	-0.117^{**}
	(0.025)	(0.053)	(0.053)
State Fixed effects	Yes	Yes	Yes
Year established Fixed Effect	Yes	Yes	Yes
Birth Year dummies	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes
Observations	7,722	1,868	1,623
R^2	0.163	0.202	0.220

NOTES: standard errors are clustered at the state level. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5% and ***1%.

B.7 More evidence on the impact of unilateral divorce on cohabitation duration

Table B.11:
Duration model: risk of marriage for cohabiting couples.

	Dependent variable: Married (0/1)			
	Full Sample	Resident	NSFH	NSFG
	(1)	(2)	(3)	(4)
Unilateral Divorce	-0.021^{***}	-0.018^{***}	-0.020^{***}	-0.028^{***}
	(0.004)	(0.004)	(0.004)	(0.010)
State Fixed effects	Yes	Yes	Yes	Yes
Year started Fixed Effect	Yes	Yes	Yes	Yes
Duration Polynomial	Yes	Yes	Yes	Yes
Socio-economic controls	Yes	Yes	Yes	Yes
Observations	137,848	81,756	77,662	60,186
R^2	0.007	0.006	0.008	0.006

NOTES: the sample is of the month-cohabitation type. In periods where the couple keeps cohabiting or breaks up, the dependent variable takes value 0. Standard errors are clustered at the state level. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5% and ***1%.

Table B.12:
Duration model: risk of breaking up for cohabiting couples.

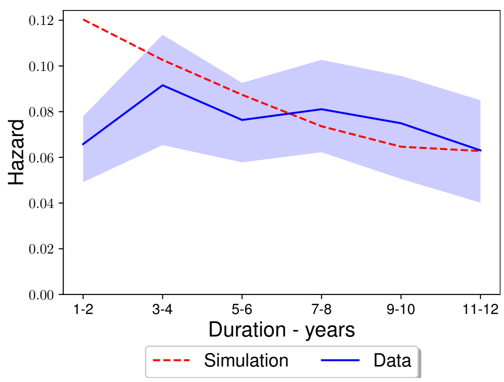
	Dependent variable: Broke up (0/1)			
	Full Sample	Resident	NSFH	NSFG
	(1)	(2)	(3)	(4)
Unilateral Divorce	-0.008^{***}	-0.008^{***}	-0.006^{**}	-0.015^{**}
	(0.002)	(0.002)	(0.002)	(0.006)
State Fixed effects	Yes	Yes	Yes	Yes
Year started Fixed Effect	Yes	Yes	Yes	Yes
Duration Polynomial	Yes	Yes	Yes	Yes
Socio-economic controls	Yes	Yes	Yes	Yes
Observations	137,848	81,756	77,662	60,186
R^2	0.003	0.003	0.005	0.004

NOTES: the sample is of the month-cohabitation type. In periods where the couple keeps cohabiting or gets married, the dependent variable takes value 0. Standard errors are clustered at the state level. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5% and ***1%.

