Economic Incentives and Learning in Relationship Formation: Evidence from Sweden

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ABSTRACT: This paper investigates the role of learning—the process by which partners gather information about their compatibility—has in explaining the marital transition. To this end, I exploit a pension reform in Sweden that penalises late marriages for cohabiting couples and provides empirical evidence that couples who are incentivised by the reform are mostly long-term cohabiting couples with lower uncertainty about match quality. Given that pre-marital cohabitation reduces divorce hazard, these couples are less likely to divorce in observable future. However, if these cohabiting couples are no different from couples married earlier, then couples that marry due to time pressure face higher probability of divorce. The effect is more salient among couples with shorter premarital cohabitation. These stylised facts imply that couples place greater value on initial cohabiting periods, and it is costlier to disrupt learning in the early stage of a relationship.

By linking the benefits couples expect to receive with the loss of information they could tolerate due to the time constraint, I develop a structural model with endogenous cohabitation, marriage and divorce where couples learn about match quality over their relationship. I first show that models without a learning component fit these facts poorly, then I assess the welfare changes of the reform and evaluate the effect of de facto marriage law in the counterfactual experiment.

Key words: Marriage, Divorce, Cohabitation, Learning.
JEL code: D15, J11, J12

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1 Introduction

Non-marital cohabitation has become more prevalent all over the world during the last thirty years (Di Giulio et al. 2019). In both Sweden and the US for example, nearly half of the children are born out of the wedlock. In Sweden alone, 1.3 million people (18% of the adult population) live in a marriage-like partnership without being married, the highest percentage among EU countries.[1] Furthermore, only 3% of the Swedish couple started their first union as married, with the remainder through cohabitation (Cantalini et al. 2024), making cohabitation a curcial phase to study in family dynamics. Why do people choose to cohabit rather than married? What is role of cohabitation in affecting people's decision to marry and divorce?

First, cohabitation allows shared consumption in a lower-commitment partnership, providing an attractive alternative to marriage in a society without distinct male and female spheres (Lundberg et al. 2016). Second, cohabitation differs from marriage in both legal status (e.g., asset division, child custody right, taxes, inheritance, alimony) and outcomes, such as the stability of the relationship, fertility rate and performance of children.[2] These differences in outcomes are driven by a higher cost of dissolving marriage relative to cohabitation, as the cost difference affects directly who selects into marriage, and the investment in their joint production during a partnership.

These distinctions aforementioned have been highlighted extensively in economic theories, including the gain of marriage by enabling joint production and sharing public consumption and various risks, as well as the cost of marriage regarding legal formalities. While these distinctions can, in a static sense, explain why some couples choose to cohabit while others marry, they fall shorts of explaining why couples transition from cohabitation to marriage over time. This paper proposes an additional motive for cohabiting before marriage —— information gathering.

Cohabitation serves as a trail period that allows individual to learn about their partner's habits, gather information about their compatibility and reduce the uncertainty in match quality. There is limited empirical evidence linking the separation risks with the marital duration, as couples in longer partnerships generally have greater knowledge of their match quality and are less likely to separate. Extending this logic, the information gathering process begins duration cohabitation , enabling partners to learn about their compatibility before making a formal commitment that is costly to break. Thus the decision to marry is determined by both match value (their perceived fitness) and match uncertainty (how confident individuals are about their perception). These two tradeoffs are the key mechanism that explains the optimal timing to select into marriage and the observed negative association between divorce rate with the duration of pre-marital cohabitation.

[1]In the US, over 40% of the new births are from unmarried women, in Sweden, over 50% of the new births are from unmarried women. For latest figure see National Centre for Heath Statistics (US) and EuroStat (Sweden).

[2]Cohabiting couples tend to have less stable relationships. Their children receive less parental investment and perform worse (Persson 2020). Section 3.2.1 shows cohabiting couples are more likely to separate, potentially contributing to the rise of single parent.

To further support this learning mechanism empirically, this paper borrowed an influential Swedish pension reform that penalises late marriages for cohabiting couples with joint children. The reform eliminated most of the survival pension for widows unless marriage precedes the reform date. The short notice of the reform created many hastened marriages close to the cutoff date as women who secured their expected benefits will get a non-negative payment upon their husband's death. Using the Swedish administrative data, this study compares couples who faces the time pressure to marry and those who married naturally before the reform. The results show that conditional on ages, couples who married under time pressure cohabit longer before marriage. Compare to natural marriages, they also experienced lower divorce probabilities. However, after controlling for pre-marital cohabitation and other observables, these couples were more likely to divorce, with the increased divorce risk primarily concentrated among those with shorter cohabitation periods. Additionally, newly-formed cohabiting couples were less responsive to the reform, while long-term cohabiting couples reacted strongly, marrying earlier than they otherwise would have would never get married in the absence of the reform.

These stylised facts provide suggestive evidence that 1) the reform pushes couples with better signals of match quality into marriage, and disrupting their learning process is costlier for short-term cohabiting couples relative to long-term couples 2) cohabiting couples values their cohabiting period differently when they face the choice to marry, reflecting the tradeoff between gathering more information about their compatibility and securing economic benefit like survival pensions. Newly-formed couples' reluctance to marry quickly indicates that the value of information is the highest at the initial stage of a relationship, as couples use this time to assess their match quality.

More importantly, these findings speak to the point that cohabitation and marriage are not just different in legal form and couples favour one over the other. Rather, they function as sequential, interdependent stages. Cohabitation and marriage are substitutes, and at the same time, complements. Reforms that are dependent on marital status such as common-law marriage may inadvertently changes the transition process and alters the optimal marital behaviour of the couples and potentially leads to welfare loss.

To better understand these mechanisms and link the findings to the proposed theory, I developed a structural model featuring endogenous cohabitation, marriage and divorce with limited commitment. The model captures two key outcomes comparing couples facing the time constraint to marry and those otherwise: 1) different cohabitation time and 2) different divorce probabilities. These results are compared against the empirical evidence. I motivate the story with a simple example discussed in appendix B. In the counterfactual exercise, I derive the value of information. Faced with the same expected match quality, a more informed agent with a better signal of the match quality enjoys higher utility and is less likely to divorce. Last but least, I compare this learning model with other standard model to understand why a learning component is necessary to explain the finds in the data.

This is the first paper to provide evidence of learning behaviour in the marriage market. By combining micro-founded evidence and a behavioural model of marriage and cohabitation choice, this paper adds an important channel to explain the marriage dynamics, namely cohabitation phase serves as a period for couples to learn their fit, and transition into marriage reflect the trade-off between match value and match uncertainty. The findings have broader implications, particularly for analysing pro-marriage policies that may unintentionally affect the learning process, and hence the welfare as whole. For example, common law marriage reduces the legal distinctions between cohabitation and marriage but making cohabitation more substitutable for marriage.

Literature

This study connects to three set of literatures. The first and foremost concerns learning about match quality in the marriage market. Very scant literatures discussed this matter in the marriage market, and none of them delve into the role of learning during the cohabitation phase, and discussed the implication of (disrupted) learning. Antler et al. (2022), for example, developed a theory model with search and learning frictions; Brien et al. (2006) and Marinescu (2016) estimate learning models to match the share of married and hazard of separation and Marinescu (2016) pointed that by looking at the divorce hazard in the US, a model with learning plays little to no role in divorce and that divorce can be fully explained by changes in the value of the relationship itself.

The second strand of literature is about how household choices such as marital decisions and labour supply shaped by changes in policy or expected welfare. Similar work include Attanasio et al. (2008), Weiss and Willis (1997), Baker et al. (2004), Frimmel et al. (2014), Brainerd and Malkova (2023), Voena (2015), Low (2023), to name a few. A few papers relating directly to this influential Swedish pension reform include Hoem (1991), Andersson (1998), Persson (2020).

The third strand of literature enquires the causes and consequences of non-marital cohabitation. A growing body of literature now analyses cohabitation and treat it differently from being married or being single, as cohabitation and childbearing under cohabitation gradually becoming an alternative arrangement in a new family structure (Lundberg et al. 2016). These work borrows from a household model with limited commitment framework to allow endogenous marriage and divorce (Mazzocco 2007, Voena 2015) and extend it to distinguish cohabitation from marriage (Blasutto 2023, 2024, Calvo 2023, Gemici and Laufer 2012, Blasutto and Kozlov 2023).

This paper contributes to literatures by showing the implications of learning by linking the results to micro-founded evidence. This learning framework share commonalities with other workhorse model with a limited commitment framework but also embed different mechanism regarding how selection into marriage works and how divorce is triggered that is consistent with the behavioural responses observed in the Swedish pension reform without the need to impose alternative mechanism. For example, marital preferences and differences in commitment drives people into marriage (Iyigun

2009); over-optimistic couples over expect their match quality, driving these couples into divorce (Berresheim and Koll 2023).

2 Background

The survival benefits reform in Sweden in 1990 abolished a large part of widows' benefits. The reform was announced in June 1988 and implemented on the first day of 1990. I introduce the reform by dividing the timeline into 3 phrases, as shown in Figure 1: pre-announcement period (before June 1988), announcement period (June 1988 - Dec 1989), and post-reform period (1990 and onwards).

In the pre-announcement period, married women were entitled to a monthly survival benefit that are set equal to half of the difference between husband's and wife's social security earnings upon husband's death.[3] One of the two conditions needs to be met in order to be eligible for the benefits: 1) they have been married for at least 5 years, or 2) they have a joint child. Note that only married women, not men, at the time of her spouse's death, can claim the survival benefit. Divorced women or cohabiting women are not eligible. The reform announced in 1988 imposed a timing condition on top of the pre-specified rules. That is, the date of marriage and the birthdate of the joint child must precede the first day of 1990, and for all marriages occurred thereafter, there is no survival benefit.[4]

Given that post-reform, new marriages were no longer eligible for the survival benefit, cohabiting partners have limited time to respond to the reform. A cohabiting woman can secure the benefit if she has a joint child and gets married before the first day of 1990. This applies to around half of the couple in 1980s. In Sweden, it is very common for couples to cohabit in a long-term relationship, and around half of the population had the first child out of wedlock.

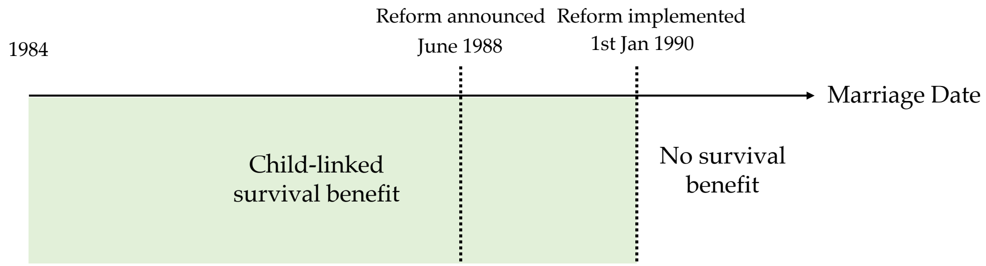


Figure 1: Timing of the reform

[3]The amount is strictly positive and set to 40% of husband's earned benefit if the age of the widow is less than 65 years old. For widow older or equal to 65 years of age, this amount is weakly positive and set at $\max\{(\text{Pension}_m - \text{Pension}_w) \cdot 50\%, 0\}$.

[4]Put it in another way, for couples married during 1984 and 1989 (married less than 5 years), they can claim the benefits if they have a joint child born before 1990. For couples married in and before 1984, they satisfy condition 1) and can claim the benefit without a child. The original survival benefit is replaced with a 1 year adjustment transfer such that surviving spouse before the age of 65 receive and is equal to 40% of the deceased partner's earned benefit.

Pension and Survival Benefits in Sweden

Pensions in Sweden consist of the national pension from the state and the occupational pension from employers. The bulk payment (around 74%, see Palme and Svensson (1997), Kolsrud et al. (2024)) comes from basic pension and supplementary pension from the national pension.

All Swedish citizens are entitled to a basic pension with the basic amount (BA) unrelated to one's previous earnings. The basic amount is linked to the consumer price index (CPI) and decided each year by the government. For example, in 1988, the BA was SEK 25,800 and in 2022, the BA was SEK 117,369. Basic pension is an income-tested pension benefit for all individuals, and it accounts for around 24% of the gross average earnings.

Supplementary pension (ATP) is related to the individual's earning history. The benefit level is determined by years of working prior to retirement and the sum of income from earnings. The formula for calculating supplementary pension is

$$y_s = 0.6 \cdot (\bar{y} - \text{BA}) \cdot \min\left(\frac{Yr}{30}, 1\right) \geq 0 \tag{1}$$

where $\bar{y}$ is individual average past income prior to retirement, BA is the basic amount, and Yr is the number of years of working prior to retirement. Supplementary pension must be non-negative, requiring $\bar{y}$ to be at least as big as BA, and the upper bound for $\bar{y}$ is set at 7.5 times BA, above which supplementary pension ceases growing. Individuals who worked less than 30 years prior to retirement can only claim a fraction of their supplementary pension. One fewer working year below 30 reduces the amount by a fraction of $\frac{1}{30}$ (Palme and Svensson 1997).

Apart from the pension benefit, a widow receive survivors benefits based on her and her husband's earned benefits. Prior to the reform, a widower has no survival benefit, but a widow who was older than 65 years of age got monthly survivors benefits that equals to half of the couple's joint social security income, had the husband been alive, minus the social security income of the wife, with the lower bound set to zero.[5] This means that survival benefit increases with the pension of the husband but decrease with the pension of the wife, and equals zero when wife earns higher social security than husband. Post-reform, surviving spouse who is younger than 65 years old regardless of gender got a small amount of 1 year adjustment transfer that equals to 40% of the deceased couples's earned benefit. Since the age of marriage for women is lower than men, and that women typically outlive men by around 4 years, the average duration of payment pre-reform survival benefit was 8 years. Upon realisation, the value of the total survivors benefits (for a family on average) is approximately SEK 280,000.

While women married before the reform date could earn a weakly positive benefit upon her spouse's death, receiving survival benefit also faces risks. There are three factors that would change the expected payment and make the choice of early marriage undesirable: 1) divorce: if the rela-

[5] For widow who were between 36 to 64 years of age, she got a monthly benefits equal to 40% of the husband income.

tionship of the couple terminates at any period after the reform date, 2) social security: survival benefit reduces as women's social security earnings increases. It becomes zero if women's pension payment exceeds that of mens', and 3) death: when wife's death precedes husband's death. There is no payment of survival benefit if any of the conditions are met, and decision to marry must take these into account.

3 Stylised Facts

This section introduces the data and displays the summary statistics. I show descriptive evidence about cohabitation and characterise the difference between cohabitation and marriage. Importantly, I lay out some key evidence that demonstrates the behavioural differences between a normal marriage (without any incentives) and marriages in the last period of 1989 (with incentives), and claim that these differences are only compatible with a framework that accounts for learning about match quality.

3.1 Data

To link couples living together, the parent-child registry is used to link partners who have had at least one child. Since the policy only incentivises cohabiting couples with children to marry, I only need to use these subset of couples to perform empirical analyses and fit the model. Due to the poor data quality in early years, I can only identify part of these couples who separated and without a child using the domestic movement data described in Appendix A. Table 1 shows the descriptive statistics.

3.2 Cohabitation VS marriage

Fact 1) Cohabitation is less stable than marriage

Does marriage mean some level of commitment or is it just couples relabel cohabitation as married without any actual effect? This concern arise particularly in Sweden where the difference between marriage and cohabitation are known to be small. To investigate, I compare couples with similar characteristics and child birth process whereas differ in their choice to stay cohabiting or married t years after their initial cohabitation and track the their chance of separation 30 years after their initial cohabitation. I run the following regression for each $t = \{1, 2, ..20\}$:

$$\text{separated}_i = \alpha \mathbb{1}[\text{married after t years}]_i + \sum_{j=0}^{20} \beta_j \mathbb{1}[\text{child after j years}]_i + \gamma X_i + \varepsilon_i \tag{2}$$

where separated$_i$ equals 1 if the couple no longer live together after 30 years. Given that cohabitation decision interacts strongly with the decision to have kids, I fully controlled the child delivery process

Table 1: Descriptive Statistics

	Child before Marriage		All Marriages	
Date of Marriage	1980-1989Q3	1989Q4	1980-1989Q3	1989Q4
Fertility and Cohabitation				
Child before marriage	1.00	1.00	0.39	0.84
Completed fertility at marriage	1.71	2.02	0.90	1.78
Duration of cohabitation before married	6.14	9.78	3.75	8.33
Marriage yr - 1st child birth yr	4.09	7.33	0.59	5.92
Divorced within 30 years	0.36	0.31	0.37	0.33
Demographics & Economics				
Wife's age at marriage	28.97	33.45	29.60	33.70
Husband's age at marriage	31.72	36.41	32.44	36.67
Wife's log earning	10.47	10.94	10.60	10.96
Husband's log earning	11.61	11.82	11.32	11.73
Wife received higher education	0.26	0.25	0.35	0.25
Husband received higher education	0.22	0.20	0.30	0.21
Annual number of marriages	31579	61409	95146	104140
Observations	111170	48884	376604	66630

Note: Column 1 and 2 show the summary statistics for only the child-first marriages, and column 3 and 4 show all marriages. Marriage in 1989 indicates that these marriages decisions are potentially affected by the survival pension reform. Earnings for both spouses are deflated to reflect changes in purchasing power across years.

using $\mathbb{1}[\text{child after j years}]_i$, which equals 1 if the couple had a joint child j years after their initial cohabitation. Although couples cannot foresee if child will arrive at point t when $t < j$, I still include child that arrives in the future because it reflects couples' expectation on fertility. And other socioeconomic controls such as household income, income parity, education of both spouses, birth year of both spouses are included in X_i.

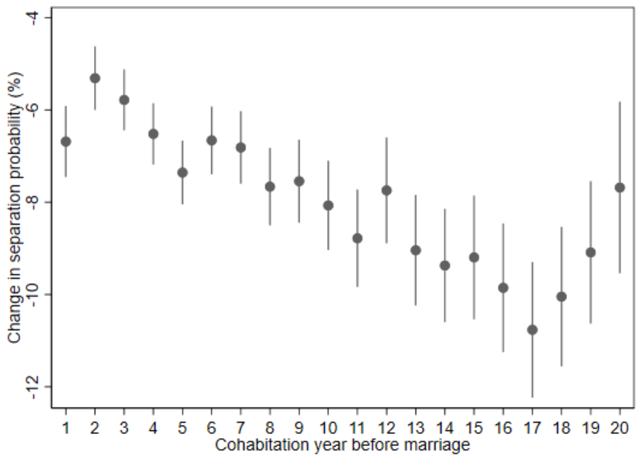
To interpret Figure 2, marriage is associated with $\widehat{\alpha}$ = 3%-11% lower probability of separation compared to similar couples who remain cohabiting in that year, holding everything else the same. The results indicate that marriage by itself differs from cohabitation in terms of stability and this is driven by the selection of more committed couples into marriage.

Fact 2) Premarital cohabitation time lowers the divorce rate, but with diminishing effect

Consider a Cox proportional hazard model using linked cohabiting couples that married from 1980 to 1989. I report the hazard ratio $exp(\gamma_d \cdot d)$ using 'less than 1 year of cohabitation' as the reference group.

$$\log h_i(t) = \beta_0(t) + \sum_d \gamma_d \text{duration}_i + \beta_1 \text{age}_{w,i} + \beta_2 \text{age}_{m,i} \tag{3}$$

Conditional on ages, the first year of cohabitation reduces divorce risks by 1-82% = 12%, and the marginal effect of extra year of cohabitation nonlinearly declined.



Note: Regression coefficient $\widehat{\alpha}$ for each t. Sample consists of cohabiting couples built in section A. I restrict couples met during 1969 to 1990 and separation is defined as couples no longer live together in 30 years since they initiated cohabitation.

Figure 2: marriage reduces the chance of separation

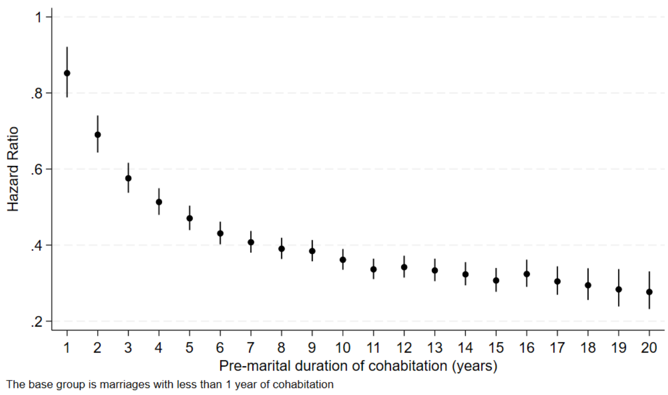


Figure 3: Share divorced by pre-marital duration of cohabitation

3.3 Evidence on learning

Fact 1) Spike in marriages comes from couples with more stable matches and longer pre-marital cohabitation.

Table 2 compares the divorce rate with and without adding controls on the premarital cohabitation duration and other demographic variables. From column (1) and (4), raw divorce rate is lower for cohorts that marry in 1989, right before the reform implementation date (henceforth referred to as *treated* group) versus cohorts that marry before the reform announcement year (henceforth referred to as *control* group). Specifically, the proportion of people end up divorced decreased by 4.5% in the treated group compared to cohorts married in the control. This result indicates that the treated group has more stable matches, hence prompting the question of who selects into marriage in 1989. Figure shows that the density of marriages is higher at the tail end of the pre-marital duration distribution in 1989 only, resulting in a longer average cohabitation period for the treated group, which is in line with Figure 3 that longer pre-martial cohabitation leads to more stable marriages.

This difference, however, is not driven mechanically by the fact that couples married in 1989 are also older as shown in table 1. While it is true that older couples may have been more inclined to marry before the reform, given fewer outside options and a more predictable widow's survival benefit, by looking at marriages by women's age on the right of Figure 4, marriages in 1989 have on average higher cohabitation years conditional on women's age of marriage. I consider a simple regression in (4) to estimate the extra years of cohabitation conditional on both spouses' age. $\hat{\beta} = 1.85$ using all child-first marriages from 1980 until 1997.

$$\text{duration}_i = \alpha + \beta \mathbb{1}[\text{marry} = 1989]_i + \gamma_1 \text{age}_{w,i} + \gamma_2 \text{age}_{m,i} + \varepsilon_i \tag{4}$$

These observations reflects a selection effect: marriages immediately before the reform period are more likely among couples with lower uncertainty about match quality, who believe that it makes little difference to remain cohabiting or to marry, aside from eligibility for survivor benefits. Although these couples may have hastened into marriage, compromising some information about their match quality that they could have learned in the absence of the reform, further learning after an extended period of cohabitation would offer limited benefit. As a result, selection effect dominates and produced on average more stable matches.

In appendix C, I perform counterfactual exercises by imposing additional assumptions about the patterns of marriages, and provide additional evidence that couples value their initial period of cohabitation more than cohabitation period in later years, and long-term cohabiting couples are more responsive to the reform.

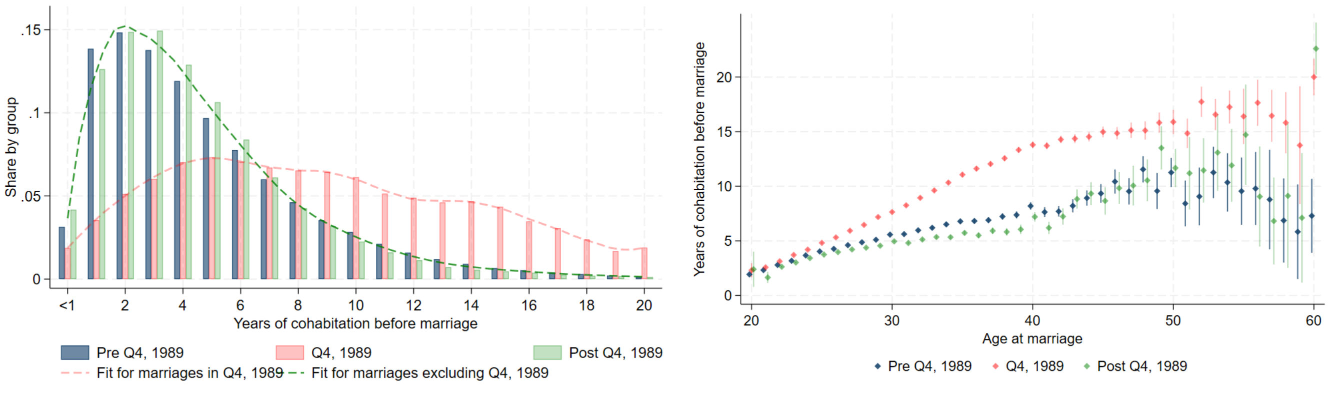


Figure 4: Marriage by pre-marital cohabitation: who select into marriage in 1989?

Fact 2) Conditional on observables, same couples that marry due to time pressure face higher divorce probability, which is more pronounced among couples with shorter premarital cohabitation time.

To isolate selection effect, I controlled observable characteristics for people marrying in 1989. In other words, I compare couples who married before the reform announcement year with the same cohorts who married after announcement year but before the reform implementation date. Column (3) and (6) of table 2 shows that divorce rate is 5% higher (or, divorce hazard is 20% higher)[6] for treated group conditional on observable characteristics, meaning that the reform results in poorer matches for these marriages.

Table 2: Effect on divorce

	OLS regression			Hazard regression		
	No control	DPC control	Full control	No control	DPC control	Full control
Divoce, if married in 1989	-0.027***	0.046***	0.062***	0.848***	1.121***	1.251***
	(0.005)	(0.005)	(0.005)	(0.014)	(0.020)	(0.023)
Ave divorce / time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Pre-marital cohabitation duration	No	Yes	Yes	No	Yes	Yes
Other observables	No	No	Yes	No	No	Yes
y: Prob divorced		0.30			0.36	
Observations	160054	159153	157589	159633	158735	157446

Note: Robust standard error in parentheses. *** : significant at 1% level. OLS and Cox Hazard regression results by adding and omitting controls. Sample includes child-before-marriage couples married during 1980 to 1989. Column 4, 5 and 6 are results from Cox hazard regression and column 1, 2 and 3 are results from OLS regression. Column 2, 3, 5, 6 add controls on the premarital duration of cohabitation, which are a set of dummy variables fully saturated at each duration of cohabitation. Other controls include age at marriage for both spouses, expected survival benefit, income of the household at marriage, man's share of income at marriage, if man/woman earns much higher at marriage, higher education indicator for both man and woman, years the first joint child was born before getting married, number of children born at the time of marriage, immigration status of man and woman. Since we cannot observe every individuals' marital status due to out-migration, Cox proportional hazard model is used as a remedy for data attribution in the very long run.

Additionally, I add a middle column (2) and (4) between the regressions with no control on observables and fully controls on observables by adding just the indicators for different duration of cohabitation. The estimates fall between the two scenarios but closer to the regression with full controls, implying that most of the selection effect can be explained by different cohabitation time.

To understand where does the extra divorce probability comes from for the 1989 cohorts, on top of the model with full control, I interacted the indicators for different duration of cohabitation with marriage in 1989 to find out where does the extra divorce rate come from. I binned the duration into every 5 years to reduce noise and plot the coefficients in Figure 5.

$$\text{Divorced}_i = \sum_d \beta_d \mathbb{1}[\text{duration} = d]_i + \sum_d \gamma_d [\text{duration} = d]_i \mathbb{1}[\text{marry} = 1989]_i + X_i\delta + \epsilon_i \qquad (5)$$

[6] In this setting OLS only looks at a 20-year window, from the first date of marriage. It omits any divorce that could have happened after 20 years. Sample attrition also occurs, as around 30% of the sample do not have yearly observations for the entire 20-year window, due to e.g., outmigration.