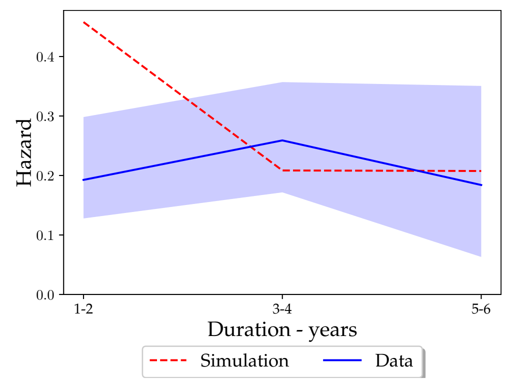
B.8 Model Fit

Figure B.3:
Hazards by duration of spells: data and simulations

(a) Hazard of Divorce



(b) Hazard of Breakup



(c) Hazard of Marriage

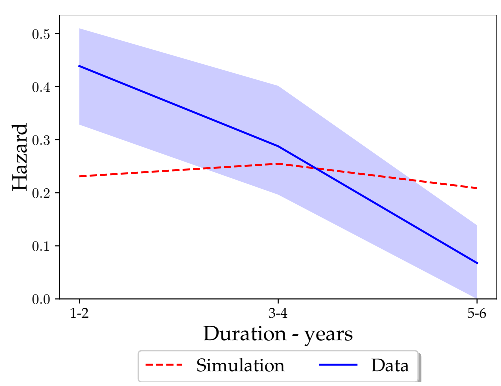


Figure B.4:
Share ever cohabited and married: data and simulations

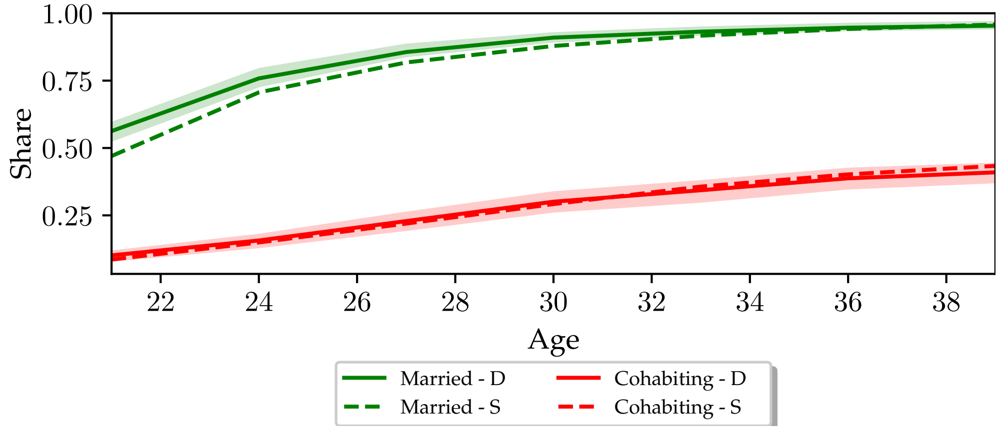
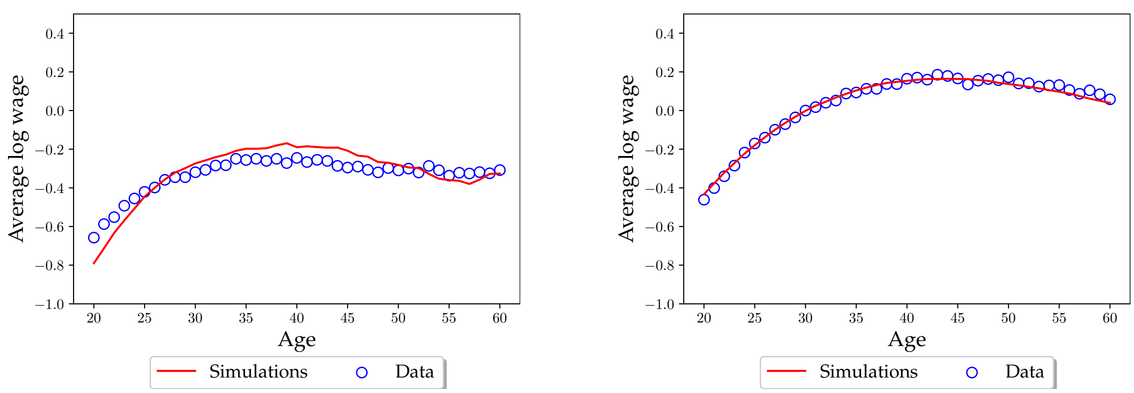