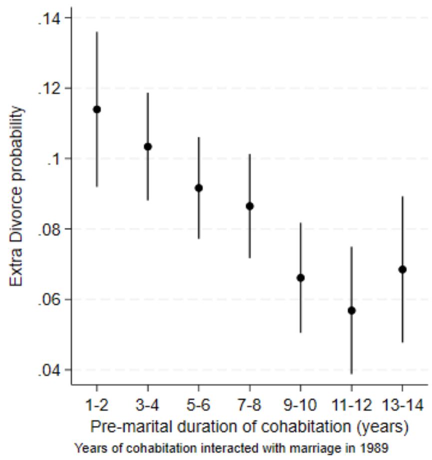


Figure 5: Extra divorce by premarital cohabitation duration

Fact 1) and 2) jointly motivate a framework with learning about matches. To test if learning exists or not, I test two necessary conditions the learning framework would naturally imply, and compare the results against frameworks without learning.

Condition 1: In a learning framework, uncertainty about match quality declines as partnership duration rises.

Condition 2: In a learning framework, the match quality of a relationship is not perfectly observable.

These two conditions could be tested by considering some alternative specification. First, consider a model where variance of match quality does not decline over time. Second, consider a model where I mechanically suppress the variance of the match quality as partnership time increases, but agents perfectly observe current match quality. I then compare these models and estimate the parameters to replicate fact 1 and 2 specified above using simulated data. From equation 4 and 5, I compare the model implied α (years of extra cohabitation) and γ_d against data implied value.

3.4 Labour Supply

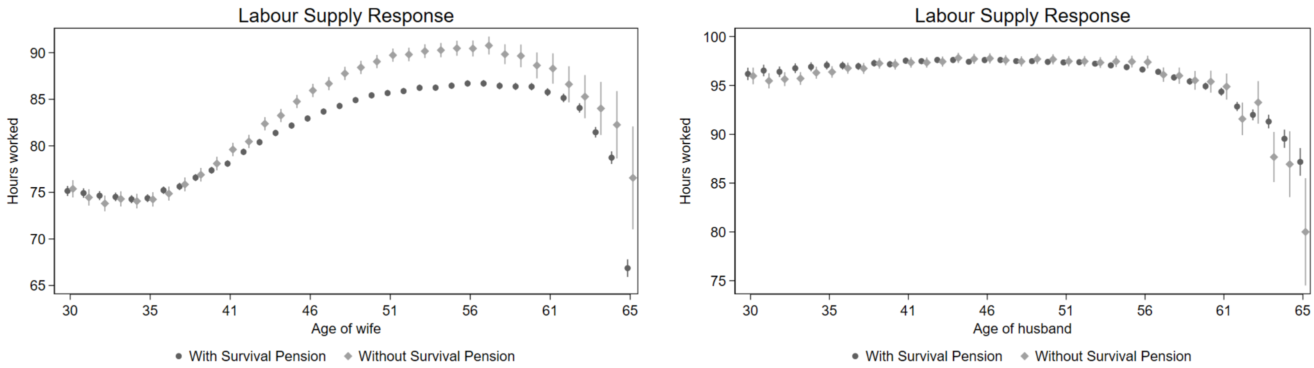


Figure 6: Effect of reform on labour supply over the lifecycle

Couples react strategically not just in terms of marriages, but also in the labour supply throughout the lifecycle. Women's labour supply over the lifecycle may decline as a result of the income effect from survival pension. Women will receive a non-negative transfer upon their husband's death, increasing their life-time wealth and leading them to substitute more leisure for labour. In the following regression, I use the sample from cohorts who married in 1989 who never get divorced to compare cohorts who are entitled survival benefit (treated) and those who are not (control) using the child birth date as a cutoff.[7] The raw effect is on the left of Figure 6, where married women who are entitled benefits have lower labour supply after the age of 40. However, for younger women or men of all ages, their labour supply is barely affected. The intuition is that for men, the reform gives little income effect for them to change their labour supply, and that women's change in their labour supply are not large enough to elicit husband's added worker effect (Lundberg 1985). For women, labour supply response is stronger 0-20 years before retirement, and weak in the very long run (30+ years).

I further explore the heterogeneity in labour supply by running a regression for women aged 40 and above:

$$\text{Hour}^w_{it} = \beta_0 + \beta_1 D_i + \sum_j \beta_{2j} D_i S_{ij} + \sum_j \beta_{3j} S_{ij} + \gamma X_{it} + \epsilon_{it} \tag{6}$$

where Hour^w_{it} is the self-reported hours worked from women and S_{ij} is the average income share of the husband (binned to 6 categories) while women are in the age of 30-39. I choose this age range because almost all workers participate in the labour force and based on Figure 6, labour supply for women in both groups have little difference so that women in the sample have little incentive to

[7]Similarly, we can also use the date of marriage as a cutoff. Couples who married before 1990 would entitle survival benefits and who married after 1990 will not. Given that the number of marriages immediately after 1990 is very few, the result (shown in appendix) exhibits similar hours of work compared to the control group in Figure 6 but with large standard errors.

alter their labour supply that could change the husband's income share. Control X_{it} includes age polynomials for women and average income of the women during age 30-39. Treatment variable D_i equals 1 if the cohorts are entitled to survival pension and 0 if otherwise. This specification mimics the difference-in-difference settings where the underlying assumption is that in the absence of the reform, both groups will choose their labour supply in the same way given husbands' income share, and the changes in the labour supply for the treated group are explained by the income effect: the reform makes women who are entitled survival benefits reduce their labour supply in the direction of their husband's income. When husbands' income exceeds wife's, wife under pre-reform rules starts receiving positive transfer upon husband's death. The higher the income the higher the lifetime income women are going to receive hence the lower the labour supply they will choose long before the transfer takes place. The estimates for the interaction term β_{2j} shown in Figure 7 implies that the effect of the reform starts to kick in only when husband's income share is above 70%. As for why there is no immediate fall in the labour supply when husband's income share exceeds wife's by below 20%, there are several explanations to this. One plausible reason is that income calculated in the young age still carries the risk of falling down in later years, and risk-averse agent is better-off keeping their strategies unchanged for a small amount of benefit.

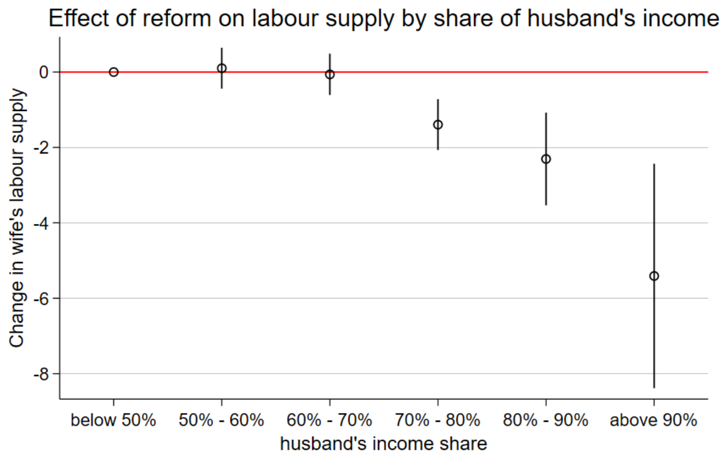


Figure 7: Effect of reform on women's labour supply by husband's income share

4 Model

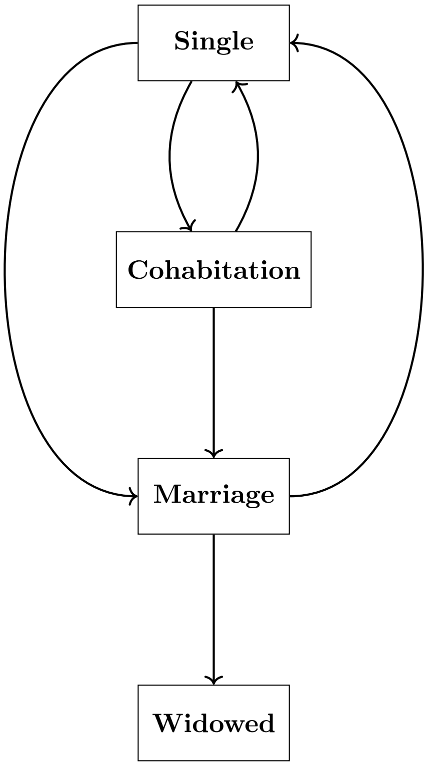


Figure 8: Transition of marital status

Set-up

In this economy time is discrete. Agents start at the age of 20 as singles and can live until the maximum age of 90. Individuals die exogenously after the retirement age 65, and upon death, married individual becomes widow(er), and cohabiting individual becomes single. Prior to retirement, each single agent at the beginning of each period meets a potential partner of opposite gender with an exogenous probability. Upon a successful meeting, they enter a Nash bargaining to determine if they want to be a couple or not, and if so, their initial bargaining weight within the family. Couples draw a match quality in each period, and the true match quality is gradually revealed in subsequent periods and couples make decisions accordingly. In each period individuals make decisions regarding their consumption-saving, marital status, and only a woman with a partner decide her labour supply. labour supply choice includes full-time work, part-time work and not working.

The model is featured by limited commitment in that within family bargaining power determines the distribution of consumption between each member, and the decision to divorce is triggered if there is no room to negotiate an acceptable bargaining weight for both partners.

Utility

Individual preference is of CRRA type. Denote individual consumption by $c_{j,t}$ for $j \in \{w, m\}$ (woman and man respectively), public goods consumption by $c_{p,t}$, and labour supply by $l_{j,t} \in [0, 1]$. The utility of a single agent of gender j is

$$U_j(c_{j,t}, c_{p,t}, l_{j,t}) = \frac{c_{j,t}^{1-\alpha_1} - 1}{1 - \alpha_1} + \phi \frac{c_{p,t}^{1-\alpha_2} - 1}{1 - \alpha_2} - \chi l_{j,t} \tag{7}$$

Singles consume out of their savings, and allocate total consumptions optimally between private and public goods.

$$c_{p,t} + c_{j,t} + a_{j,t+1} = R a_{j,t} + y_{j,t} \tag{8}$$

where individual income, $y_{i(j),t}$ follows:

$$\ln(y_{i,t}) = \beta \text{ gender}_i + \mathbb{1}\{t < t_R\}\text{Age polynomial}_{i,t} + \mathbb{1}\{t \geq t_R\}\text{pension}_{i,t} + z_{i,t}$$

$$z_{i,t} = \rho z_{i,t-1} + \epsilon_{j,t} \ , \quad \epsilon_{i,t} \overset{\text{iid}}{\sim} \mathcal{N}(0, \sigma_\epsilon^2) \tag{9}$$

During a relationship, perceived match quality $\hat{\psi}_d \in \mathbb{R}$ also enters individual's utility function:

$$U_j^R(c_{j,t}, c_{p,t}, l_{j,t}, \hat{\psi}_t) = U_j(c_{j,t}, c_{p,t}, l_{j,t}) + \hat{\psi}_t \tag{10}$$

Couples consume from their total resources, and the allocation of consumption depends on the bargaining power (μ) within the family.

$$c_{w,t}, c_{m,t}, c_{p,t} = \arg\max \mu U_w(c_{w,t}, c_{w,t}, l_{w,t}) + (1 - \mu) U_m(c_{m,t}, c_{p,t}) \tag{11}$$

subject to

$$c_{p,t} + c_{w,t} + c_{m,t} + a_{j,t+1} = R a_{j,t} + y_{w,t} l_{w,t} + y_{m,t} \tag{12}$$

Match quality and learning

Upon meeting a potential partner, and during cohabitation and marriage, agents draw utility from a match quality shock. They have a noisy observation on true match quality L_d:

$$\psi_d^n = L_d + \eta_d \tag{13}$$

The true match quality is assumed to follow a random walk:

$$L_d = L_{d-1} + u_d \tag{14}$$

where errors are identically and independently distributed for all duration d with $u_d \sim \mathcal{N}(0, \sigma_u^2)$ and $\eta_d \sim \mathcal{N}(0, \sigma_\eta^2)$. Initial true love quality draw from $L_0 \sim \mathcal{N}(0, \sigma_0)$ Agents use realisation of perceived match quality to update their belief through Bayesian learning. Using formula for scalar Kalman filter, I can write down the evolution of expected love shock, $\psi_d \equiv \mathbb{E}(L_d|\psi^n_{1:d})$, expected variance of the shock, $\sigma_d^2 \equiv \mathbb{E}(L_d|\psi^n_{1:d})^2$ and the Kalman gain, K_d:

$$\psi_d = \psi_{d-1} + K_d(\psi_d^n - \psi_{d-1}) \tag{15}$$

$$\sigma_d^2 = (1 - K_d)(\sigma_{d-1}^2 + \sigma_u^2) \tag{16}$$

$$K_d = \frac{\sigma_{d-1}^2 + \sigma_u^2}{\sigma_{d-1}^2 + \sigma_u^2 + \sigma_\eta^2} \tag{17}$$

To save one state variable, I assume that agent gain utility from expected love shock ψ_d, not ψ_d^n, and I relax the assumption about prior distribution in that agents can have inaccurate belief about initial prior, such that $\psi_1 = \mu_1 + K_1\psi_1^n$ with $\mu_1 > 0$, and $\sigma_1^2 = (1 - K_1)(\delta\sigma_0^2 + \sigma_u^2)$ given that inaccurate belief and overoptimistic expectation about marriage explains why couples's actual divorce rate is higher than their expectations (Berresheim and Koll 2023).

Children

The arrival of children is stochastic and exogenous. The probability of arrival varies with the woman's marital status, education status and age. Children affect survival pension eligibility, and the opportunity cost of women's time in the labour market. I first estimate, among all women at each age in the sample, how many of them have had at least one child, and calculate the marital status-specific fertility rate. Only cohabiting couples or married couples could have children. At the beginning of each period, household observe the fertility realisation, and make subsequent choices regarding labor supply, savings and couple dissolution. Since the fertility process is exogenous, the marital contract chosen by a family implicitly takes into account the fertility process that governs the child's arrival.

Pension

In the model, we simplify the pension system by abstracting from the pension payment years (by assuming all agents work for at least 30 years throughout lifecycle) and other source of pension and post-retirement income apart from the basic pension and supplementary pension mentioned in section 2. In addition, I do not model the survival benefit payment before retirement (65 years old), as these widow only account for a very small share of the population.

I model the reform as an unexpected information shock, and agents have only one period to react to the policy announcement. This is roughly consistent with the empirical finding that most extra marriages occurred in the last quarter of 1989 and fertility behaviour barely changes during

1989. If agent married or re-married after 1989, then they will enter the new marital contract where survival pension no longer exists.

I keep the original survival benefit rule that prior to the reform, annual survival benefit amount was set at the 50% of the social security income of the wife (SS_w) and husband (SS_m) had the husband been alive, minus the social security income of the wife, with a lower bound of 0:

$$SB_w = \max\left\{0.5 \cdot SS_w + 0.5 \cdot SS_m - SS_w \ , \ 0\right\} \tag{18}$$

where the annual social security payment depends on the individual income in the last period before retirement (y_{T_R-1}). We approximate the past average income using $\phi y_{T_R-1} = \bar{y}$ with $\bar{y}$ capped at maximum 7.5 times the basic amount (BA) to make it consistent with complementary pension rule, and then find the value of ϕ using simulated data. Incorporating equation 1, we have:

$$SS_j = BA_t + \underbrace{0.6(\bar{y} - BA_t) \times 1}_{\text{equ (1)}} \tag{19}$$

$$= BA_t + \max\left\{0.6(\phi w_{T_R-1} - BA_t) \ , \ 0\right\} \ , \quad j \in \{w, m\} \tag{20}$$

For example, total income for widows who are entitled to the survival benefit equals

$$\begin{aligned} w_t &= SS_w + SB_w \\ &= SS_w + \max\left\{0.5 \cdot SS_m - 0.5 \cdot SS_w \ , \ 0\right\} \\ &= \max\left\{0.5 \cdot SS_m + 0.5 \cdot SS_w \ , \ SS_w\right\} \end{aligned} \tag{21}$$

And the total income for retirees who are not eligible for the survival benefits comes only from pension (SS_j). Since marital decisions are made way earlier than the pension payment date, agents can only form expectations on the income they would claim in the future, including the basic pension and future income. We assume that agents form expectations based on current observations of income and inflation, so that their expectation does not need to equate the actual amount they get upon retirement.[8]

State Space

The state space for a single individual is $\boldsymbol{\omega_t} = \{h_t, z_t, a_t\}$, for a widowed individual is $\boldsymbol{\omega_t^w} = \{h_{w,t}, h_{m,t}, z_t, a_t\}$. The state of widow's deceased partner is added to keep track of the amount of pension for the person's deceased partner. The state space for couples are $\boldsymbol{\Omega_t} =$

[8] That is, the amount of basic pension is basic pension amount in 1980s times their expectation on income growth based on past observations.

$\{h_{w,t}, h_{m,t}, z_{w,t}, z_{m,t}, \mu_t, \psi_t, d_t, n_t, a_t\}$. Throughout these expressions z_t represents the persistent income shock of the agent, h_t the education of the agent, $\mu_t \in [0,1]$ the bargaining power of woman (hence $1-\mu_t$ for man), ψ_t the perceived match quality, and d the duration of partnership.

4.1 Problem of the singles and couples

I describe the problem for a single, cohabiting and married individual at time t. First, the value of remaining single and not entering the mating market at time period t is the value for staying single in this period plus and then start searching for partner from the next period:

The value of remaining single is the value conditioning on having chosen to stay single in period t and then start searching for partner from the next period,

$$\begin{aligned} V^S_{j,t}(\boldsymbol{\omega_t}) &= \max_{c_{j,t},c_{p,t}} U(c_{j,t}, c_{p,t}, l_{j,t}) + \beta\mathbb{E}\Big\{ && (22)\\ &= (1-\Lambda^*_{t+1})V^S_{j,t+1}(\boldsymbol{\omega_{t+1}}) && \text{(no meeting)}\\ &+ \Lambda^*_{t+1}(1-M^*_{t+1})(1-C^*_{t+1})V^S_{j,t+1}(\boldsymbol{\omega_{t+1}}) && \text{(meet, stay single)}\\ &+ \Lambda^*_{t+1}M^*_{t+1}V^M_{j,t+1}(\boldsymbol{\Omega_{t+1}}) && \text{(meet, marry)}\\ &+ \Lambda^*_{t+1}(1-M^*_{t+1})C^*_{t+1}V^C_{j,t+1}(\boldsymbol{\Omega_{t+1}})\Big\} && \text{(meet cohabit)} \end{aligned}$$

where $\Lambda^*_{t+1} \in \{0,1\}$, $M^*_{t+1} \in \{0,1\}$, $C^*_{t+1} \in \{0,1\}$ represent respectively whether meeting, marriage and cohabitation would occur in the next period. The decision rule of these will be detailed later.

The joint value of remaining married is the joint value of marriage conditioning on having not chosen to divorce at period t.

$$\begin{aligned} V^M_t(\boldsymbol{\Omega_t}) = &\max_{c_{w,t},c_{m,t},c_{p,t},l_{w,t}} \mu_t U_w(c_{w,t}, c_{p,t}, l_{w,t}, \psi_t) + (1-\mu_t)U_m(c_{m,t}, c_{p,t}, l_{m,t}, \psi_t) + \beta\mathbb{E}_t\Big\{ \quad (23)\\ &D^*_{t+1}\big[\mu_t V^{\to S}_{w,t+1}(\boldsymbol{\omega_{t+1}}) + (1-\mu_t)V^{\to S}_{m,t+1}(\boldsymbol{\omega_{t+1}})\big] +\\ &(1-D^*_{t+1})V^M_{t+1}(\boldsymbol{\Omega_{t+1}})\Big\} \end{aligned}$$

The individual value of remaining married can be derived after solving for the optimal allocation of consumption and labour, $\{c^*_{j,t}, c^*_{p,t}, l^*_{j,t}\}$ in a joint problem in equation (23). It is the value of individual marriage conditioning on having not chosen to divorce by both partners at period

t.[9]

$$V_{j,t}^{M}(\boldsymbol{\Omega_t}) = U_j(c_{j,t}^*, c_{p,t}^*, l_{j,t}^*, \psi_t) + \beta\mathbb{E}_t\Big\{ D_{t+1}^* V_{j,t+1}^{\to S}(\boldsymbol{\omega_{t+1}}) + (1 - D_{t+1}^*)V_{j,t+1}^{M}(\boldsymbol{\Omega_{t+1}})\Big\} \tag{24}$$

The value of transitioning into singlehood is similar but different from the value of remaining single. Agent who divorces or breaks up in period t first splits total asset a_t after ending the partnership with share κ_w allocated to woman (and κ_m allocated to men, s.t. $\kappa_w + \kappa_m = 1$). Divorced agent then receive a one-shot cost τ_D in individual asset share whereas cohabitating couples transitioned to single are free from paying such a cost.

$$V_{j,t}^{\to S}(\kappa_j A_t(1-\tau_D), h_t, z_t, a_t) = V_{j,t}^{S}(A_t, h_t, z_t, a_t) \tag{25}$$

Post-retirement, singles stop searching for partners, and individual faces exogenous probability of death. Denote the survival probability at period t for gender j by $\varrho_{j,t} < 1$ (partner of opposite gender by $\varrho_{-j,t} < 1$), $t \in [Tr, T],\ j \in \{w, m\}$. Since the only possibility to transition to widowhood is to remain married in the previous period (for cohabiting couples, one becomes single upon partner's death), the individual value of remaining married (post-retirement) becomes

$$\begin{aligned} V_{j,t}^{M}(\boldsymbol{\Omega_t}) = U_j(c_{j,t}^*, c_{p,t}^*, l_{j,t}^*, \psi_t) + \beta\mathbb{E}_t\Big\{ & \\ \varrho_{j,t+1}(1-\varrho_{-j,t+1})V_{j,t+1}^{W}(\boldsymbol{\omega_{t+1}^{w}}) + & \quad \text{(partner died)} \\ \varrho_{j,t+1}\varrho_{-j,t+1}D_{t+1}^* V_{j,t+1}^{\to S}(\boldsymbol{\omega_{t+1}}) + & \quad \text{(both survived, divorced)} \\ \varrho_{j,t+1}\varrho_{-j,t+1}(1-D_{t+1}^*)V_{j,t+1}^{M}(\boldsymbol{\Omega_{t+1}}) & \quad \text{(both survived, remain married)} \Big\} \end{aligned} \tag{26}$$

4.2 Bargaining Power

Meeting

The initial bargaining power for a potential partner pair is pinned down through symmetric Nash bargaining. Formally, we first check if there exists a set of Pareto weight such that both couples prefer to stay in a cohabitation union rather than to remain single:

$$\Theta_t^C = \{\mu_t : V_{w,t}^{C}(\boldsymbol{\Omega_t^-}, \mu_t) - V_{w,t}^{S}(\boldsymbol{\omega_t}) \geq 0, V_{m,t}^{C}(\boldsymbol{\Omega_t^-}, 1-\mu_t) - V_{m,t}^{S}(\boldsymbol{\omega_t}) \geq 0\} \subseteq [0,1] \tag{27}$$

[9] In the same manner we can derive the next period value of cohabitation: $D_{t+1}^* V_{j,t+1}^{\to S}(\boldsymbol{\omega_{t+1}}) + (1-D_{t+1}^*)(1-M_{t+1}^*)V_{j,t+1}^{C}(\boldsymbol{\Omega_{t+1}}) + (1-D_{t+1}^*)M_{t+1}^* V_{j,t+1}^{M}(\boldsymbol{\Omega_{t+1}})$. The difference is that conditioning on not breaking up at period $t+1$, the couples then decide whether to get married.

where Ω_t^- is the state variables for couples excluding Pareto weight; V_j^C is the value of a cohabiting couple. If $\Theta_t^C \neq \emptyset$, a couple agrees to cohabit and finds the Pareto weight that maximises the Nash product of the two marital surplus.

$$\Upsilon_t^C = \max_{\mu \in \Theta_t^C} [V_w^C(\boldsymbol{\Omega_t^-}, \mu) - V_w^S(\boldsymbol{\omega_t})] \times [V_m^C(\boldsymbol{\Omega_t^-}, 1-\mu) - V_m^S(\boldsymbol{\omega_t})] \tag{28}$$

Marriage

Cohabiting couples could bargain for a new marriage contract when they decide to marry. Conditional on staying as a couple, each partner $j \in \{m, w\}$ compare the value of getting married versus the value of staying single.

1. If $V_w^C \leq V_w^M$ and $V_m^C \leq V_m^M$, they both agree to marry at the old bargaining power negotiated when they first met.
2. If $V_w^C > V_w^M$ and $V_m^C > V_m^M$, they both disagree to marry, and will remain cohabitation.
3. If $V_j^C \leq V_j^M$ and $V_{-j}^C > V_{-j}^M$ for $j \in \{w, m\}$, one partner agrees but the other disagrees to marry. They start bargaining based on equation 28 that maximises the Nash product. These updated bargaining power, μ^* satisfies rebargaining condition specified above, such that $S_{w,t}^R(\boldsymbol{\Omega_t^-}, \mu_t) \geq 0$ and $S_{m,t}^R(\boldsymbol{\Omega_t^-}, \mu_t) \geq 0$. If not, move μ^* towards the direction until both couples weakly prefer to stay together. In the end, a couple
   (a) marry if the joint value of marriage is higher than the joint value of cohabitation:
   $$\mu V_w^C + (1-\mu)V_m^C \leq \mu^* V_w^M + (1-\mu^*)V_m^M + \xi_i \tag{29}$$
   where $\xi_i \sim N(\mu_\xi, \sigma_\xi^2)$ is time-invariant idiosyncratic preference that distinguishes marriage from cohabitation for each couple.
   (b) remain to cohabit if otherwise.

Rebargaining

At the current Pareto weight, it is possible that one agent find it is preferable to become single rather than to stay together. In this case, marital contract could be rebargained with the other partner possibly willing to give up part of the Pareto weight in order to keep the relationship unchanged. If so, the solution departs from the Pareto optimal allocation. To elaborate the rebargaining process, I first find the surplus of a relationship by assuming that rebargaining will not occur and partnership will not dissolve, such that $\mu_t = \mu_{t+1}$. And I define the surplus for married and cohabiting couples' surplus for each $j \in \{w, m\}$ as

$$S^R_{j,t}(\boldsymbol{\Omega^-_t}, \mu_t) = V^M_{j,t}(\boldsymbol{\Omega_t}) - V^{\to S}_{j,t}(\boldsymbol{\omega_t}) \tag{30}$$

denote the marital surplus of household member j. For both $S^C_{j,t}$ and $S^M_{j,t}$, go through the following steps:

1. If $S^R_{w,t}(\boldsymbol{\Omega^-_t}, \mu_t) \geq 0$ and $S^R_{m,t}(\boldsymbol{\Omega^-_t}, \mu_t) \geq 0$ given current μ_t, then $D^\star_t = 0$. Couples remain together and keep the bargaining power unchanged ($\mu_t = \mu_{t+1}$).
2. If $S^R_{w,t}(\boldsymbol{\Omega^-_t}, \mu_t) < 0$ or $S^R_{m,t}(\boldsymbol{\Omega^-_t}, \mu_t) < 0$ given current μ_t, then $D^\star_t = 1$. Couples divorce.
3. If the case does not fall into 1) or 2), then suppose one agent would like to separate, $S^R_{j,t}(\boldsymbol{\Omega^-_t}, \mu_t) < 0$, and for the other $S^R_{-j,t}(\boldsymbol{\Omega^-_t}, 1-\mu_t) \geq 0$, they will re-negotiate μ_t. Partner $-j$ gives some Pareto weight to j by finding the value $\tilde{\mu}_t$ that solves

$$\tilde{\mu} : S^R_{j,t}(\boldsymbol{\Omega^-_t}, \tilde{\mu}_t) = 0$$

   making the unhappy partner j just indifferent between staying in the partnership and get separated. If $-j$ also has a non-negative surplus for this value, $S^R_{-j,t}(\boldsymbol{\Omega^-_t}, 1-\tilde{\mu}_t) \geq 0$, they remain married, setting $\mu_t = \tilde{\mu}$, $D^\star_t = 0$. If, on the other hand, $S^R_{-j,t}(\boldsymbol{\Omega^-_t}, 1-\tilde{\mu}_t) < 0$, there is no value of μ_t that can sustain the marriage, then the couple divorce. $D^\star_t = 1$.