Figure B.5: —Low wages over the life cycle: simulations and data

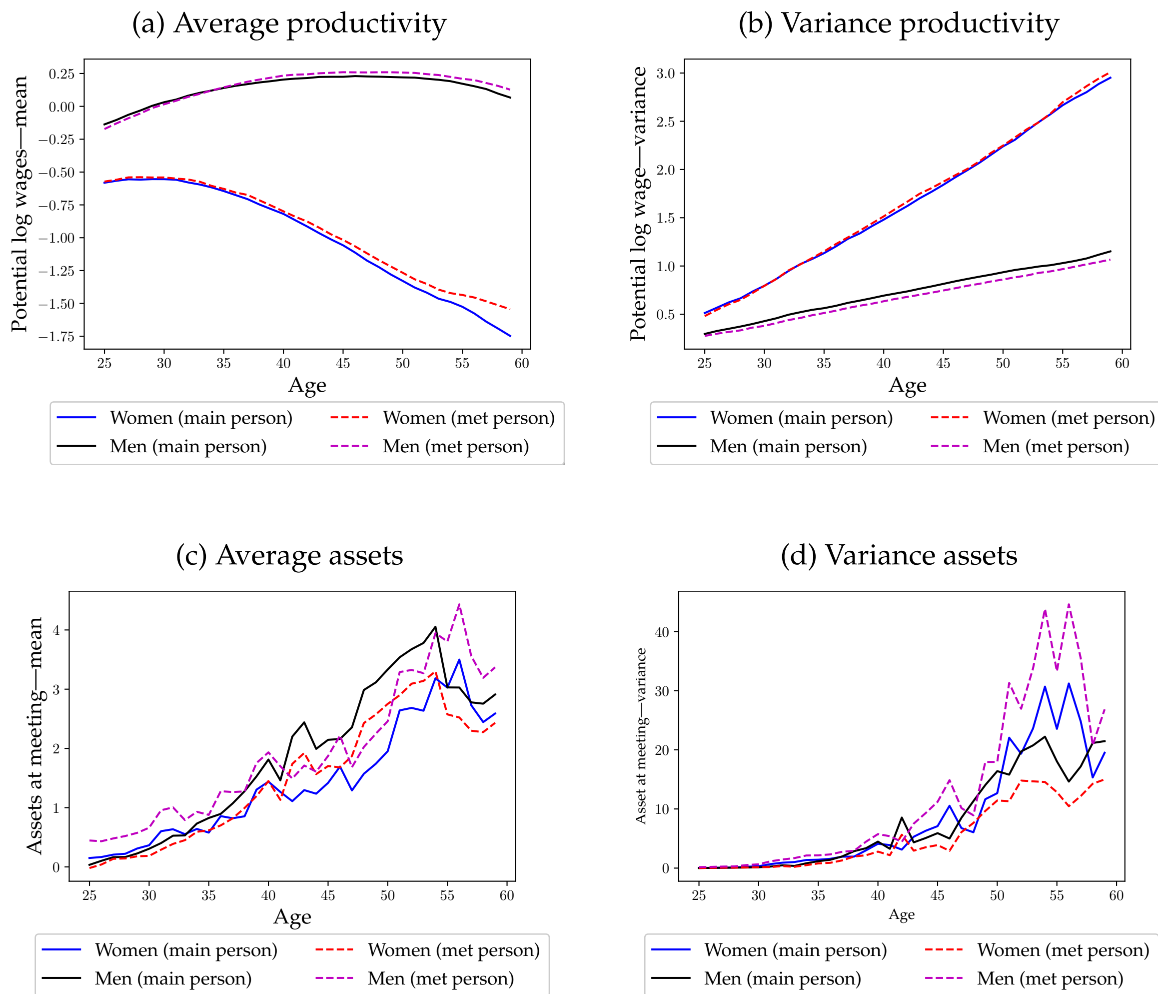
(a) Women (b) Men



NOTES. This figure depicts simulated and empirical low wages over the life cycle. Data on wages are constructed by dividing the annual labor income by the total number of hours.

B.9 Additional Figures and Tables

Figure B.6:
Log Income and assets mean and variances by age—simulated data



NOTES. The figures display means and variances of simulated log wages and assets of men and women in a couple over their lifespan. We label as “main person" the variables that are computed from agents that are simulated and followed through their whole life-cycle, while we label as “met person" the variables constructed using the partners met by the people whose behavior is simulated for their whole life-cycle. Wage variables are constructed using couples at any point of their relationship, while for assets we use only the period when the couple met, where we can still distinguish the title of ownership of assets.

Figure B.7:
Cumulative distribution of love shock ψ at meeting

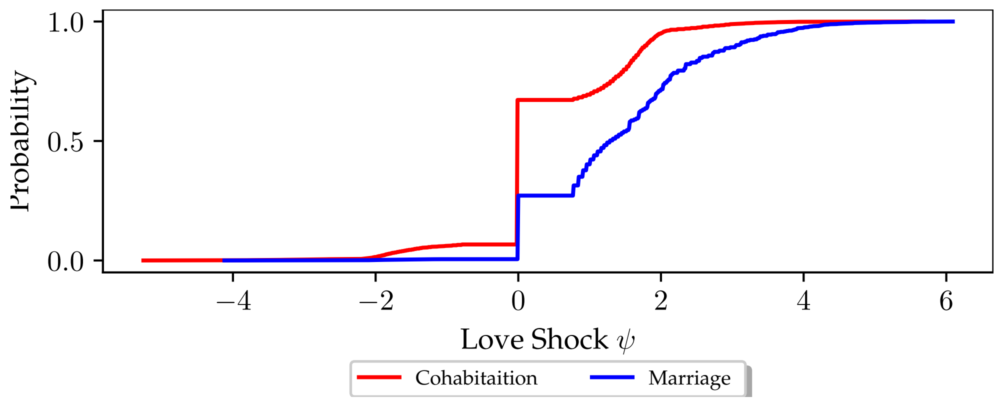
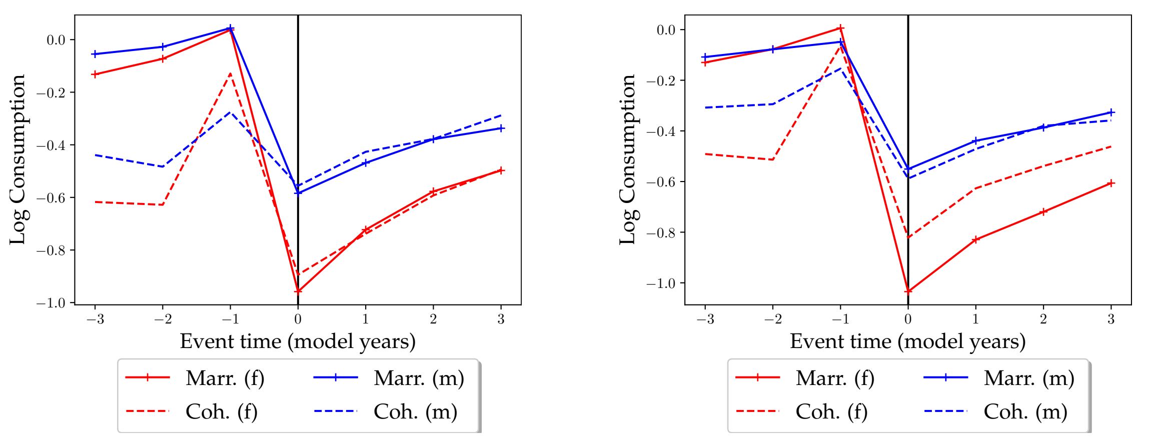