Solving the Nash bargaining problem, rebargaining problem and marriage decision, the bargaining power μ_t, decision to separate D^*_t and the decision to marry M^*_t are a function of state vector $\boldsymbol{\Omega_t}$. They pin down the value of remaining single, $V^S_{j,t}(\boldsymbol{\omega_t})$ specified in equation (22), and the value of remaining married $V^M_t(\boldsymbol{\Omega_t})$ in equation (24).

Agents make choices in each period in the following order: agents start as a single, they meet potential partners and decide whether to cohabit, and if so, whether to marry. Conditional on staying married or cohabiting, couples splits resources based on the bargaining power they previous agreed . If a partner prefers to separate, they try to negotiate a new bargaining power and continue the relationship. If negotiation failed, separation occurs.

5 Estimation

I estimate the structural model following a three-step approach. In the first step, I set some parameters of the model based on literature or matching some features of the data manually without the need to run any estimation algorithm. The result is in Table 3. In the second step, I estimate parameters outside the model using auxiliary regression. This specifically concerns the estimation of income process of individuals. In the last step, I internally estimate a set of parameters inside the model using indirect inference. The parameters are set such that the model implied moments are as close as possible to the moments derived from the data. I discuss how I derive these parameters in the following section.

Table 3: Pre-set and externally estimated parameters of the model

Parameter	Symbol	Value	Source
Panel A: Pre-set values			
Demographics			
Age at $t = 1$ (w, m)		20	
Retirement age	T_R	65	Swedish Pension age
Longest life span (w, m)	T	90	
Years per period		1	
Pensions replacement rate		60%	See text
Risk aversion over private goods	α_1	1.5	Literature
Discount factor	β	0.98	Literature
Mating market[i]			Distribution of education
Pr. meeting low & high educ woman		74.3%, 25.7%	
Pr. meeting low & high educ man		71.5%, 28.5%	
Panel B: Externally estimated parameters			
Income			
Age profile of women's log earnings	$f_0^l, f_1^l, f_2^l, f_3^l$	0.5984, -0.0236, 0.0019, $-3.3 \cdot 10^{-10}$	
	$f_0^h, f_1^h, f_2^h, f_3^h$	0.4865, 0.0018, 0.0014, $-2.8 \cdot 10^{-5}$	
Age profile of men's log earnings	$m_0^l, m_1^l, m_2^l, m_3^l$	0.6200, 0.0076, 0.0005, $-1.5 \cdot 10^{-5}$	
	$m_0^h, m_1^h, m_2^h, m_3^h$	0.3738, 0.0463, -0.0003, $-1.1 \cdot 10^{-5}$	
Variance of w's log earnings at $t = 1$	$\sigma^2_{1,w,l}, \sigma^2_{1,w,h}$	0.0406, 0.0477	
Variance of m's log earnings at $t = 1$	$\sigma^2_{1,m,l}, \sigma^2_{1,m,h}$	0.0456, 0.0579	
Variance of w's log earnings shocks	$\sigma^2_{w,l}, \sigma^2_{w,h}$	0.0192, 0.0240	
Variance of m's log earnings shocks	$\sigma^2_{m,l}, \sigma^2_{m,h}$	0.0230, 0.0311	
Stochastic Death[ii]			Swedish life expectancy
women, survival probability at $T - 1$	$\varrho_{T-1,w}$	0.9717	
men, survival probability at $T - 1$	$\varrho_{T-1,m}$	0.8559	

i): The probability of meeting a partner of opposite sex is estimated internally, and conditional on that, meeting partner of low or high education is based on the distribution of education in the entire population in Sweden.
ii): survival probability for all ages post-retirement is linearly interpolated given end-of-period survival probability, such that it genenerates correct life-expectancy for men and women.

5.1 Externally estimated parameters

I estimate income process of men and women separately outside the model. The income process is estimated by fitting the following model using annual observed earnings from working age population.

$$\ln(w^j_{i,t,y}) = \kappa^j_0 + \kappa^j_1 t + \kappa^j_2 t^2 + \kappa^j_3 t^3 + z^j_{i,t,y} \ , \ j \in \{m, w\} \tag{31}$$

where $w^j_{i,t,j}$ denotes the observed annual real earnings of individual i of gender $j \in \{m, w\}$ at age t and year y. The error term $z^m_{i,t,y}$ follows a AR(1) process as specified in equation 9: $z_{i,t} = \rho z_{i,t-1} + e_{i,t}$, and $e_{i,t} \overset{\text{iid}}{\sim} \mathcal{N}(0, \sigma^2_e)$.

I then find the variance of the permanent component of the income by taking first difference of equation 31 and run a regression with covariate t. After obtaining the residual income growth $\Delta\hat{z}^j_t$, we can derive the variance of the permanent income shocks for men and women separately using the following moment condition:[10]

$$\mathbb{E}[\Delta z^j_t(\Delta z^j_t + \Delta z^j_{t-1} + \Delta z^j_{t+1})] \tag{32}$$

where $\Delta z^j_t = z^j_t - z^j_{t-1} \ , \ j \in \{m, w\}$. The initial realisation of the income reflect individual heterogeneity such as education or location fixed effect which are not accounted for in the model. There is no correlation in the shocks of wage between couples, and such correlation only arise endogenously through the marital decision.

$$\mathbb{V}ar(z_t) = \rho^{2t}\mathbb{V}ar(z_0) + \frac{1-\rho^{2t}}{1-\rho}\sigma^2_e \tag{33}$$

and

$$\mathbb{C}ov(z_t, z_{t-j}) = \rho^{t(t-j)}\mathbb{V}ar(z_0) + \rho^j \frac{1-\rho^{2(t-j)}}{1-\rho^2}\sigma^2_e \tag{34}$$

And the left hand side of equation 33 and 34 are approximated by empirical moments using the residuals $\hat{z}_t$ (omitting the year and individual subscript). $\mathbb{V}ar(z_0)$ is set to the initial residual variance in the first period of the model. σ_e and ρ are the parameters to be estimated using a minimum distance estimator and the information from $\frac{T(T+1)}{2}$ moments.

5.2 Internally estimated parameters

Simulated methods of moments are used to implement the internal estimation. I first use the parameters derived from the previous steps, and select the remaining parameters to construct simulated moment, where the model-implied moment, $\Delta(\theta)$ is a function of parameters. I proceed to minimise the following criteria function:

$$\min_\theta \left(\Delta(\theta) - \widehat{\Delta}\right) W \left(\Delta(\theta) - \widehat{\Delta}\right)' \tag{35}$$

[10]See Voena (2015) on how to estimate income process.

where W is a diagonal weighting matrix where its diagonal is the inverse of the empirical variance of the data moments. Given the non-smooth nature of the simulated moment, gradient-based methods are not practical to use. To make sure that the parameters chosen are not of local nature, a global search algorithm *TikTak* is used to pick the best parameter vector candidates.[11]

In the simulation, I impose information shock of the reform for everyone at different ages based on the age distribution of the population in 1989, where agents in the life-cycle model are exposed to the information of the forthcoming reform in the same way as reality. The effect of the reform are assessed by comparing agents who are exposed to the reform against those who did not, using a subset of the cohorts in the simulated sample as 'control group' who are not affect by the reform. I detailed how I solve cohorts under different survival pension regimes in the Appendix D.

All moment conditions and estimated values are labelled out in Table 4, with a brief explanations of the mechanisms provided below:

Adjusting the noise parameters σ_η^2 will change the speed of learning. A small value of σ_η^2 means agents already know a lot about their match quality at the early duration d, making further learning less valuable. Conversely, if σ_η^2 shrinks too slowly, agents may not gain enough knowledge about their match quality even after a long cohabitation period. And the initial dispersion of the match quality is determined by parameters σ_0 and δ.

Changing the cost of divorce c and benefit of marriage μ jointly change the difference between cohabitation and marriage. If all of them set to zero, agents are indifferent between marriage and divorce, and if all of them set to a very high value, marriage and cohabitation will be very different such that the reform is hardly pushing any cohabiting couples into marriage.

Lastly, the weight in the public good ϕ controls the relative importance of resource sharing versus private consumption. A higher weight means agents values being a couple more than being a single.

Table 4: Internally estimated parameters

Estimated Parameters		Value
Cost of divorce	τ_D	1.079
Variance of the true match quality	σ_0^2	0.3572
Variance of the noise in match quality	σ_η	0.9505
Concavity of the utility function	α	1.50
Weight of public goods in the utility function	ϕ	3.80
Standard deviation of the idiosyncratic preference to marry	σ_ξ^2	0.3219
Probability of meeting for single	Pr	0.6212

[11] Tiktak is a multi-start global optimisation algorithms that is used to conduct local searches from carefully selected points in the parameter space. This optimisation could work in parallel and provide the strongest performance against other global optimisation methods in economic applications (Arnoud et al. 2019).

6 Result

6.1 Model fit

Table 5: Model fit

Targeted Moment	Data	Model
Cohabitation		
Duration of premarital cohabitation	6.14	7.27
Extra years of premarital cohabitation for treated	3.64	2.14
Divorce		
Raw divorce share for all marriages	36%	31%
Share of extra divorce from incentivised group	6.2%	5.3%
Raw divorce share by pre-marital cohabitation	see Figure 9	
Share of extra divorce by pre-marital cohabitation	see Figure 9	

Untargeted moments:	Data	Model
Share of people married at retirement	64.1%	70.1%
Average age of marriage	32	37
Share of cohabting couples end up breaking up	60.7%	62.1%

I target three key moments as described in the stylised fact section. As shown in Table 5, the first moment is the difference in pre-marital cohabitation duration for treated cohort versus control cohorts. Treated cohorts (cohabiting couples married due to the reform announcement) have longer cohabitation periods compare to control cohorts (couples that married naturally), reflecting the selection of couples with greater certainty into marriage.

The second moment relates to the fact that treated cohorts have higher divorce rate compared to the control cohorts once the pre-marital cohabitation duration is controlled, in the sense that marriages at the reform period produce extra divorce rate.

The third moment is that these extra divorce rate comes from cohorts with shorter pre-marital cohabitation duration, reflecting that learning being disrupted at early stage is most impactful.

In the untargeted moment, the share of cohabiting couples end up breaking up is significantly higher than the share that end up divorced, consistent with the empirical findings in the data. This fact can be explained in the model where less committed couples in a more flexible relationships are more likely to separate. The average match quality for them is also lower than for married couples, showing that marriage selects couples who are confident about their future relationship.

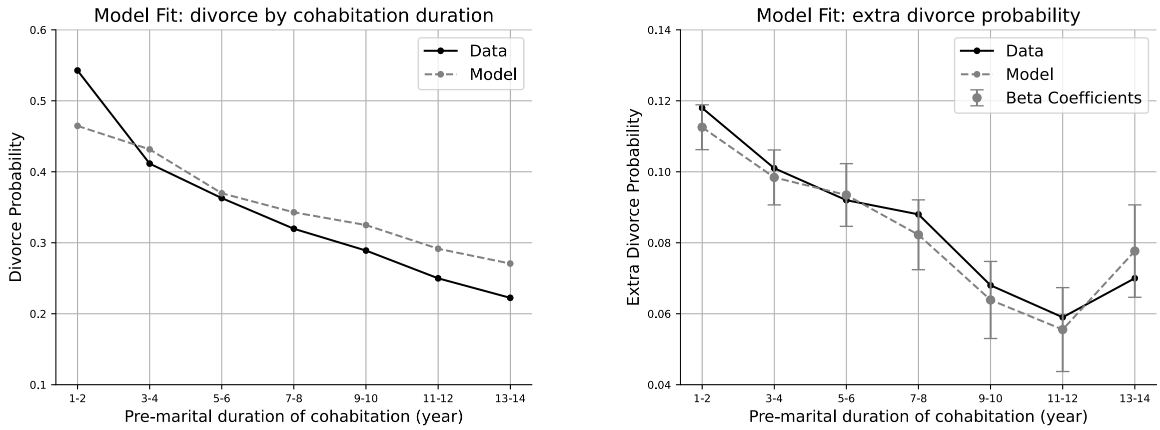


Figure 9: Model fit

6.2 Effect of learning

To understand the role of learning in shaping marital transitions, I analyse a counterfactual scenario where the learning mechanism is effectively removed. By 'shutting down' learning, couples are exposed to a perfectly observable changes in the match quality that generate the same share of divorcees but couples no longer gather information about their match quality during the cohabitation phase. This counterfactual exercise allows me to isolate the contribution of learning to observed marital and divorce patterns.

Under perfect information, the most notable change is how agents respond to the information shock of the forthcoming pension reform. In Figure 10, I plot the distribution of cohabitation year using perfectly observable match quality (left figure) and noisy match quality with learning (right figure), where the white bar are those couples who married due to the policy shock. The difference is that the learning model generates the pre-caution in making decisions early on, making agent to delay their marriage choice by cohabiting longer and knowing more about the true match quality. Whereas perfect information makes the duration of cohabitation useless in the information gathering, and therefore the precautionary decision largely disappears.

Under perfect information, pre-marital cohabitation time dropped from 7.3 years to 5.4 years, and a large number of the couples also get married when they just met, reflecting that better information reduces the need for cohabitation. On top of that, there is a sizeable drop in the break-up rate, from 64.4% to 42.3%. However, although divorce rate dropped from 31.1% to 28.4%, divorce rate in the first marriage rises from 31.5% to 33.0%. Better information on the match quality indeed helped couples make better choices, resulting in a lower separation probability. But better information at the same time increases the outside option, i.e. the value of singles, by making agents less likely to making mistakes in identifying a good partner during the meeting. This means that single agent potentially faces more good choices, and hence more likely to divorce the first marriage.

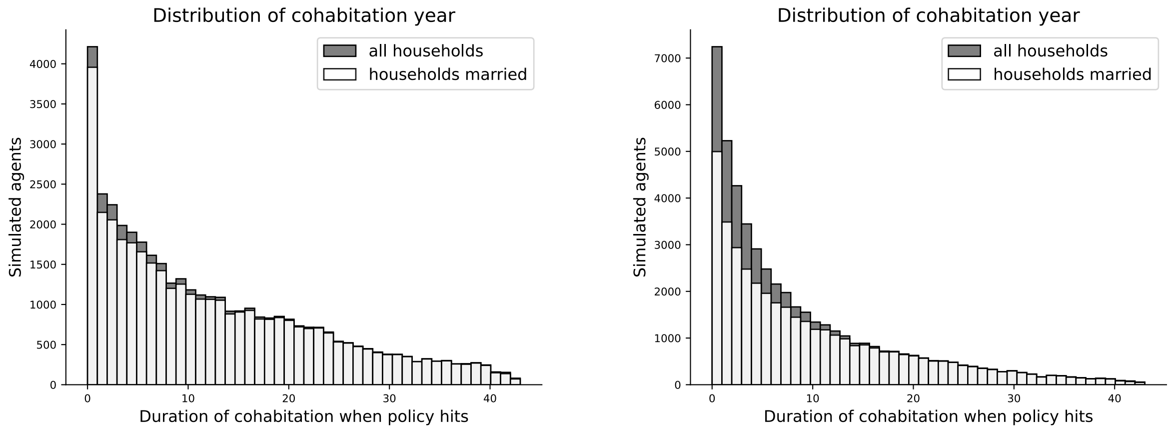


Figure 10: Transition to marriage, with perfect information (left) vs. learning (right)

I further investigate agent's pre-caution in making marital decisions by calculating how much extra income on average is needed to make cohabiting couples just indifferent between marriage and cohabitation. Figure 11 shows a clear downward slope on the financial incentives needed to marry. On average, a new couple needs around 10,000 USD compared to a long-term cohabiting couple (8,390 USD). This willingness to pay reflect the price of reduced learning — amount of money needed to let couples make early commitment. Such an effect could only be generated in a model of learning, as once cohabitation duration is no longer something to consider, cohabitation is no longer useful to gather any information and avoid costly mistakes.

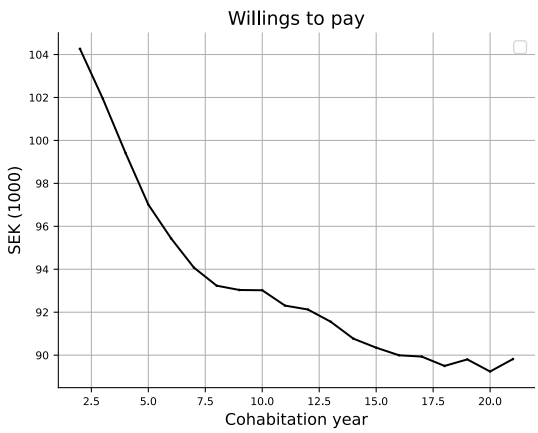


Figure 11: Willingness to pay

6.3 Welfare analysis

To assess the welfare implication of the reform, I measure welfare change using consumption equivalent variation. That is, the percentage of consumption changes needed in order to make agent indifferent between the baseline economy and the economy with survival pension throughout (henceforth referred to as counterfactual economy). Since agents' marital status could differ in this economy versus the counterfactual economy post-reform, I track individuals ex-ante welfare by marital status at the reform announcement period t_0 (at which the event time is defined to be zero), and allow these cohorts' marital status to differ in the two economy post-reform.

$$\sum_i \sum_{t \geq t_0} \mathbb{E}\big[\tilde{U}(c_{i,t})|\mathbf{\Omega}_{t_0}\big] = \sum_i \sum_{t \geq t_0} \mathbb{E}\big[U((1+\lambda)c_{i,t})|\mathbf{\Omega}_{t_0}\big] \tag{36}$$

Table 6: Ex-ante welfare changes

	Married	Cohabiting	Single
Women	-0.56%	-1.20%	-2.13%
Men	0.54%	0.50%	0.06%

Table 6 shows that welfare for women has a salient change at the policy announcement period, particularly for single women. After knowing that they cannot marry immediately, single women lose the benefit permanently. For cohabiting women, welfare level drops because getting the benefit requires them to marriage immediately. Not only does hastened marriage changes their optimal timing, but also as we showed empirically, hastened marriage leads to higher divorce, thereby losing the benefit with additional chance. For the married women, even though they secured benefits, the outside option value decreased permanently and any possibility of divorce in the future period means a loss in the welfare.

Married and cohabiting men's welfare slightly increased at the policy announcement period. This is particularly the case if family is in a position that may trigger renegotiation. Since men can exploit the relationship by knowing that women's outside options are worse and, therefore, are more willing to remain married. Men will take advantage of women's costlier separation in the future rebargaining process by demanding more bargaining power.

Table 7 shows the changes in the average bargaining weight before and after the reform for men and women separately. When men demand a separation, women are willing to give up more bargaining weight ($0.48 - 0.403$) than the amount men are will to give up when women demand a separation. This unbalance is due to the fact that survival pension reform only affects women and therefore, making women more likely to stuck in a bad marriage, driving women's overall bargaining weight lower (0.485 to 0.475) after the reform.

	Average female bargaining power	
Before the reform	0.485	
After the reform	0.475	
	Average female rebargained power	
	Men want to separate	Women want to separate
Before the reform	0.482	0.564
After the reform	0.403	0.580

Table 7: Changes in bargaining power due to changes in women's marital surplus

6.4 De facto marriage law

De facto marriage laws blur the legal distinctions between marriage and cohabitation by granting long-term cohabiting couples similar rights to married ones. De facto couples are typically entitled to a fair share of shared assets, right to alimony, right to inheritance, and right of joint custody on their children. In several countries, de facto relationships or common-law partnerships are recognised automatically after a certain period of cohabitation, without requiring formal registration. Some countries known for their de facto rules include Portugal, Canada, Australia, New Zealand, where couples are considered in a de facto relationship after a few years of cohabitation, and of course, the length of the cohabitation before which de facto rules apply varies in each places and by whether they have a joint child. Such rules protect the vulnerable in long-term cohabiting relationships who are not legally married.

How does such rules affect the choice to cohabit, marry, separation and divorce? I do a simple experiment by changing the duration cutoff after which cohabitating couples will be treated as married by paying the same divorce cost. I plot the cohabitation duration and share of separation. By reducing the legal distinctions between cohabitation and marriage, de facto marriage laws make cohabitation a closer substitute for marriage. This increased substitutability has two potential effects. On the one hand, it encourages marriages by pushing medium to long-term cohabiting couples who weakly prefer a more flexible relationship to marry as they feel marriage and cohabitation are almost perfect substitutes. On the other hand, it may lead to unintended consequences by altering the optimal timing of marriage and disrupting the learning process for early cohabiting couples, where they would have stayed in cohabitation phase much longer. On the left of Figure 12, the rise in divorce share (when d decreases) and the decline and rise in the break-up share reflect the interplay between these two forces.

When d is low (i.e., short-term cohabitation), the break-up rate is high, as many couples have not yet gathered sufficient information about their match quality. The model predicts that uncertainty is highest in the early stages of cohabitation, and couples are more likely to dissolve relationships that turn out to be poor matches. However, these couples also tend to remain cohabiting longer before marrying in the presence of a de facto marriage law, because the law makes cohabitation a closer substitute for marriage.

At intermediate values of d, break-up rates decline because couples who have cohabited for a moderate duration have gathered sufficient information to commit to marriage. The de facto marriage law, by reducing the distinction between cohabitation and marriage, encourages some medium-term cohabiters to formalise their relationships earlier than they otherwise would have. The rest of the couples who remained cohabiting is also benefited from sufficient learning, and a higher separation cost, so the probability of break-up falls.

At higher values of d (i.e., long-term cohabitation), break-up rates rise again. This reversal can be explained by the fact that the policy would take effect after a long period of cohabitation, making it difficult to reach for most cohabiting couples. As a result, most cohabiting couples will have a costless break-up, just like in a standard settings.

The divorce rate, however, exhibits a different pattern. It declines as d rises because longer pre-marital cohabitation generally means that couples are making more informed marital decisions. Consistent with the learning framework, couples who marry after a longer cohabitation period have lower match uncertainty and have already screened out low-quality matches. The declining divorce share reinforces the idea that extended cohabitation before marriage allows couples to learn about their compatibility, reducing post-marital separation risks.

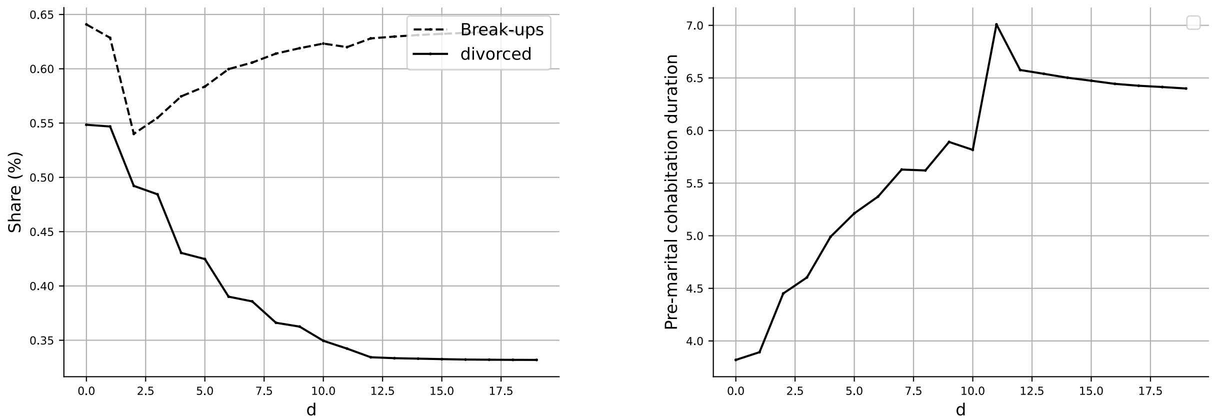


Figure 12: Effect of the de facto marriage law

6.5 Joint taxation

Joint taxation is another policy that directly influences marital decisions by altering the economic incentives associated with marriage. Under joint taxation, the tax liability is calculated on the aggregate household earnings, rather than on an individual basis. This system tends to benefit couples with large income disparities because the lower-earning spouse pulls the household into a lower tax bracket, reducing the total tax burden.

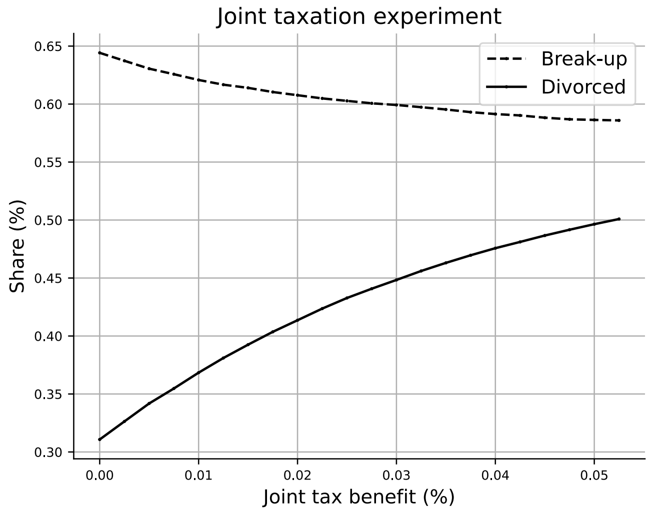


Figure 13: Effect of joint taxation

Within the learning framework developed in this study, joint taxation may also interfere with the process by which couples gather information about their match quality. If tax incentives create financial benefit to marry earlier, some couples may commit before they have fully learned about their compatibility, leading to higher divorce risks. Conversely, if tax policies discourage marriage, some couples may delay marriage indefinitely, potentially reducing the stability of long-term partnerships. In this sense, joint taxation policies can be seen as an external financial incentives that play a role in the dynamics of relationships, influencing both the timing of marriage and the likelihood of divorce.

In Figure 13, I showed that by making the joint tax benefit (the percentage of income that can be exempted from tax) higher, divorce also becomes higher as more marriage decision are made out of financial incentives.

7 Conclusion

This paper provides empirical evidence that couples respond strategically to economic incentives, with long-term cohabiting couples being more likely to transition into marriage when faced with policy-induced time constraints. However, this transition disrupts the learning process, leading to higher divorce risks, especially among couples with shorter pre-marital cohabitation periods. These findings underscore the importance of match uncertainty in relationship stability and suggest that cohabitation serves as an essential screening phase before marriage.

By developing a structural model that incorporates endogenous decisions about cohabitation, marriage, and divorce under limited commitment, I match several stylised facts about how couples marry, divorce and respond to financial incentives. The model reveals that the Swedish pension reform leads to hastened marriages and as a result of reduced learning time, generates higher divorce rate. The reform reduces the welfare of women and results in them being in a worse bargaining position in the household. I use the calibrated model to study other policies affecting the incentives to marry such as de facto marriage laws and joint taxation.

The results contribute to a further understanding of the economic forces shaping marital behaviour. Policies that reduce the distinction between cohabitation and marriage, such as de facto marriage laws, may shorten the learning phase during a less costly relationships, potentially leading to less stable unions. Moreover, policies that impose external pressures to marry——whether through economic penalties or tax benefits——may disrupt the natural selection and learning process, reduceing increasing the likelihood of marital dissolution. These findings highlight the importance of accounting for learning dynamics when designing policies aimed at influencing family formation and stability.

Future research could explore how other legal and economic factors, such as divorce laws, child custody regulations, or social norms, interact with the learning process in marriage markets. Additionally, understanding the heterogeneity in how different demographic groups respond to such policies could further help understand household decision-making.

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Economic Incentives and Learning in Relationship Formation: Evidence from Sweden

Appendix

A Data construction

A.1 Linking Couples

To link couples living together, I combined several registry datasets. Firstly, I categorise couples into two types 1) whether they ever get married, and 2) whether they have had a joint child. Couples with a joint child can be identified using the biological parent registry, a dataset containing the IDs of both parents and their children across the entire population.

Name of registry	**Married**	**Not married**
With joint child	`biological parent`	`biological parent`
No joint child	`partner`	`domestic moves + property ID`

Table 8: Registries used to identify cohabiting couples

In Sweden, around 15% of women and 20% of men remain childless at the ages of 45 and 50, respectively[i]. In the case that childless couples cannot be identified in the biological parent registry, I use alternative registries to identify these couples who live or have lived together, depending on their marital status. If partners have married in the past, most of them will be recorded in the partner registry, where both spouses' id are given. The only challenge is identifying childless couples without a marriage history. Since family id is only given post-1990 for married couples or couples with domestic relationship, cohabiting couples will be assigned with different ID. I use the domestic movement dataset combined with property ID as a remedy to identify a subset of cohabiting couples.