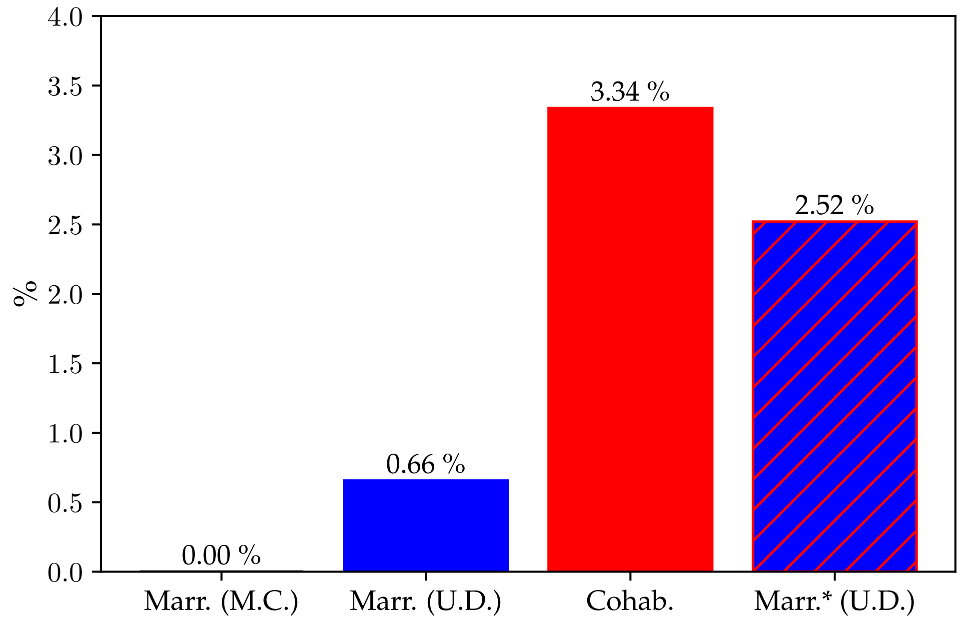
Figure B.8:
Event studies of log consumption around divorce–simulated data

(a) Log consumption—unilateral divorce regime (b) Log consumption–mutual consent regime



NOTES. The figures display the evolution of simulated consumption around divorce and breakup. The displayed patterns are normalized coefficients from event studies around divorce/breakup.)

Figure B.9:
% of periods t for which $\theta_t \neq \theta_{t+1}$



NOTES. The figures display the share of consecutive periods where the bargaining power in the couple changes. The abbreviation M.C. means mutual consent regime, the abbreviation U.D. stands for unilateral divorce regime. The values are computed using the first simulated partnership of individuals who spent their lives under the same divorce regime. The asterisk $*$ means that these marriages are obtained by imposing marriage (under unilateral divorce regime) as a partnership on couples that had decided to cohabit.

Table B.13:
Partnership type and consumption insurance against income shocks

	Married and Cohabiting Women		
	Married		Cohabiting
	M.C.	U.D.	
Baseline	0.201	0.164	0.329
Only marriages preceded by cohabitation	0.097	0.183	-
Only marriages not preceded by cohabitation	0.210	0.160	-
Marriages with cohabitation selection	0.329	0.331	-

NOTES: the table reports the estimates of coefficients μ obtained from regression

$$\Delta \log c_{it} = \alpha + \mu \Delta \log(w_{it}) + \nu_t + \epsilon_{it}.$$

The sample includes the whole duration of the first relationship of simulated women i. The last row is run on a sample of women who decided to cohabit but we imposed marriage on them instead. This allows us to analyze the insurance within marriage controlling for selection into a relationship.