The domestic movement dataset recorded all changes of residential address by individuals on specific dates from 1968 to 1997. It contains each individual's pre-movement property number, post-movement property number and move date. We can identify couples that moved from, or moved to the same property on the same date, but it misses those who moved from or moved to the same building on different date.

Similar to Persson (2020), I then identify cohabiting couples who live in the same property with no other adult. I keep the sample to properties where only two unmarried adults live and drop properties of larger sizes, as it is not possible to link cohabiting couples in large buildings. Combining this result with couples linked via domestic movement forms the sample of final cohabiting couples.

In this appendix, I focus mainly on these subset of cohabiting couples because couples who married and had a child are analysed substantially in the main body of this paper. Concerns arise

[i]See this report at Statistical Sweden: `https://www.scb.se/publication/41273?menu=open`.

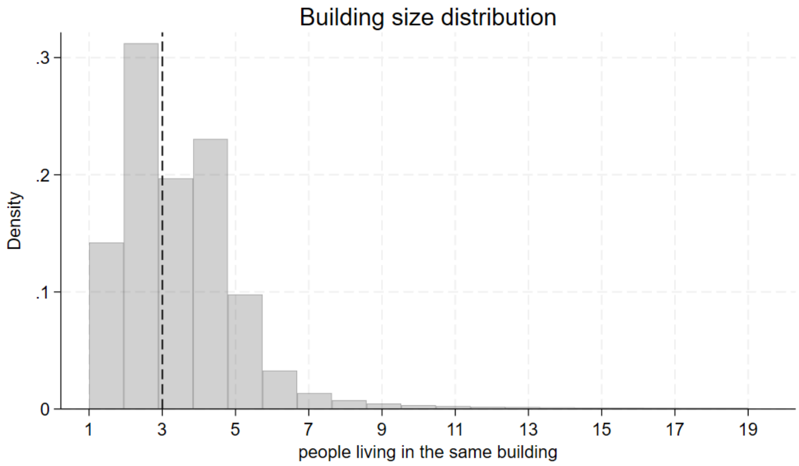

Figure 14: Histogram and medium of building size

regarding whether the adult pairs I linked are actually cohabiting couples, and Figure 14 shows that one building may house many people living together. I do my best to mitigate these concerns by restricting the sample to pairs such that 1) they are of the opposite sex, 2) only two adults live in, move in or move out of the same property in the same date can be counted, 3) they cannot be siblings, and 4) the age gap between these adult pairs cannot exceed 15 years.

Once these steps are completed, we identify a subset of cohabiting couples with the total number of observations of 851,340, among them 69.3% of the samples comes from the domestic moves and the rest from the property ID. we can back out their year of first living together using the property ID again. The initial year of cohabitation is the year from which they started to live in the same property in the same parish. And for married couples, the date of divorce can be inferred from the date of marital status change in the total population registry whereas it is not given if couples are not married. I again use the property ID to infer the separation year, the year in which these unmarried couples no longer live together.[ii]

Next, I use the subset of cohabiting couples (identified using property ID and domestic movement data) to track the proportion of cohabiting couples who will get married at any point in the future. I restrict samples to couples who initiate cohabitation between 1969 and 1980, so that I can track their marriage history and date of separation in the long run, and report the share of these couples by their marital status and child status in Table 9. Table 10 reports the share of these couples who end up separated in 20 years since their initial cohabitation, and Figure 15 reports the share of couples remaining by duration of cohabitation.

[ii]The definitions of divorce and separation are slightly different because we do not require married couples to live together before divorce, but we do require cohabiting couples to live together before separation. Given that more than 95% of the married couples live in the same place, I ignore this difference. Note that around 7% of the cohabiting couples cohabit again after separation. To ease the concern that couples moved out temporarily are miscounted as separation, I define separation as the couples who moved out and live in separate properties for the next 3 years.

A final caveat is that these cohabiting couples may not be fully representative of the total cohabiting couples living in Sweden, because couples who moved more regularly are easier to be identified in the domestic movement dataset, and couples who cohabit for a short period of time is easily missed by the method of counting property ID. If more long-term cohabiting couples are counted in the dataset, we risk oversampling couples with more stable relationships and overestimate the share of couples who married in the end.

Cohabiting couples	**No joint child**	**With joint child**	**Total**
Not Married	39.05%	18.51%	57.56%
Married	3.72%	38.71%	42.44%
Total	42.77%	57.23%	100%

Table 9: Share of cohabiting couples by their final marital and child status

Cohabiting couples	**No joint child**	**With joint child**	**Ave.**
Not Married	5.87%	36.85%	16.72%
Married	64.71%	82.16%	80.63%
Ave.	10.99%	67.50%	43.32%

Table 10: Share of cohabiting couples still living together in 20 years since their first cohabitation

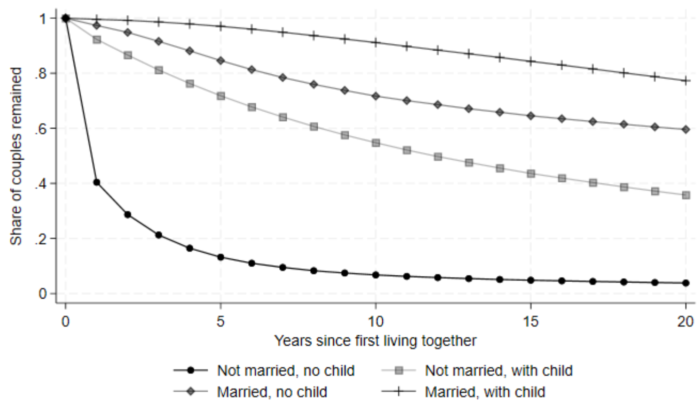

Figure 15: Share of couples still living together in 20 years

A.2 Infer date of marriage and divorce

Total population registry provides the date of most recent marital status change from 1972 to 2023, and annual marital status (single, married, divorced, and widowed) from 1968 to 2023. I combine these two information to infer the date of marriage and divorce. Specifically, I first use linked couples from the previous steps to check if they have any joint date of marital status change, and if so, I check their marital status before and after the change date. In some rare occupations, two marital status changes are recorded in the same year, and the annual marital status could remain unchanged because two changes are made within the two adjacent recording periods. In this case, I use the previous period's marital status to infer the changes. For example, if a couples is married at year t and t+1, then two changes means this couple divorced and remarried in the same year. If a person is single at year t, then two changes means this couple is married and divorced in the same year. Typically in any given year this only applies to less than 1000 individuals.

B Motivating Example

I develop a minimalist model to demonstrate the core idea. The economy is populated with cohabiting couples. The only two heterogeneities are couple's duration of cohabitation and their perceived match quality. Each couple decide if they are going to continue cohabitation (C), getting married (M) or separate (S). Denote the mapping function by $f : \mathbb{R}^2 \to \mathcal{C}$, where $\mathbb{R}^2$ is the space of perceived match quality and the uncertainty (measured by variance) associated with this match quality, $(\tilde{\psi}, \sigma^2)$, and $\mathcal{C} = \{C, M, S\}$ is a set of discrete choices specified above.

Couples live for two periods in total. In the first period, given the two state variables, discrete marital decision specified above is made. Use $\tilde{\psi}$ to denote the (unbiased) perceived match quality in period 1 and ψ the eventual realised match quality in period 2. ψ is drawn from certain continuous distribution with cumulative distribution function $F(.)$. In the second period, when match quality is realised, couples react exogenously if they stay separate or stay together based on realised match quality. They separate if $\psi < \underline{\psi}$. Denote the flow utility of marriage in each period by U^M, flow utility of cohabitation by U^C, and flow utility of separation by U^S. If couples transitioned from marriage to separation, they need to pay a utility cost equal to c to reflect costly divorce, but couples transition from cohabitation to separation do not need to pay the cost.

The expected utility by choosing to marry in period 1 is

$$V^M = U^M + Pr(\psi \geq \underline{\psi})U^M + Pr(\psi < \underline{\psi})(U^S - c) \tag{37}$$

The expected utility by choosing to cohabit in period 1 is

$$V^C = U^C + Pr(\psi \geq \underline{\psi})U^M + Pr(\psi < \underline{\psi})U^S \tag{38}$$

where ψ is a random variable in period 1, and the variance of it reflect the magnitudes of uncertainty. For simplicity, I assume there is no discounting across periods and cohabiting couples in the second period must decide either to marry or separate. By setting equation 38 equal to 37, we can solve for the match quality cutoff that makes agents indifferent between cohabitation and marriage in period 1:

$$\frac{U^M - U^C}{c} = F\left(\frac{\underline{\psi} - \tilde{\psi}}{\sigma^2}\right) \tag{39}$$

From equation 39, we can derive the expression for the threshold $\tilde{\psi}$ as a function uncertainty level σ^2 by inverting cumulative distribution function F,

$$\tilde{\psi} = \underline{\psi} - \sigma^2(d) \underbrace{F^{-1}\left(\frac{U^M - U^C}{c}\right)}_{(-)} \tag{40}$$

To see why $\tilde{\psi}$ increases with σ^2, first see that for any given level of uncertainty σ^2, $\tilde{\psi}(\sigma^2) > \underline{\psi}$ must be satisfied otherwise couples will marry if their match quality falls below separation threshold. This implies that $F^{-1}(.)$ is negative. Under the assumption that marriage-cohabitation premium, $U^M - U^C$ is independent of the duration of cohabitation[iii], we conclude that

C1. The marriage decision cutoff increases with the match quality uncertainty, and therefore decreases with the duration of cohabitation.

The second conclusion follows naturally from the previous conclusion and economic intuition. The speed of learning on match quality should be high for newly-met couples, but low for long-cohabiting couples. Denote d as the duration of cohabitation, by imposing some nice properties such as $\frac{\partial \sigma^2}{\partial d}|_{d=0} = -\infty$ and $\frac{\partial \sigma^2}{\partial d}|_{d=+\infty} = 0$, and by chain rule and equation equation 39, $\frac{\partial \tilde{\psi}}{\partial d}|_{d=0} = -\infty$ and $\frac{\partial \tilde{\psi}}{\partial d}|_{d=+\infty} = 0$ hold. In words,

C2. The slope of the cutoff is steep when couples just met as learning is speedy. It becomes flatter as the duration of cohabitation rises.

Similar exercises can be done to derive the separation decision cutoff. Combining these two results gives graph B.

The pension reform is introduced such that couples who married late are not eligible for some benefit. I model the amount of benefit as part of the utility for married couples, denoted by b, and if couples cohabit in period 1 and decide to marry in period 2, it is too late to be eligible for the benefit and will bear the utility cost b.

$$V^C = U^C + Pr(\psi \geq \underline{\psi})(U^M - b) + Pr(\psi < \underline{\psi})U^S \tag{41}$$

Solving equation 41 with equation 37, we arrive at

$$\tilde{\psi}(b) = \underline{\psi} - \sigma^2(d)F^{-1}\left(\frac{U^M - U^C + b}{c + b}\right) \tag{42}$$

Since $\frac{U^M - U^C}{c} < \frac{U^M - U^C + b}{c+b}$ as $b > 0$ and $0 < \frac{U^M - U^C}{c} < 1$ to be in the domain of F^{-1}. Since $F(.)$ is an increasing and continuous function, $F^{-1}(.)$ will also be increasing and continuous. Therefore, we find that $\tilde{\psi}(b = 0, \sigma^2) > \tilde{\psi}(b > 0, \sigma^2)\ \forall\ \sigma^2$.

C3. Penalising late marriages results in shortened duration of cohabitation and lower the required match quality to get married.

[iii] This assumption could be relaxed. Readers could verify that if marriage-cohabitation premium is decreasing with the duration of cohabitation to reflect that long cohabiting couples find it is almost indifferent to marry or cohabit, then conclusion of this model remains unchanged.

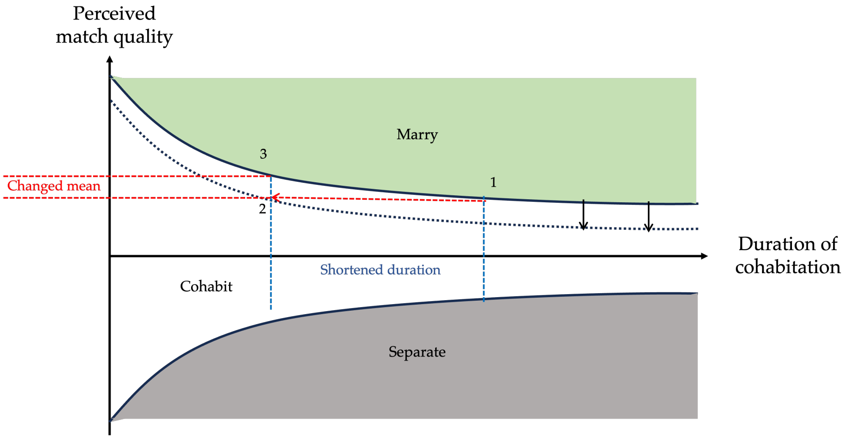

Figure 16: Cutoff for marital decisions

C Counterfactual marriages

To unravel the policy effect on the duration of cohabitation, I record the number of transitions from cohabitation to marriage, assuming that in absence of the policy the counterfactual marriages would follow the trend pre-policy. I do this exercise by the year in which couples entered cohabitation and plot the number of marriages in Figure 17.

$$\begin{aligned} n_{ct} &= f(d) + \eta_c + \mathbb{1}[t > 1989] \sum_{c=1975}^{1988} R_c + \\ &\mathbb{1}[t = 1989] \sum_{c=1975}^{1988} \gamma_c^{89} + \mathbb{1}[t = 1990] \sum_{c=1975}^{1988} \gamma_c^{90} + \mathbb{1}[t = 1991] \sum_{c=1975}^{1988} \gamma_c^{91} + \varepsilon_{ct} \end{aligned} \tag{43}$$

where n is the natural logarithm of the number of marriages in year t for cohort who initiates cohabitation in year c. A higher order polynomial $f(d)$ is used to capture the density of number of marriages as a function of cohabitation duration, d. L_c represents the cohort-specific reductions in entry into marriage post-policy. Additional cohort-specific set of parameters, γ_c^{89}, γ_c^{90}, γ_c^{91} added more flexibility to reflect effect of bunching and policy effect a few periods afterwards.

After fitting the polynomial, we can derive how much longer the treated group would have cohabited had there been no reform. Denote the extra mean duration of cohabitation for cohort c as $\mathbb{E}(\Delta d_c)$, we have

$$\mathbb{E}(\Delta d_c) = \int x \cdot (g_c^{predict}(x) - g_c^{real}(x))dx \tag{44}$$

where $g_c^{predict}(x)$ is the counterfactual distribution of entry into marriage. $g_c^{real}(x)$ is the real (smoothed) distribution of entry into marriage.

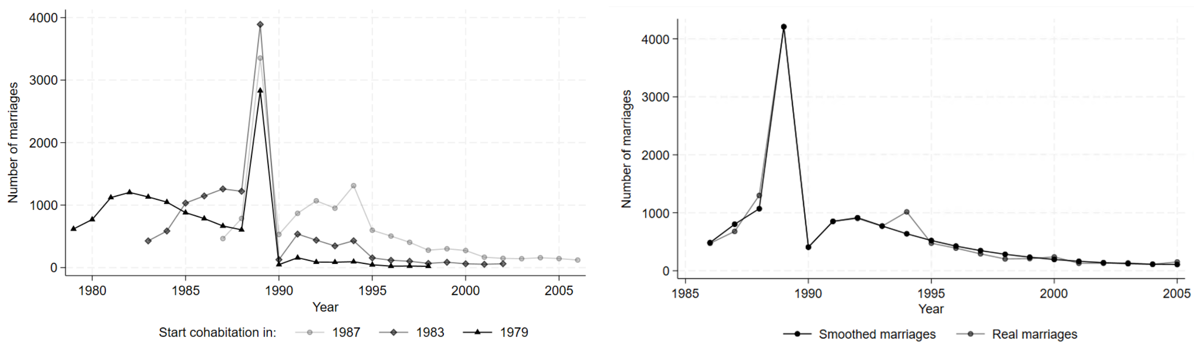

Figure 17: Marriage numbers by date of starting cohabitation (left) and example of polynomial fit (right)

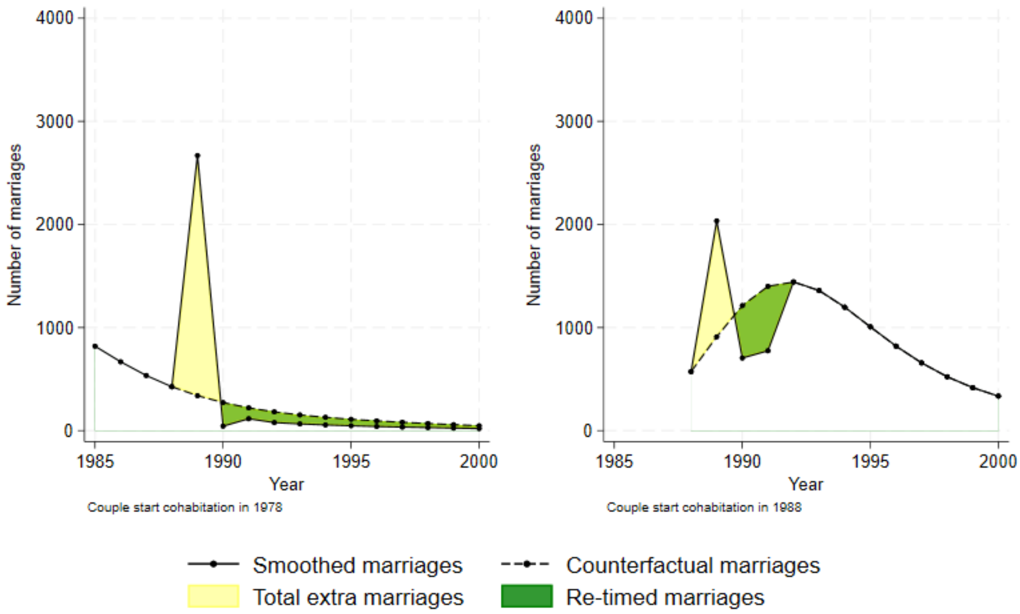

Figure 18: Marriage numbers decomposition by date of starting cohabitation

Table 11: Counterfactual Prediction Results

Duration of cohabitation before married	1-2 years	3-4 years	5-7 years	8-10 years
Reduction in cohabitation duration (yr)	1.45	3.42	4.42	4.99
Share of extra marriages	0.29	0.44	0.43	0.53
Share of retimed marriages	0.71	0.56	0.57	0.47
Predicted number of extra marriages (thousand)	1.73	3.03	2.91	2.75

Note: Results of finding counterfactual duration of cohabitation exercise. Sample includes all marriages with joint child(ren) after 1-10 years of cohabitation. I divide total heightened marriages in 1989 into the retimed marriages and extra marriages and then calculate their respective share in each bin.

Table C summarises the post-estimation result. I first divide the total sample into 4 groups by their duration of cohabitation and for each group, I then divide the observed spike in the number of marriages in 1989 into retimed marriages and extra marriages (see Figure 18 for detail). Retimed marriages refers to marriages that would have occurred in later years but moved forward to 1989, and extra marriages refers to marriages that would have never occurred in absence of the reform.

D Computational detail: model changing survival pension regime

The reform consists of 3 stages: 1) before the reform announcement, when all women know that there will be survival pension as long as they are married. 2) after the reform announcement, before the reform implementation, when the information shock comes and women know that divorce and re-marry will no longer secure the benefit, and lastly 3) after the implementation, no more survival pension for new marriages.

D.1 Model solving

To model different survival pension eligibility, I add an additional state variable `Sur` to represent the survival pension regime, and `Sur` takes 3 values corresponding to the three stages I will describe below. I solve the model backwards and get the value function for starting as a single (V^S), starting as a cohabiting person (V^C) and starting as married (V^M), and impose stochastic survival probability for household head (ϱ_j) and his/her partner (ϱ_{-j}) that is gender-age specific, such that men have higher death probability than women after retirement.

For brevity, I ignore other state variables and only label the pension regime in the bracket, where `Sur` $= \{0, 1, 2\}$. At `Sur` $= 2$, the economy will always provide survival pension to widows. At `Sur` $= 0$, survival pension no longer exists. These are the two absorbing states that are easy to solve. I focus on describing `Sur` $= 1$ below, where survival pension is revoked once divorce is triggered.

I first break down the starting period value function into the value of remaining single ($V^{S\to S} = V^{C\to S}$), the value of divorcee ($V^{M\to S}$), and the value of remaining a couple ($V^{S\to M} = V^{C\to M} = V^{M\to M}$ and $V^{S\to C} = V^{C\to C}$). I can write down the starting period value of being in `Sur`$=1$ as follows

$$V^M(1) = D^* V^{M\to S}(0) + (1 - D^*)V^{M\to M}(1) \tag{45}$$

$$V^S(1) = M^* V^{S\to M}(1) + C^* V^{S\to C}(0) + (1 - C^* - M^*)V^{S\to S}(0) \tag{46}$$

$$V^C(1) = M^* V^{C\to M}(1) + C^* V^{C\to C}(0) + (1 - C^* - M^*)V^{C\to S}(0) \tag{47}$$

where D^*, C^*, $M^* \in \{0, 1\}$ represent the choice to divorce, cohabit and marry respectively. Take the first equation for example, it means that if a married couple starts in `Sur` $= 1$, then she can secure the benefit provided that she stay married ($D^* = 0$). Once she divorces ($D^* = 1$), she permanently moved to the absorbing state `Sur` $= 0$.

When the partner of a married couple dies, she transitioned into an absorbing state of 'widowhood', where for women, $V^W(0) \leq V^W(1) = V^W(2)$ to reflect survival pension weakly increases the value of the widow, conditional on other state variables. Men do not get survival pension regardless hence making no direct difference which survival pension state they are in. Men's value before and after the reform only change through women's change in the bargaining power within the household.

$$V^{M\to M}(1) = U(c) + \beta\mathbb{E}\Big[\varrho_j(1-\varrho_{-j})V'^{W}(1) + \varrho_j\varrho_{-j}V'^{M}(1)\Big] \tag{48}$$

D.2 Simulation

In simulation, everyone starts at `Sur`=2, where married women expect to have the benefit secured throughout their life. I then impose the information shock for everyone at different ages. Crucially, I use the age distribution of the population in 1989, where agents in the life-cycle model are exposed to the information of the forthcoming reform in the same way as reality. Agents who receive the information shock are put into `Sur`=1 so that single and cohabiting agents know that this is the last period to secure the benefit by marrying someone. And married couples know that divorce will become more costly. One period later, the reform is implemented, and all single and cohabiting agents transitioned to `Sur`=0. They permanently lose the benefit, but married agents who married before the reform are still in `Sur`=1.

E Other supplements

E.1 incentive to survival pension

I create a simple measure that reflects the women' expectation of their survival pension that can be claimed in the future. It is the function of the age difference plus life expectancy difference between men and women times the average income difference before getting married. This measure reflects the length of survival pension claim period multiplied by the amount of each year's pension amount, and therefore is proportional to the final survival pension the couple could receive.

$$\text{expected benefit}_i = \mathbb{1}[\text{entitled}]_i \cdot \max\Big\{(age_m - age_w + 4)\cdot(\overline{income}_w - \overline{income}_m), 0\Big\} \tag{49}$$

A threat to the identification is that cohabiting couples right before the reform face higher expected benefit than couples that married naturally. If that is the case, then the spike in marriages observed in the last period of 1989 comes not only from couple facing the time pressure to marry, but also from high economic incentive compared to previous periods. By comparing the average expected benefit for marriages observed yearly from 1980 to 1989, I show that marriages in 1989 does not exhibit higher expected benefit.

E.2 Income profile over the lifecycle

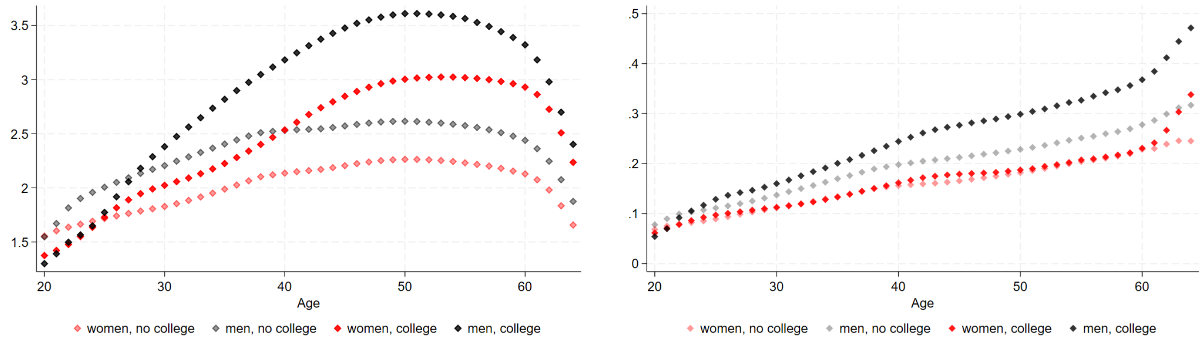

Figure 19: Income profile and income variance

E.3 Age distribution

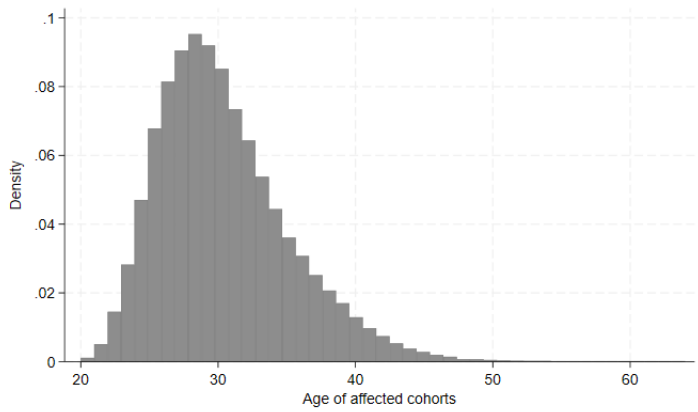

Figure 20: Age distribution of the cohabiting couples with a child

E.4 Labour supply

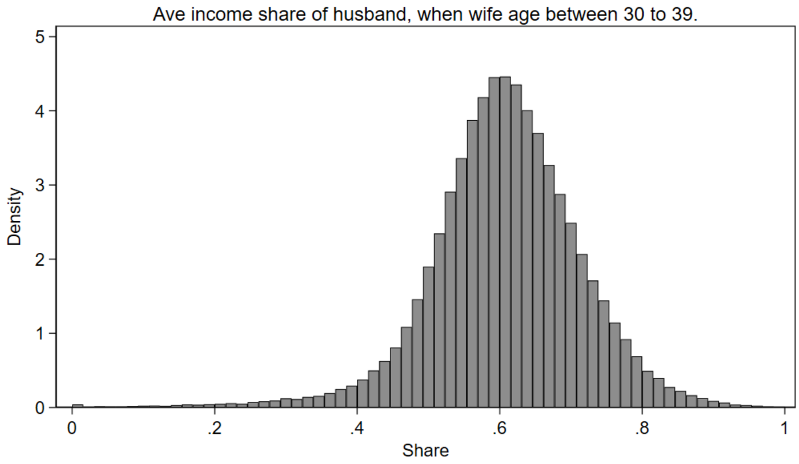

Figure 21: Distribution of the income share of husband

To find the reform on the labour supply of women by age difference between wife and husband, I estimate the following regression:

$$\text{Hour}_{it}^{w} = \beta_0 + \beta_1 D_i + \beta_2 \Delta\text{Age}_i + \beta_3 D_i \Delta\text{Age}_i + \beta_4 X_{it} + \epsilon_{it} \tag{50}$$

where D_i equals 1 if the individual is entitled to the survival benefit, and ΔAge_i is the age difference between wife and husband, and equals to $age^w - age^m$. Controls X_{it} include age polynomials of the wife, average income of the husband and wife when wife aged between 30 to 39 and whether wife and husband received higher education. The coefficient plot is in Figure 22.

Figure 22: Distribution of the income share of husband